Cost-Benefit Analysis of Mining & Milling Uranium at the Swanson Site in Pittsylvania County, Virginia

Prepared for the
Virginia Coal and Energy Commission
under the direction of its Uranium Task Force

Tayloe Murphy Institute
The Colgate Darden Graduate School of Business Administration
University of Virginia

August 1984

Cost - Benefit Analysis of Mining & Milling Uranium at the Swanson Site in Pittsylvania County, Virginia

Dr. John L. Knapp, Project Leader and Co-author
Deputy Director, TMI
Research Director, Economic Studies Center, TMI
Associate Professor, General Faculty

Ms. Beverly H. Capone, Co-author
Staff Member, Economic Studies Center

Mr. Bruce F. Parsell, Co-author
Staff Member, Economic Studies Center

Mr. William T. Smith, II, Co-author
Staff Member, Economic Studies Center

Dr. James C. Dunstan, Advisor
Director, TMI
Professor, The Colgate Darden Graduate School of Business Administration

Prepared for the
Virginia Coal and Energy Commission
under the direction of its Uranium Task Force

Tayloe Murphy Institute
The Colgate Darden Graduate School of Business Administration
University of Virginia

August 1984

Production
Acknowledgements

Cover Design: Barry A. Jackson

Typing: Sandra F. Napier
Amanda H. Shull
Joan Vaclavicek
Janet T. Wilson

Editing: Elizabeth J. Dell

PREFACE

In March, five months ago, the Tayloe Murphy Institute (TMI) began an intensive study on the costs and benefits of mining and milling uranium in Pittsylvania County. This study exemplifies TMI's role, which is to conduct research serving government, business, and citizens of Virginia. The work was prepared under contract for the Virginia Coal and Energy Commission and funded by the Commission and the TMI endowment. In fulfillment of the contract, TMI performed the following tasks: a) obtained background information on the industry; b) reviewed past studies on uranium mining; c) surveyed cost-benefit literature; d) gathered information on the local economy; e) reviewed material on economic analysis of secondary benefits and on other relevant subjects that was presented in support of uranium development in Pittsylvania County by the Marline Uranium Corporation and Union Carbide Corporation;[1/] and f) reviewed assumptions and data that had been provided, checked for methodological and computational accuracy, evaluated the quality of estimates, and developed alternative estimates when appropriate.

In the course of our analysis, the project team had detailed discussions with employees of Marline Uranium Corporation and its consultants, representatives of state and federal agencies responsible for environmental regulation, and persons connected with environmental organizations. The project team contacted the staff of the Bureau of Economic Analysis in order to gain an understanding of the RIMS II input-output model used to develop local multipliers. Team members reviewed publications about the uranium industry and about other industries that create real or perceived negative environmental effects. In addition, we examined the cost-benefit literature. We also visited the proposed site and contacted individuals in the local area affected by the project.

Without the assistance of many individuals, the completion of this study would not have been possible. Appendix G contains a complete listing of persons who assisted, but we would also like to give special recognition to a few individuals. Richard C. Collins and his staff at the Institute for Environmental Negotiation at the University of Virginia were instrumental in getting TMI involved in the study and provided assistance by sharing information, conducting fact-finding meetings, and commenting on concepts and study design. Georgia H. Herbert and Tamara A. Vance of the Piedmont Environmental Council provided useful analyses and information. Robert J. Nagy of Gibbs and Hill, Inc. was helpful in retracing the economic analysis previously done by his firm for the original study developed by the Marline Uranium Corporation and Union Carbide Corporation. John A. Yellich of the Marline Uranium Corporation

---

1/ The subsidiary of Union Carbide now involved in the project is known as Umetco Minerals Corporation.

served as the principal contact for the joint venture proposing the project. His hospitality at the site and his efforts to answer our questions were greatly appreciated.

We gratefully acknowledge all of the assistance we received in the preparation of this report, but, of course, we accept full responsibility for the analyses and conclusions based on the information we obtained.

John L. Knapp
Project Leader

CONTENTS

CONTENTS (continued)

CONTENTS (continued)

TABLES AND EXHIBITS

Text Tables

Text Tables (continued) page

Text Exhibits

Appendix Tables

Appendix Tables | page

EXECUTIVE SUMMARY

The purpose of this study is to analyze the costs and benefits associated with a proposed uranium mining and milling facility at the Swanson site in Pittsylvania county. In this study, we review and evaluate information presented in support of the project by Marline Uranium Corporation and Umetco Minerals Corporation (Marline-Umetco), the companies that propose to jointly develop the site. In addition, we also make independent estimates for some costs and benefits.

Although many quantitative estimates are provided, we wish to emphasize that a large degree of uncertainty exists as to the magnitude of some costs and benefits. Where we do not find it feasible to assign dollar values to particular costs or benefits, we discuss the possible outcomes qualitatively. Although we refer to some costs and benefits as intangible, we consider them no less important than those that can be quantified in dollar terms; but we are unable to estimate their value. In addition, as is the general practice in cost-benefit studies, we do not consider the distribution of costs and benefits; we consider only their aggregate value. We do not ignore distributional issues because they are unimportant, but because they are beyond the scope of this study.

We examined the proposed project's effects from the perspective of the state and residents of the regional study area (RSA--the cities of Danville and South Boston and the counties of Halifax and Pittsylvania). Because of this focus, we evaluated some of the costs and benefits differently than Marline-Umetco. Marline-Umetco, for example, counted the value of uranium oxide produced as a benefit. We, however, do not include it because the benefits accrue primarily to individuals outside the state. Similarly, we do not address the question of whether the project would be profitable, except to the extent that its profitability affects the costs or benefits received by residents of the RSA or state. Nor do we consider the costs and benefits that have occurred in the past because such dollar amounts have already been spent and will not be changed by the decision to allow uranium mining and milling at the Swanson site.

Currently, excess capacity and low levels of output and employment characterize the uranium industry in the U.S., yet between now and the end of the century the industry is expected to gradually recover from its depressed state. Two factors could cause the recovery to be stronger than anticipated: the introduction of import restrictions on uranium and an unexpected surge in the use of nucler power. Other factors could weaken the recovery: additional cancellations or delays in the construction of nuclear power plants, the introduction of fuel reprocessing in the U.S., and the exploitation of new high-grade ore deposits in foreign countries. Although the foregoing observations apply to the industry as a whole, the profitability of the Marline-Umetco project depends on costs and other conditions unique to the Swanson site.

It appears that the company would enjoy a slight cost advantage relative to other domestic producers because of the use of nonunion (and thus lower wage) labor and the use of open pit, rather than underground, mining techniques. However, we believe that costs would be significantly higher at the Swanson site than at sites outside the U.S.; in comparison, many foreign firms benefit from higher ore grades, more cheaply exploited deposits, and less stringent environmental, health, and safety regulations.

A major benefit we considered is the stimulus that the project would provide to the economies of both the RSA and the state. Specifically, we examined the project's effects on employment, earnings, and tax revenues for both the 18-month construction phase and the 13-year operations phase. During the operations phase, which has the largest effect on the local economies, direct annual employment by the company would be 468 and earnings would be $6,117,228. After allowing for multiplier effects, the increase in employment would be 620 in the RSA and 810 statewide. Earnings would range from $6,748,000 to $10,122,000 in the RSA and from $9,706,000 to $14,560,000 statewide. These estimates represent an increase from current levels of less than 1 percent.

The major categories of costs examined were increased state and local government expenditures caused by the project, effects on industry in the area, and environmental degradation. For example, if the project is approved, the state government would incur regulatory costs. The regulations governing uranium mining and milling have not been established, and for this reason, our estimates of regulatory costs are necessarily incomplete. Other costs include services provided to Marline-Umetco employees, road improvements, and road maintenance. Local governments in the RSA would incur costs for services provided to the company and to the households of employees immigrating to the area. Pittsylvania County, the location of the site, would also incur a small cost because of the loss of property tax revenue on land that remains unavailable for use after the mine closes.

The effect of the mine/mill complex on industries in the area is difficult to predict. Based on literature concerning activities perceived to have negative externalities (spillovers) and on interviews with individuals in the RSA, we make several observations concerning the potential effects of the project on the agricultural sector: 1) the uranium mine and mill could affect demand for local agricultural goods based on perceived rather than actual environmental changes; 2) because the size and composition of the agricultural industry are changing, it is difficult to isolate the effect of uranium mining and milling on agriculture in the RSA; and 3) the input-output model employed in the study could be used to estimate the effects of a change in demand if the necessary data were available.

We do not anticipate that the project would have any measurable negative effects on local businesses. We base our judgement on the following observations: 1) respondents to an informal survey of local businesses, institutions, and chambers of commerce do not expect adverse effects as a result of the proposed project; 2) uranium mining and milling in other locations has not resulted in any discernible adverse effects on local industry; and 3) the accident at Three Mile Island, another situation in which there was a risk of radiological contamination, did not cause any measurable, long-term damage to local industries or the local economy in general.

Another category of cost that we considered is the effect of uranium mining and milling on the environment. The major topics covered within this section are air quality, radiation, and water resources.

Based on the data provided to us, air pollution should not be a serious problem. We emphasize the following caveats:

1. Our conclusions are based on the assumption that the State Air Pollution Control Board would insure Marline-Umetco's use of an adequate dust suppressant system and that Marline-Umetco institutes "continuous" reclamation of the site so that only one-tenth of the tailings (the waste material from mining and milling) are exposed at any given time.

2. All of our data pertain only to the operations phase of the project. Air pollution would likely be a more serious problem during the 18-month construction phase. Also, peak concentrations of the pollutants examined would be higher than the annual concentrations indicated.

The mine/mill facility would cause increased exposure to radon, a radioactive gas. We estimate only the loss from the increased probability of cancer deaths caused by radon exposure. These probabilities, which are very small, are converted to costs by using estimates of the value of a life that are taken from the economics literature. During operations, the present value of the incurred loss ranges from $63,119 to $166,104. During post-operations and post-closure, the estimates are small, never exceeding $111.

The analysis of water resources includes groundwater and surface water. We draw the following conclusions:

1. Provided that the General Assembly implements the State Water Control Board's (SWCB) proposed standard of zero degradation, we can conclude that there would be no adverse effects on the quality of groundwater. Even if the SWCB's proposed standards are not implemented, it appears that federal regulations, if enforced, would prevent significant degradation of groundwater.

2. There would likely be some localized depression of the water table associated with the mine pit. Marline-Umetco estimates that this would be minimal. The SWCB has expressed concern that the effect may be more widespread than Marline-Umetco believes.

3. Except for some increase in sedimentation due to the diversion of Mill Creek, no significant degradation of surface waters is expected during normal operations, assuming enforcement of current state and federal regulations.

4. The diversion of Mill Creek would cause the destruction of its aquatic habitat and may also have adverse effects on the ecology of downstream areas. We have no way of valuing the losses associated with the environmental changes if Mill Creek is diverted.

5. Our analysis emphasizes the costs and benefits associated with this project during normal operations, but because of difficulties in establishing the probability of different events, we do not attempt to estimate the loss due to accidents. We do, however, give a hypothetical example to illustrate how such calculations could be performed if reliable data concerning probabilities and damages were available.

We compared total benefits and costs for those elements that can be quantified. Since most of the costs and benefits occur over a long period of time, or at different points in time, we discount them to present values using appropriate real discount rates. Total benefits of the project range from $101,024,000 to $149,692,000. total costs range from $4,046,000 to $5,611,000. Thus, using the middle values of the estimates, the benefit to cost ratio is 26:1. Although this favorable ratio is certain to be of interest to readers, we caution that it is based on incomplete and rough information and certain costs and benefits have not been quantified. We encourage a careful reading of the full study and the review of additional information that will be provided by other consultants.

CHAPTER 1

INTRODUCTION

PURPOSE OF STUDY

In this study, we propose to examine the costs and benefits to the Commonwealth of Virginia of allowing Marline Uranium Corporation and Umetco Minerals Corporation (Marline-Umetco) to mine and mill uranium at the Swanson site in Pittsylvania County.

We wish to emphasize that a large degree of uncertainty exists as to the magnitude of some of the costs and benefits. Where possible, dollar values are assigned to the individual costs and benefits that are anticipated to result from this particular project. For costs and benefits that cannot be estimated with a reasonable degree of accuracy, we present a range of values that we feel represent the most likely outcomes. Where we do not find it feasible to assign dollar values to particular costs or benefits, we discuss the likely outcomes in a qualitative manner.

The following three points should be emphasized:

1. We were commissioned to provide information to the state to assist decision-makers in their deliberations concerning the mining and milling of uranium in Pittsylvania County. The decision concerning the economic viability of the project is a private one, given the institutional and regulatory framework established by government agencies. Our emphasis here is on the governmental decision of whether or not to pursue the issue of uranium mining and milling at the Swanson site. Hence, we confine our study to the likely effects of the project on the area and state in terms of the economy, the population, and the environment. The economic viability of this project to its owners is a separate issue from Virginia's decision to license such projects and is considered only to the extent that it affects the costs and benefits accruing to the people of Virginia.

2. This cost-benefit study is specific to the Swanson project area in Pittsylvania County; we assume that all uranium ore is to be mined and milled at this site. Although many of the same types of costs and benefits would be present in other areas, their magnitudes would likely vary depending on, among other things, size of the project, type of mining and milling processes, population of the area, types of industry present in the area, and the specific geophysical and hydrological characteristics of the area. While our results are specific to the Swanson project area, we feel that our basic methodology could easily serve as a model for analyzing the costs and benefits of uranium mining and milling in other areas within the state.

3. Although cost-benefit analysis places a dollar value on many of the costs and benefits associated with a given project, it will not give a final answer to the question of whether benefits are greater than costs. Cost-benefit analysis is as much an art as a science. Accordingly, views differ concerning what this analysis actually is. Some feel that it should provide unequivocal answers to allocative questions; in other words, when properly estimated, if total benefits exceed total costs, then the project is, on balance, desirable. Others argue that the cost-benefit criterion is but one of a number of criteria on which a project should be judged. Not only must one evaluate the costs and benefits of a project but one must also consider how they are distributed among different groups in society--that is, who gains or loses if the project is implemented. Although there is much we can say about the dollar value of particular benefits and costs, some benefits and costs, by their nature, preclude precise valuation in money terms. For this reason, cost-benefit analysis should not be used as the sole criterion for making a policy decision; rather, it should be viewed as a way of providing information to decision-makers concerning the possible effects of a particular course of action. Decision-makers and the public must decide whether the benefits of this project exceed the costs, based on their own valuation of those benefits and costs that cannot be accurately represented in money terms.

DESCRIPTION OF THE SWANSON SITE

The Marline Uranium Corporation and Umetco Minerals Corporation have formed a joint venture to develop what is thought to be a major uranium deposit in Pittsylvania County, Virginia. The Swanson site is located about 20 miles north of Danville, Virginia, just east of U.S. 29. The two towns nearest the site are Chatham, seven miles to the southwest, and Gretna, seven miles to the northwest. The site encompasses approximately 1,460 acres. About 44 percent of this land is used for agriculture; the rest is forested.1/

In this analysis, we focus our attention on the effects the project would have on the regional and state economies. In examining the effects of this project, we focus on a regional study area (RSA) that incorporates the counties and cities that will be most directly affected by the mining and milling operations. Specifically, the RSA is defined as the counties of Pittsylvania and Halifax and the cities of Danville and South Boston. The majority of the benefits and costs of this project will accrue to the residents of Pittsylvania County. Halifax County

---

1/ Except where noted, the information in this section is from Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County, Virginia, 15 October 1983, vol.1, sec. A-7.

and the cities of Danville and South Boston were included in the RSA because of their proximity to the Swanson site. Increased incomes due to the project, increased demand for social services, and other possible effects of the project will be concentrated within the RSA. The project may have direct effects on some of the counties adjacent to the RSA; for example, some people employed at the site may live outside the RSA. Therefore, some of the benefits may accrue to these individuals. Adjacent counties are not included in the RSA because the vast majority of the effects of the project will occur in the counties of Halifax and Pittsylvania and the cities of Danville and South Boston. Little additional information would be obtained from including other areas in the RSA.

According to the 1980 Census, the population of the RSA is 149,481. The largest concentrations of population within the RSA are in the cities of Danville with a population of 45,642 and South Boston with a population of 7,093. The area immediately surrounding the site is sparsely populated. The population within one mile of the site is approximately 200. Within two miles of the site, there are just over 700 residents.[1/] The two largest concentrations of population near the site are located in Chatham with a population of 1,390 and in Gretna with a population of 1,255.

Manufacturing, centered in and around Danville, provides about half of the employment in the RSA; textiles and furniture are two of the major manufacturing industries. In terms of income generated, agriculture is another major industry in the RSA. Tobacco is, by far, the most important agricultural commodity in the area, accounting for about 75 percent of total agricultural sales.

Total employment in the RSA was 66,223 in 1981. During the operations phase, Marline-Umetco will employ 468 workers, or roughly 0.7 percent of all employees in the RSA. They will pay a total of $6,117,000 (in constant 1981 dollars) per year in wages, which represents roughly 0.9 percent of the total wages and salaries paid to workers in the RSA during 1981.

The Swanson site's approximately 1,460 acres include the mine, mill, tailings management, and clay barrow areas. Mining operations will cover about 135 acres; the mill complex will cover about 25 acres. It is anticipated that after an initial construction phase of 18 months, mining and milling operations will continue for approximately 13 years. The estimated average ore grade for the deposit is 0.1 to 0.2 percent (two to four pounds of uranium oxide per ton of ore), which is about average for uranium deposits in the U.S. Marline-Umetco's plans call for a conventional open pit mining and milling complex with the capacity to handle approximately one million tons of ore annually. After processing, this ore will produce roughly 1,000 tons of uranium

---

1/ Based on estimates using 1980 Census block data.

oxide per year. In the milling process, the uranium is separated from waste rock by crushing and then chemically treating the ore. The residue left after the removal of the uranium from the ore is called the tailings. Because the removal of uranium does not significantly reduce the volume of the ore, the tailings will be nearly equal in volume to the ore removed.

After the ore is exhausted, the site will be decommissioned and reclaimed. The mine pit will be allowed to fill with water, eventually forming a lake of approximately 100 acres. The mill will be decommissioned in accordance with applicable federal and state laws. The tailings from the milling process will be stored in the tailings management area along with equipment that is not decontaminated and salvaged. A clay liner and cap will supplement the use of waste rock in the encapsulation of the tailings. As a final step, a layer of soil will be placed over the waste rock, and the area will be revegetated. After reclamation is complete, the tailings management area will be approximately 220 acres and 100 feet high and will be fenced and monitored. It is anticipated that, except for the 220 acres used for the tailings management area, the Swanson site will be available for unrestricted use after decommissioning and reclamation. Under current Nuclear Regulatory Commission regulations, the tailings management area is unlikely to be available for any commercial, industrial, or residential use.

STATE OF THE URANIUM INDUSTRY

The benefits of the proposed uranium mining and milling project are partially dependent on the condition of the uranium industry. Marline-Umetco's plans call for full-time, year-round operation of the mine/mill complex, and assume that full-time operation will be economically viable, which partially depends on conditions in the uranium industry. For this reason, we have included a brief description of the uranium industry in our report.1/

Currently, excess capacity and low levels of output and employment characterize the uranium industry in the U.S. Established to meet military needs in the 1940's and 1950's, the industry now relies on demand generated by civilian use of nuclear power. In fact, since 1970 the federal government has made no purchases of uranium on the open market and has, instead, relied on previously stockpiled uranium.

The uranium industry's depressed state is the result of several factors. First, mining and milling capacity grew rapidly in the early to mid 1970's in response to optimistic predictions that nuclear generating capacity would expand rapidly through the rest of the century, but this

---

1/ Most of our information came from U.S. Department of Energy, United States Uranium Mining and Milling Industry: A Comprehensive Review, A Report to Congress by The President of the United States, May 1984; hereafter, we refer to this as The President's Report.

expansion has not materialized in the United States. In fact, the 1970's saw the cancellation or delay of many planned nuclear facilities as the result of rapidly increasing construction costs. Since 1972, 105 reactors have been canceled.1/ Second, the decline of the uranium industry in the U.S. is partially due to the relaxation of processing restrictions on imported uranium and the development of mining and milling operations overseas, particularly in Australia, Canada, and South Africa.

Because of the rapid expansion in the use of nuclear energy anticipated throughout the century, utilities entered long-term purchase agreements for uranium. When construction plans were scaled back beginning in the early 1970's, uranium inventories rapidly accumulated. Currently, utilities using nuclear power hold uranium inventories approximately four times larger than desired. As a result of increased foreign competition and large inventories, the market price of uranium has dropped drastically, from over $65 per pound in 1976 to $17.50 per pound currently.2/ At this price, most domestic producers cannot produce uranium as cheaply as it can be purchased from foreign sources or currently held inventories. Output has also fallen sharply. From a peak of 21.9 thousand tons in 1980, domestic output fell to only 10.6 thousand tons in 1983. This rapid drop in production caused a large amount of excess capacity to develop. In 1983, only 12 of 23 mills in the U.S. were in operation; those 12 mills operated at 58 percent of capacity. Including mills not in operation, the industry operated at 33 percent of capacity.

Historically, imports have been an insignificant part of the uranium market in the United States. Between 1964 and 1977, the federal government would not process imported uranium. Because the federal government had a monopoly on uranium processing, this regulation effectively eliminated any imports of foreign uranium. Between 1977 and 1984, the restrictions on processing foreign uranium were gradually lifted. Presently, no restrictions remain on the amount of imported uranium that may be processed, and as a result the importation of uranium has increased. Imports delivered for enrichment increased from 700 tons in 1977 to 2,200 tons in 1983. The percentage of uranium delivered for processing from non-domestic sources rose from 4.7 percent to almost 17 percent between 1977 and 1983.

Reasons for the Decline of the U.S. Uranium Industry

The most important reason for the decline in the domestic uranium industry is the cutbacks in the construction of nuclear power plants. In the late 1960's and early 1970's, demand for electricity was expected to grow about 7 percent per year. The actual rate of growth has been

---

1/ "Cost May Halt New TVA Reactors," Washington Post, 17 July, 1984. sec. A, p.2.

2/ All prices are in constant 1983 dollars.

less than half that, about 2 percent per year. Because of this slow increase in demand, many utilities have cut back on the construction of new capacity. Nuclear capacity in particular has suffered because of rapid increases in construction costs relative to conventional plants. With this cutback in the construction of nuclear plants, the demand for nuclear fuel has declined, as is reflected by large inventories and recent declines in output from domestic mining and milling operations.

Domestic firms are at a competitive disadvantage relative to foreign producers because of lower grade ores and higher costs. Presently, the average grade of the domestic ore being mined is 0.2 percent uranium oxide (four pounds of uranium oxide per ton of ore), and is expected to decline to about 0.1 percent (two pounds of uranium oxide per ton of ore) by the 1990's. In contrast, some foreign operations are mining ore that is 2 to 3 percent uranium oxide (40 to 60 pounds of uranium oxide per ton of ore). Much of American uranium is mined underground while many of the newer operations opening outside the U.S. are using less expensive open pit mines. Also, American mines are on average deeper and thus more expensive to operate than those outside the U.S. Besides these disadvantages, U.S. producers have experienced higher costs than foreign operations due to increasingly stringent health, safety, and environmental regulations.

Future of the Uranium Industry

With the depletion of excess inventories, the current decline in the domestic uranium industry is expected to bottom out in the mid-1980's and in the following decade to improve slowly with prices and output increasing gradually. Beginning in the mid-1990's with increasing foreign use of nuclear power and the partial depletion of low cost foreign resources, it is anticipated that the uranium industry will grow more rapidly with prices and output levels continuing to rise into the next century. These predictions assume that regulatory policies will not change and that domestic and foreign use of nuclear power will grow as anticipated.

From a current price of $17.50 per pound of uranium oxide, prices are expected to increase to $50 per pound by the mid-1990's and to $73 by the year 2000. It should be noted that there is a great deal of uncertainty attached to these projections of future prices. The President's Report indicates that the 95 percent confidence interval for the price of uranium in 1995 is $22.90-$73.50. In the year 2000, the spread is even larger, with the 95 percent confidence interval being $24.80-$121.40.

Domestic production is expected to remain at or below the current level of 10.6 thousand tons through the 1980's, then after 1990 it is expected to increase slowly in response to increases in domestic and foreign demand. By the end of the century, the projected annual output is 17.5 thousand tons per year, still below the 1980 peak of 21.9 thousand tons.

Under current regulations, imports are expected to capture a larger share of the market as new contracts are negotiated for lower cost imports. At their peak in 1987, imports will account for between 41 and 54 percent of domestic utility requirements. In the 1990's, this share is expected to decline to between 32 and 46 percent due to an increase in foreign demand and an increase in the cost of imports caused by the depletion of some deposits.

Qualifications

Although the domestic uranium industry is expected to grow steadily, it could either improve more rapidly than anticipated or remain relatively stagnant due to certain qualifications listed below.

1. Possible Import Restrictions: Congress has expressed interest in maintaining a viable domestic uranium industry. It is possible that import restrictions will be imposed in response to perceived threats to the viability of the industry. The President's Report examined the effects of several different types of import restrictions. These included limiting imports to 20, 30, or 40 percent of domestic requirements or imposing a 25 percent duty on imported uranium. The 40 percent restriction has little effect on projected prices or output. The more severe restrictions of 20 or 30 percent increase both price and output. It appears that price is more sensitive to these restrictions than output. With the most severe restriction of limiting imports to 20 percent of the market, projected output is 24.7 thousand tons annually by the year 2000, compared to 17.7 thousand tons in the absence of the restrictions. The projected price is significantly higher at $106 per pound than it would be in the absence of the restriction. (Without restrictions, the projected price in the year 2000 is $73 per pound.) The effect of a tariff of 25 percent would be between the effect of limiting imports to 20 percent of the market and limiting them to 30 percent of the market.

2. Fuel Reprocessing: Reprocessing of used nuclear fuels could cut the demand for newly mined uranium. Depending on how soon such a reprocessing program is instituted and whether or not plutonium is also reprocessed, fuel reprocessing could cut the demand for newly mined and milled uranium by 10 to 15 percent per year.

3. Cancellation of Orders for New Plants: One of the primary reasons for the current depressed state of the uranium industry is the slower than anticipated growth in the use of nuclear power. Since the publication of The President's Report in May of 1984, ten planned nuclear generating stations have been canceled due to large increases in construction costs. Additional cancellations, either here or abroad, would have a depressing effect on the market.[1/]

1/ There is some indication that cancellations of nuclear plants are continuing. See "Closings of Nuclear Plants," U.S. News and World Report, 97 (30 July, 1984): 58.

4. Potential Opening of New Mines: There are several areas outside the U.S. such as Australia, Canada, and South Africa with large, high-grade deposits of uranium ore. The government of Australia is currently discussing the opening of mines that have a potential output of 50 thousand tons of uranium oxide per year, about five times the current output of U.S. mines.[1/] The exploitation of such areas would tend to keep the price of uranium down.

Summary

Conditions in the uranium industry indicate the economic environment in which Marline-Umetco has to operate if it proceeds with the Swanson project. The United States uranium industry is currently in a depressed state. Output, price, and employment are all at very low levels compared to the recent past. The outlook for the industry between now and the end of the century is somewhat better. Though employment and output are not anticipated to reach their previous peaks, prices are expected to rebound to their former levels (in constant 1983 dollars). These projections assume no change in the regulatory environment of the industry. Two factors could cause the improvement in the industry to be stronger than anticipated--the introduction of import restrictions and an unexpected surge in the use of nuclear power. Other factors could weaken the recovery, such as the introduction of fuel reprocessing in the U.S., additional cancellations or delays in the construction of nuclear power stations, and the exploitation of new high-grade ore deposits in foreign countries.

While conditions in the uranium industry give an indication of the economic viability of the uranium industry as a whole, the profitability of this particular project depends on costs and other conditions unique to the Swanson site. Although they will have to meet more stringent environmental regulations than many domestic firms because of recently passed legislation, other factors lead us to believe that Marline-Umetco will enjoy a slight cost advantage relative to other domestic producers. The factors that lead us to believe that costs will be below average are the use of nonunion (and thus lower wage) labor and the use of open pit rather than underground mining techniques. Other factors, however, lead us to believe that costs will be significantly higher than at many foreign sites: lower ore grades, more stringent environmental, health, and safety regulations, deeper mines, and expenses associated with the start up of the mine/mill complex that current producers do not face.

1/ See David Dickson, "Uranium Shortage Turns to Glut," Science 22 (3 August, 1984): 484; and "Meltdown," Economist 291 (19-25 May, 1984): p. 87-88.

SCOPE OF THE ANALYSIS

In this analysis, we focus on the costs and benefits to the residents of the Regional Study Area (RSA) and the Commonwealth of Virginia of the proposed mining and milling operation in Pittsylvania County. Many cost-benefit studies analyze government spending decisions--for example, the construction of dams and harbor improvements. In contrast, we are examining the costs and benefits of government licensing of a particular type of private investment. Therefore, we focus on the costs and benefits associated with the state's decision to license uranium mining and milling operations in Pittsylvania County. We do not address the question of whether the project would be profitable if it is allowed to proceed, except to the extent that the project's profitability changes the level of costs or benefits received by residents.

For the purposes of this study, we focus strictly on the direct benefits to the RSA and the state. These benefits are divided into three broad categories: increased employment, regional income, and tax revenues at the state and local levels.

We also examine costs from the perspective of the project's effects on the residents of the RSA and the state: expenditures by state and local governments for licensing and monitoring the project, public outlays for services provided to new residents and to the mine/mill complex (for example, road improvements and law enforcement), reductions in local tax revenues due to the removal of land from the tax base, and changes in the local environment.

Because we are examining the effects of the licensing decision on the residents of Virginia, benefits that accrue to Marline-Umetco or individuals outside the state are not included. For instance, one of the primary benefits of the project is the value of the uranium oxide produced. However, because these benefits accrue to Marline-Umetco rather than to the residents of the RSA or the state, they are not included. Similarly, the other primary benefits of the project--such as possible reductions in the price of nuclear fuels, additional generation of electricity, and reduced reliance on foreign supplies of fossil fuels--accrue mainly to people outside the Commonwealth. For this reason, we do not include them.

LIMITATIONS AND ADVANTAGES OF COST-BENEFIT ANALYSIS

Limitations inherent in any cost-benefit analysis include the valuation of intangibles, the treatment of uncertainty, and the neglect of the distributional aspects of the project. One problem encountered in this particular study is that, for some topics, we were forced to examine total costs and benefits of the Swanson project, rather than the additional, or incremental costs and benefits, because of the difficulty of obtaining these estimates. In this section, we discuss each of these issues in turn. Another problem common to all cost-benefit studies, which we discuss in Appendix E, is the appropriate method of discounting future costs and benefits. After the discussion of the limitations of cost-benefit studies, we briefly examine some of their advantages.

Intangibles

Inevitably, in any cost-benefit analysis, some costs and benefits cannot be accurately summarized in dollar terms. Such costs and benefits, usually referred to as intangibles, are an especially severe problem in this study because one important effect of the project, environmental degradation, is largely intangible. Like authors of other studies, we find it difficult to obtain precise estimates of the environmental effects of this project, let alone place a dollar value on such changes; by referring to costs and benefits as intangible, we do not intend to indicate that we consider them any less important than those that can be quantified in dollar terms, only that we cannot enumerate them in such terms. We include a description of important intangible costs and benefits, and where possible we include an estimate of the magnitude of such intangibles.

Uncertainty

In any cost-benefit study, a degree of uncertainty is often attached to the estimated values of the costs and benefits of a project. Our estimates for this project depend on information gathered from a variety of sources; hence, our estimates will only prove accurate to the extent that the information provided to us is accurate. Two examples will illustrate the nature of uncertainty and show how our estimates of costs and benefits are related to the information provided. The first example will be the effect of uncertainty on one aspect of estimated benefits, the second on estimated costs.

Following Marline-Umetco's example, we assume that the mining and milling facilities will be operated full time for 13 years. However, whether or not these facilities actually do operate full time for 13 years depends on a number of factors that cannot be accurately predicted. These factors include:

1. The grade and extent of the ore body: Marline-Umetco has made its prediction of a 13-year operating life based on geological surveys of the Swanson site. The ore body may be larger or smaller than anticipated or the average grade of the ore may be higher or lower than expected. Either of these two factors may cause the project to last longer or shut down sooner than anticipated. The length of the operational stage, of course, affects the size of the benefits accruing from the project. If the project continues longer than expected, then the benefits will be larger; if it shuts down sooner than anticipated, the benefits will be smaller than projected.

2. The future price of uranium: There are several reasons the future price of uranium is uncertain: decreased demand due to the possibility of additional cancellations of nuclear power facilities, large increases in supply as a result of the development of rich uranium deposits outside the U.S., and trade policies that may be instituted by the federal government to protect the domestic uranium industry. Clearly, if the price of uranium is higher than anticipated, the operation will be more profitable and may continue longer than originally planned; just the reverse would be true if the price of uranium is lower in the future than currently expected.

3. The stringency of regulation: A third factor, the stringency of the health, safety, and environmental regulations that the state sets for mining and milling can influence the length of operations at the Swanson site. If regulations are more stringent, the project will be less profitable, increasing the chances that it will not be undertaken, will not be operated full time, or will close down sooner than anticipated, thus eliminating or reducing the benefits. If regulations are less stringent, the project will be more profitable, increasing the chances that it will be undertaken; if so, will continue to operate beyond the planned 13 years, thus increasing the benefits of the project.

Not only is there uncertainty about the size of some benefits but also of some costs. One of these costs is the possible adverse effect on the health of local residents. Assuming that all applicable environmental standards are met, we can predict the maximum releases of various pollutants into the environment. We cannot, however, precisely predict what the exposure of any one individual may be, nor can we predict the health effects of such releases. Although the absence of data for most pollutants prevents us from estimating the losses associated with them, we were able to collect sufficient data to estimate the losses due to cancer caused by radon emissions from the tailings management area. Uncertainty also arises because we focus on the costs of the project during normal operations. As with any project of this nature, accidents could cause much greater changes in the environment and, thus, larger costs than anticipated.

As can be seen from these examples of benefits and costs, many factors can affect the magnitude of costs and benefits resulting from the Swanson project. We have pointed out the areas where we feel that uncertainty is most important and have attempted to give a plausible range of values.

Distributional Aspects

As with all cost-benefit studies, this one deals only with the aggregate dollar value of the costs and benefits of a particular project. As such, it ignores the issue of the distribution of costs and benefits among the residents of the RSA.

A project may have total benefits greater than total costs (including intangible costs and benefits), and yet still be undesirable because of its effect on the distribution of income. An example might be a local government using tax revenues for the construction of a yacht club. The benefits to those who use the facility may well be larger than the costs of construction and maintenance, yet most people would consider such a project undesirable because of its effect on income distribution. The benefits of such a facility would accrue almost entirely to the wealthy, who can afford yachts. A substantial part of the costs would be borne by those less wealthy in the form of taxes they paid to support the project. Thus, the effect of the project would be to redistribute wealth from the relatively poor to the relatively wealthy.

Conversely, a project may have total costs greater than total benefits and still be desirable due to a beneficial redistribution of income. All welfare programs are of this nature. In any welfare program, the benefits received by the beneficiaries will be less than costs because it is costly to administer such programs. For each dollar that goes toward such programs, less than a dollar is received in benefits because of administrative costs. Therefore, for any welfare program, the identifiable costs are greater than the identifiable benefits, yet such programs are considered desirable because they redistribute income from the relatively wealthy to the relatively poor.

Total versus Incremental Costs and Benefits

In this cost-benefit analysis, we have examined some of the effects of the Swanson project in terms of total costs and total benefits. Ideally, we would like to examine only the incremental costs and benefits of the project, but we have sometimes focused on total costs and benefits because to discuss incremental benefits we would have to know how the site would be used in the absence of the Swanson project. Currently, the area is used for agriculture, yet over the next 15 to 20 years other industry may develop in the absence of the project. Because we do not have predictions concerning future use, we cannot determine the incremental costs and benefits of uranium mining and milling. Hence, for some effects, we focus on total costs and benefits. An example will illustrate the distinction between incremental and total costs and benefits.

We have assumed that the increase in employment in the RSA will equal the number of people hired at the Swanson site and also that labor income will increase by the full amount of Marline-Umetco's expenditure on labor. For several reasons, we expect that these assumptions will tend to overstate the employment benefits of the project.

First, other employment opportunities would most likely develop if the Swanson project were not undertaken. Therefore, some of the people hired by Marline-Umetco would be employed anyway, even without the Swanson project. Only if we make the assumption that all the people hired at the project remained unemployed in its absence can we say that total employment at the site equals the amount of the benefit. If some of the people obtained jobs in the absence of the project, then only the addition to employment, over what it would be without the project, should be counted as a benefit.

Second, some of the people hired at the Swanson site will likely be hired away from other jobs in the area. If the vacated jobs are filled by people who receive the same wage as those they replace, then the benefits of the increased employment are correctly measured by the total wages paid. If the vacated jobs remain unfilled, then only the increase in the workers' salaries should be included in benefits. We have assumed that the total earnings of workers employed by Marline-Umetco correctly measures benefits received, though actual benefits would likely be slightly less. We made this assumption because of the difficulty of predicting where employees will be hired from, whether the vacated positions will be filled, and what the workers' previous salaries might have been.

Third, there may be some second earners who leave the labor force as a result of the hiring by Marline-Umetco. The classic example is the husband who has been out of work for a period of time and whose wife has entered the labor market to provide supplemental income. After the husband finds another job, the wife quits hers and returns to being a full-time housewife. While employment increases with the addition of one worker, it also decreases as a secondary earner leaves the labor force. In this case, there is no net change in employment, yet there may be an increase in wages or total man-hours of employment because the husband may work for a higher wage or longer hours.

The limitations of cost-benefit analyses emphasize the fact that they are not intended to be the single criterion for judging a public project. Rather, such studies should be viewed as one piece of information available to officials when making decisions.

Advantages of Cost-Benefit Analysis

In spite of the limitations, cost-benefit studies are an important tool in the analysis of any major project. Some of their advantages are listed below:

1. Orders of magnitude can be obtained for some types of costs and benefits. For example, it is much more useful to a policymaker to know that a particular project will likely increase tax revenues by $100,000 per year, plus or minus 10 percent, than it is to know that the project will probably increase tax revenues, but by some unknown amount.

2. For subjects about which there is a great deal of uncertainty concerning the level of costs or benefits, a study can proint out that such uncertainty does exist and attempt to show the most likely outcome of the project. In situations where it is impossible to

discern one outcome more likely than others, a study can point out a range of possible outcomes that are about equally likely.

3. It may not be possible to estimate dollar values for some types of costs and benefits. However, in a cost-benefit study, these intangible costs and benefits can be examined within context, and their relative importance discussed.

4. In cost-benefit analysis, one of the most significant advantages is the convenient way in which we can, in a consistent manner, enumerate all the various costs and benefits (including intangible costs and benefits) of a particular program. This is an aid to policymakers in their examination of the many diverse factors that bear on the decision of whether or not to pursue a particular program.

5. A second advantage is that in doing cost-benefit analyses we may discover important gaps in information that can be filled by doing additional research.

CHAPTER 2

BENEFITS

INTRODUCTION

In this chapter, we examine benefits that would result from the Swanson project under various given assumptions. The major benefits to the local and state economies are employment and earnings provided directly to Marline-Umetco's workers and suppliers, employment and earnings generated by the additional spending, and taxes paid by Marline-Umetco, workers, local businesses, and institutions as a result of this project. One issue we do not address in depth is the distribution of benefits among residents of the RSA and state. We do not neglect this issue because it is unimportant but because it is beyond the scope of our analysis.

Marline-Umetco spent a total of $19,012,000 for uranium exploration and development activities in Virginia during the period 1977 to mid-1983 and a portion of these expenditures were for the Swanson site. Although these expenditures were a benefit to the state, they have no bearing on the decision by the General Assembly to either ban or allow uranium mining and milling. The legislature is concerned with future benefits and costs, not those already incurred, which in business terminology are known as "sunk costs." Therefore, even though past expenditures are evidence that Marline-Umetco has a commitment to mining and milling uranium in the state, it is inappropriate to include them in the analysis that follows.

EMPLOYMENT AND EARNINGS IMPACTS OF THE PROJECT

Introduction

The Marline-Umetco project will have both direct and indirect impacts upon the local and state economies. The direct impacts of the project are defined as the company's expenditures on goods and services and the employees' consumption expenditures within the relevant geographical area. The indirect impacts are defined as the expenditures by other firms resulting from the initial purchases by Marline-Umetco.

This section reports our estimates of both types of impacts. The estimates of the direct impacts are revised and updated versions of Marline-Umetco's anticipated expenditures.1/

1/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County, Virginia (15 October 1983), vol. 3.--henceforth referred to in tables as Marline-Umetco.

Direct Impacts

Table 2.1 shows the summary of direct employment and earnings resulting from the Marline-Umetco project. Our estimates of the direct expenditures are reported in Tables 2.2 through 2.5. Each of these tables summarizes the direct expenditures, in 1981 dollars, of a particular phase of the project on a given geographical area. Table 2.2, for example, shows the direct impacts of the construction phase of the project on the RSA. Our estimates differ from those of Marline-Umetco for several reasons:

1. Marline-Umetco omitted expenditures on tailings management from its analysis. New data from Marline-Umetco[1/] indicate that expenditures on tailings management will be about $16 million during the 18-month construction phase of the project, and $4.8 million annually during the operations phase. We have been able to approximate the distribution of these expenditures across Bureau of Economic Analysis (BEA)[2/] industry categories,[3/] and so have incorporated them into our analysis.

2. Our estimates of wholesale expenditures, exclusive of expenditures on tailings management, are 15 percent of those reported in the Marline-Umetco tables. In making this reduction, we conform to the procedure of Gibbs and Hill, Marline-Umetco's economic consultants, who reduced the wholesale figures in their I-O model by this percentage on the grounds that most of the dollars received by wholesale agents would be passed through to manufacturers without affecting the regional or state economy.[4/] Gibbs and Hill did not, however, reduce the wholesale figures in their expenditure tables. We accept the lower figure and its rationale, but believe that numbers used in the I-O model should be consistent with numbers reported in the table of direct impacts.

3. Our wage bill for the construction phase is approximately 7.43 percent higher than that reported by Marline-Umetco. We made this

---

1/ Letter of July 30, 1984 from John A. Yellich of Marline Uranium Corporation to John L. Knapp of the Tayloe Murphy Institute.

2/ The Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce has developed an industrial taxonomy used in the input-output analysis employed by Marline-Umetco.

3/ For details see Section II.B of Table A.2.

4/ Letter of July 13, 1984 from Joseph Nagy of Gibbs and Hill to John L. Knapp of the Tayloe Murphy Institute.

TABLE 2.1

SUMMARY OF DIRECT EMPLOYMENT AND EARNINGS

Period	Employment	Average Annual Salary	Cost
Construction			
excluding tailings management			
year 1	305	$12,069	$3,681,000
year 2 (6 months)	305	12,069	1,840,000
			5,521,000
Construction			
including tailings management			
year 1	305	13,567	4,138,000
year 2 (6 months)	305	13,567	2,069,000
			6,207,000
Operations			
excluding tailings management	453	13,071	5,921,000
Operations			
including tailings management	468	13,071	6,117,000[a]

Source: Marline-Umetco Table I.3-6 with adjustments.

a/ In the expenditure and I-O tables, we report a total wage bill for the operations phase of $6,112,000; this was derived by adding $192,000 for tailings management (=.04 x $4,800,000) to Marline's estimate of $5,920,000. The discrepancy probably reflects the fact that Marline's suggested 4%/96% split between labor and nonlabor expenditures for tailings management is only an approximation.

TABLE 2.2

SUMMARY OF THE ALLOCATION OF CONSTRUCTION AND TAILINGS MANAGEMENT EXPENDITURES DURING THE CONSTRUCTION PHASE--REGIONAL STUDY AREA[a/]

Industry Classification	Allocation
Wholesale Trade	$ 6,619,000
Labor	6,207,000
Stone and Clay Mining and Quarrying	4,581,000
Ready-mixed Concrete	4,008,000
Miscellaneous Professional Services	3,659,000
Real Estate	802,000
Total	$25,876,000

Source: Tables A.6, A.7 and A.8.

a/ This table is also shown as Table A.9 in Appendix A.

TABLE 2.3

SUMMARY OF THE ALLOCATION OF ANNUAL OPERATING AND TAILINGS MANAGEMENT EXPENDITURES DURING THE OPERATIONS PHASE--REGIONAL STUDY AREA[a/]

Industry Classification	Allocation
Wholesale Trade	$ 1,557,000
Labor	6,112,000
Stone and Clay Mining and Quarrying	379,000
Ready-Mixed Concrete	332,000
Electrical Services	671,000
Gas Production and Distribution	1,264,000
Miscellaneous Professional Services	303,000
Real Estate	210,000
Total	$10,828,000

Source: Tables A.10, A.11, and A.12.

a/ This table is also shown as Table A.13 in Appendix A.

TABLE 2.4

SUMMARY OF THE ALLOCATION OF CONSTRUCTION AND TAILINGS MANAGEMENT EXPENDITURES DURING THE CONSTRUCTION PHASE--VIRGINIA[a/]

Industry Classification	Allocation
Wholesale Trade	$ 1,151,000
Labor	6,207,000
Stone and Clay Mining and Quarrying	3,569,000
Ready-mixed Concrete	3,123,000
Paints and Allied Products	904,000
Concrete Block and Brick	6,328,000
Electrical Industrial Apparatus	2,965,000
Gas Production and Distribution	808,000
Pipes, Values, and Pipe Fittings	3,872,000
Miscellaneous Professional Services	7,924,000
Real Estate	833,000
Construction Machinery and Equipment	5,166,000
Mining Machinery	5,166,000
Total	$48,016,000

Source: Tables A.14, A.15, and A.16.

a/ This table is also shown as Table A.17 in Appendix A.

TABLE 2.5

SUMMARY OF THE ALLOCATION OF ANNUAL OPERATING AND TAILINGS MANAGEMENT EXPENDITURES DURING THE OPERATIONS PHASE--VIRGINIA[a]

Industry Classification	Allocation
Wholesale Trade	$ 838,000
Labor	6,112,000
Stone and Clay Mining and Quarrying	224,000
Ready-mixed Concrete	196,000
Paint and Allied Products	57,000
Concrete Block and Brick	398,000
Electrical Services	671,000
Electrical Industrial Appliances	186,000
Gas Production and Distribution	5,307,000
Pipes, Value, and Pipe Fittings	243,000
Miscellaneous Professional Services	498,000
Real Estate	196,000
Industrial Inorganic and Organic Chemicals	1,812,000
Explosives	1,208,000
Construction Machinery and Equipment	325,000
Mining Machinery	325,000
Total	$18,596,000

Source: Tables A.18, A.19 and A.20.

a/ This table is also shown as Table A.21 in Appendix A.

adjustment because historical data indicate that Marline-Umetco slightly understated the average annual salary for construction workers.1/

The reader interested in a more detailed development of our estimates of these expenditures may refer to Section III of Table A.2.

Direct and Indirect Impacts

In order to estimate indirect impacts we use input-output (I-O) analysis and economic base analysis, two well known techniques used in regional impact studies. We will employ both in order to determine if the results are roughly comparable.

Input-Output Estimates

The I-O model we use to estimate the indirect impacts of the project is the same as that used by Gibbs and Hill, namely the Regional Industrial Multiplier System (RIMS II) of the Bureau of Economic Analysis. A brief discussion of the nature and limitations of I-O analysis, and a detailed exposition of the assumptions, data, and calculations in our use of RIMS II, are contained in Appendix A. Here, for the sake of brevity, we only report the results.

Again, following Gibbs and Hill, we estimate the effects in four different categories, each of which attempts to capture the impacts of a certain phase of the project on a given geographical area. These categories are denoted as:

1. RSA/Construction
2. RSA/Operations
3. State/Construction
4. State/Operations

The construction phase is assumed to last 18 months, the operations phase 13 years.

For each of the categories, table 2.6 shows the total estimated increase in earnings2/ resulting from the project. The column labeled middle

---

1/ For a more detailed discussion of the calculations, see III.D.1. of Table A.2. There also seem to be minor arithmetic or typographical errors in Marline-Umetco's calculation of the wage bills. Our calculations correct these errors. See III.D.2 of the same table.

2/ Earnings are defined as the sum of wages, salaries, other labor income, and proprietors income. The estimated earnings reported for the construction phase cover the entire 18-month period.

TABLE 2.6

TOTAL ESTIMATED INCREASES IN EARNINGS[a/] FROM THE SWANSON PROJECT USING I-O ANALYSIS

	Low Value	Middle Value	High Value
RSA Construction [b/]	$12,975,400	$16,219,300	$19,463,200
RSA Operations [c/]	6,748,100	8,435,100	10,122,100
State Construction [b/]	25,102,300	31,377,900	37,653,500
State Operations [c/]	9,706,900	12,133,600	14,560,300

a/ In thousands of 1981 dollars; derived by reflating I-O estimates with the 1981 GNP Price Deflator of 195.14. See U.S. Congress Joint Economic Committee, Economic Indicators, May 1984 (Washington, D.C.: U.S. Government Printing Office, 1984), p. 4.

b/ Total earnings during the 18-month construction period.

c/ Total annual earnings during the operations period.

value is calculated using the direct impacts reported in the preceding Tables 2.2 through 2.5. The high and low values are generated by varying expenditures upwards and downwards by 20 percent.[1/] For example, estimated total increases in RSA earnings during construction range from $12,975,400 to $ 19,463,200. The middle value is $16,219,300. The following figures are middle values. The estimated increase in state earnings during construction is $31,377,900. During operations, the estimated increase in earnings is $8,435,100 for the RSA and $12,133,600 for the state.

Table 2.7 shows the estimated increases in employment, with the same range of plus and minus 20 percent. Construction and operations employment are shown in terms of average number of jobs at an annual rate. The construction jobs are expected to have a duration of 18 months. Marline-Umetco presents construction employment estimates in person-years (see Marline-Umetco Table I.3-7). Thus, the companys' average number of jobs at an annual rate is converted to 457.5 person years by multiplying 305 x (18 months/12 months) Although this method is acceptable, we prefer to show employment in terms of average number of jobs at an annual rate because we think the concept is easier to grasp.

1/ John A. Yellich of the Marline Uranium Corporation assumes that expenditures will fall within this range. Letter of July 23, 1984 from Yellich to John L. Knapp of the Tayloe Murphy Institute. Earnings vary by exactly the same percentage as expenditures because of the linearity of the model.

TABLE 2.7

TOTAL ESTIMATED INCREASES IN EMPLOYMENT FROM THE SWANSON PROJECT USING I-O ANALYSIS

	Low Value	Middle Value	High Value
RSA Construction[a/]	521	652	782
RSA Operations[b/]	496	620	744
State Construction[a/]	625	782	938
State Operations[b/]	648	810	972

a/ Average number of jobs at an annual rate during 18-month construction phase.

b/ Average number of jobs at an annual rate during operations.

The estimated increase in employment in the RSA during construction range from a low of 521 to a high of 782; the middle value is 652. The following estimates are the middle values. The estimated increase in state employment during construction is 782. During operations, the estimated increase in employment is 620 for the RSA and 810 for the state.

Limitations of the I-O Model

There was a time in the 1950's when the advantages and disadvantages of I-O analysis were hotly contested within the economics profession.[1/] No definitive answers issued from this debate, and we do not presume to provide any now. Nonetheless, we believe that the fundamental limitations of I-O analysis in general, and of this application of RIMS II in particular, should be enumerated so that policymakers will not put unwarranted faith in the numbers generated by these models.

1. A traditional criticism of I-O analysis has been the assumption that the relative proportions of inputs used in production are

1/ See the collection of papers and comments in National Bureau of Economic Research, Studies in Income and Wealth, vol.18, Input-Output Analysis: An Appraisal (Princeton, New Jersey: Princeton University Press, 1955).

fixed. This assumes that if relative prices of inputs change, producers will not make substitutions nor will they use more of the cheaper input. However, prices found in a region do change and they do influence the flow of resources into and out of the area. This is especially true over a long period of time when producers can adjust their production process. However, the RIMS II model has not been used in a short-run context.[1/] The model is based on 1972 national coefficients, and it is being employed here to make forecasts through the end of the century. When one considers the profound structural changes that the American economy has experienced since the oil price shocks of 1974, the inadequacy of forecasting with a static I-O model is apparent.[2/]

2. It is possible that the size of the project may induce structural changes in the local economy even in the short run, thus changing the I-O coefficients. This probably will not be important over the operations phase of the project, but could be fairly significant over the construction phase.

3. RIMS II is a single-region model, and hence not capable of capturing feedback effects with adjacent regions. This means RIMS II is most appropriate to compact, fairly self-contained areas that include most of the inputs supplying industries appearing in the structural matrix.[3/] The RSA defined for this study may not meet this criterion because of its obvious linkages north (to Lynchburg) and south (to North Carolina) with other economic regions.

Economic Base Analysis Estimates

As previously mentioned, economic base analysis is also used to derive estimates of employment and earnings multipliers. The description and limitations of the technique along with our sources of data are contained in Appendix B. In Tables 2.8 and 2.9, which appear below, we present the estimated increases on earnings and employment from the base analysis and compare them with the results of input-output analysis.

The estimated increased earnings to the RSA during construction are $8,876,000; estimated increased earnings to the state are $10,614,000.

1/ See Carl F. Christ, "A Review of Input-Output Analysis," in NBER, Input-Output Analysis: An Appraisal, 140-141; and Walter Isard, Methods of Regional Analysis: an Introduction to Regional Science (Cambridge, MA: The M.I.T. Press, 1967), p. 340.

2/ Dynamic I-O models have been developed, but scarcity of data has prevented their wide use. See Miernyk, Input-Output Analysis, pp. 113-125.

3/ Cartwright, RIMS II: Regional Input-Output Modeling System, p. 59.

TABLE 2.8

ESTIMATED INCREASES IN EARNINGS[a/] FROM THE SWANSON PROJECT, COMPARISON OF I-O AND ECONOMIC BASE ANALYSIS

	Economic Base Analysis Earnings	RIMS II Low Value Earnings	RIMS II High Value Earnings
RSA Construction	$ 8,876,000	$12,975,400	$19,463,200
State Construction	10,614,000	25,102,300	37,653,500
RSA Operations	8,747,000	6,748,100	10,122,100
State Operations	10,460,000 17,066,000[b/]	9,706,900	14,560,300

a/ In 1981 dollars.

b/ The economic base analysis estimate is computed here using the differential multiplier.

TABLE 2.9

ESTIMATED INCREASES IN EMPLOYMENT[a/] FROM THE SWANSON PROJECT, COMPARISON OF I-O AND ECONOMIC BASE ANALYSIS

	Economic Base Analysis Employment	RIMS II Low Value Employment	RIMS II High Value Employment
RSA Construction	457	521	782
State Construction	783	625	938
RSA Operations	702	496	744
State Operations	1,203 1,114[b/]	648	972

a/ Average of jobs at an annual rate.

b/ The economic base analysis estimate is computed here using the differential multiplier.

Both figures are below the ranges derived from the I-O model.1/ The estimated increased earnings to the RSA from operations are $8,747,000; estimated increased earnings to the state are $10,460,000 and $17,066,000.2/ Except for the estimated state earnings of $17,066,000,3/ the estimates are within the I-O range.

The estimated increase in employment for the RSA during construction is 457. As with earnings during construction, this figure is below the range derived from the I-O model. The estimated increase in employment for the state during construction, 783, is within the I-O range. Estimated increased employment in the RSA during operations, 702, is also within the I-O range. Two estimates of increased employment for the state during operations are 1,203 and 1,114.4/ Both figures are above the I-O range.

Given the roughness of both techniques, the estimates provided by the two approaches are acceptably close. In the remainder of our report we will only refer to the estimates obtained from the I-O model.

STATE AND LOCAL GOVERNMENT REVENUE

Marline-Umetco would pay various state and local taxes during the construction and operation phases. These are called "direct taxes." Additional taxes, called "secondary taxes" or "indirect taxes" would be paid by Marline-Umetco employees, suppliers, and residents benefiting from the multiplier effects of the mine/mill activity. Because of the difficulty of quantifying the multiplier effects on revenue, the estimates of secondary taxes are restricted to the taxes paid by Marline-Umetco employees. Similarly, when we estimate costs to the state and local governments, we limit secondary costs to those associated with Marline-Umetco employees.

Direct Taxes, Construction Phase

In the RSA, the real estate tax would be the major source of revenue. Other sources of revenue would be the machinery and tools tax, the tangible personal property tax, and the 1 percent local sales tax. Together, these sources would provide $212,572 in year 1 of construction and $329,062 in year 2 (see Table 2.10). All of this revenue would go to Pittsylvania County, except a portion of the sales tax that would be received by Danville, South Boston, and Halifax County.

1/ Construction is usually considered part of the nonbasic sector. Therefore, it is not surprising that our results are quite different.

2/ Two types of state earnings multipliers for operations are derived. See Appendix B for details.

3/ The multiplier for coal mining is used as a proxy for uranium mining.

4/ Two types of state employment multipliers for operations are derived. See Appendix B for details.

TABLE 2.10

**MAJOR DIRECT TAXES DURING THE CONSTRUCTION PHASE--
REGIONAL STUDY AREA**

Tax	Base (1981$)		Rate	Year 1	Year 2
Real property	Land	$ 1,000,000a/	.0033b/	$ 3,300	$ 3,300
	Building	70,600,000	.0033b/	$116,490c/	232,980
Machinery and tools		12,000,000	.0030d/	36,000	36,000
Tangible personal property		820,000e/	.01275f/	10,455	10,455
Sales		9,265,500g/	.01	46,327h/	46,327h/
				$212,572i/	$329,062i/

Source: Marline-Umetco Table I.4-19 with adjustments as noted below.

a/ Increment over current land value as estimated by Marline-Umetco.

b/ 1984 nominal rate of 35¢ per $100 multiplied by the average assessment ratio (94.4%) as estimated by the Virginia Department of Taxation in its 1982 Assessment/Sales Ratio Study.

c/ Assumes one-half completion in first year.

d/ 1984 nominal rate of $3.00/$100 multiplied by 10% assessment ratio.

e/ Limited to mobile equipment as shown in Marline-Umetco Table I.4-5.

f/ 1984 nominal rate on motor vehicles of $4.25 per $100 multiplied by 30% of the average trade-in value.

g/ Based on Table A.6 (limited to direct construction) categories "plant concrete and excavation" less labor; "building, structural, painting" less labor; "electrical" less labor; and "instrumentation" less labor. The result was multiplied by 1.42, the ratio of total direct construction and tailings management expenditures to total direct construction expenditures. Purchases subject to the sales tax were based on Virginia Department of Taxation, "Virginia Retail Sales and Use Tax Regulation 1.65.2: Mining and Milling Processing" (March 15, 1983).

h/ Assumes one-half of the sales occur in each year.

i/ All of this revenue would go to Pittsylvania County, except a portion of the sales tax that would go to Danville, South Boston, and Halifax County. Marline-Umetco (Table I.4-20) assumed that 33% of sales tax collections would go to Pittsylvania County, 57% to Danville, and 10% to Halifax County.

TABLE 2.11

MAJOR DIRECT TAXES DURING THE CONSTRUCTION PHASE--
VIRGINIA

Tax	Base (1981$)	Rate	Tax Year 1	Tax Year 2
Corporate income	No income assumed during construction phase			
Sales	$16,714,000[a]	0.03	$250,710[b]	$250,710[b]
Motor vehicle sales and use	820,000[c]	0.02	16,400	
			$267,110	$250,710

Source: Marline-Umetco Tables I.3-4 and I.4-5 with adjustments as noted in footnotes. Letter from John A. Yellich to John L. Knapp dated July 30, 1984.

a/ Based on Table A.14 (limited to direct construction expenditures) total categories "plant concrete and excavation" less labor; "building, structural, painting" less labor; "electrical" less labor; and "instrumentation" less labor. The result was multiplied by 1.19, the ratio of total direct construction and tailings management expenditures to total direct construction expenditures. Purchases subject to the sales and use tax were based on Virginia Department of Taxation, "Virginia Retail Sales and Use Tax Regulation 1.65.2: Mining and Milling Processing" (March 15,1983).

b/ Assumes one-half the sales occur in each year.

c/ Based on Marline-Umetco Table I.4-5 category "mobile equipment."

At the state level, total collections were estimated to be $267,110 in year 1 and $250,710 in year 2 (see Table 2.11). Most of the total in year 1 and all of the total in year 2 are attributable to the state's 3 percent sales tax. No taxable corporate income was assumed during the construction years.

Direct Taxes, Operations Phase

In the RSA, annual local tax revenue collected from Marline-Umetco would total $284,775 with the real estate tax accounting for more than four-fifths of the total (see Table 2.12). Except for a small amount of sales tax, the revenue would be collected by Pittsylvania County.

At the state level, the principal source of revenue would be the corporate income tax (see Table 2.13). Marline-Umetco has estimated that during operations its taxable income would be $20 million in 1981 constant dollars. Based on the state's 6 percent rate, the annual tax revenue would be $1,200,000. The company's tax estimate assumes the mine/mill complex would be taxed as a single entity. The more likely occurrence is that the Virginia facility would be treated as a joint operating venture by both Marline Uranium Corporation and Umetco Minerals Corporation, each of which would probably be subject to taxes in Virginia and other states. The joint venture income attributable to each corporation would then be subject to the allocation and apportionment factors applicable to multistate corporations. These factors are property, payroll, and sales. If this were the case, then the taxable income in Virginia would be estimated based on each company's total taxable income and on each company's total property, payroll, and sales as well as on the respective values for Virginia. In the absence of information on all of these variables, we have not provided an estimate of the company's income tax liability.[1/]

Most of the company's purchases during the operations phase would be exempt from the sales tax according to Virginia Department of Taxation regulations for mining and milling processing.[2/] We estimate that only $410,000[3/] of purchases would be subject to the state's 3 percent sales tax. Thus, the annual tax would be $12,300.

1/ For a fuller description of the corporation income tax see Peggy M. Ware, Virginia: An Outline of State and Local Taxes (Richmond: Virginia Division of Industrial Development, June 1984), pp. 4-7.

2/ Virginia Department of Taxation, "Virginia Retail Sales and Use Tax Regulation 1.65.2: Mining and Milling Processing" (March 15, 1983).

3/ One-half of total maintenance and repair parts shown in Table A.18 multiplied by 1.18, the ratio of total operations and tailings management expenditures to total operations expenditures.

TABLE 2.12

MAJOR ANNUAL DIRECT TAXES DURING THE OPERATIONS PHASE--
REGIONAL STUDY AREA

Tax	Base (1981$)		Rate	Amount
Real property	Land	$ 1,000,000[a/]	.0033[b/]	$ 3,300
	Building	70,600,000	.0033[b/]	232,980
Machinery and tools		12,000,000	.0030[c/]	36,000
Tangible personal property		820,000[d/]	.01275[e/]	10,455
Sales		204,000[f/]	.01	2,040
				$284,775[g/]

Source: Marline-Umetco Table I.4-19 with adjustments as noted in footnotes.

a/ Increment over current land value as estimated by Marline-Umetco.

b/ 1984 nominal rate of 35¢ per $100 multiplied by the average assessment ratio(94.4%).

c/ 1984 nominal rate of $3.00 per $100 multiplied by 10% assessment ratio.

d/ Limited to mobile equipment as shown in Marline-Umetco Table I.4-5.

e/ 1984 nominal rate on motor vehicles of $4.25 per $100 multiplied by 30% of the average trade-in value.

f/ One-half of maintenance and repair parts shown in Table A.10. The result was multiplied by 1.20, the ratio of total direct operations and tailings management expenditures to total direct operations expenditures. Purchases subject to the sales tax were based on Virginia Department of Taxation, "Virginia Retail Sales and Use Tax Regulation 1.65.2: Mining and Milling Processing" (March 15, 1983).

g/ All of this revenue would go to Pittsylvania County, except a portion of the sales tax that would go to Danville, South Boston, and Halifax County. Marline-Umetco (Table I.4-20) assumed that 33% of sales tax collections would go to Pittsylvania County, 57% to Danville, and 10% to Halifax County.

TABLE 2.13

MAJOR ANNUAL DIRECT TAXES DURING THE OPERATIONS PHASE--VIRGINIA

Tax	Base ($1981)	Rate	Amount
Corporate income	*** a/	.06	***
Sales	410,000 b/	.03	12,300

Source: Marline-Umetco Table I.4-23 with adjustments as noted in footnotes.

a/ We did not estimate the company's income tax liability. See text for explanation.

b/ One-half of total maintenance and repair parts shown in Table A.18. The result was multiplied by 1.18, the ratio of total operations and tailings management expenditures to total operations expenditures. Purchases subject to the sales tax were based on Virginia Department of Taxation, "Virginia Retail Sales and Use Tax Regulation 1.65.2: Mining and Milling Processing" (March 15, 1983).

Secondary Taxes, Construction Phase

Major RSA secondary taxes that would be collected from Marline-Umetco employees are shown in Table 2.14. To make the estimates, we followed Marline-Umetco's assumption that most of the construction employees would be hired locally. Therefore, they would not represent new households and with the exception of sales taxes, their tax liabilities would not increase. For the ten new employee households forecast by the company, we allowed for real estate and other taxes (see Table 2.14). As explained earlier, we developed a range of earnings estimates for Marline-Umetco employees. These different estimates are used to develop low, middle, and high tax estimates for all employee households. Because of the difficulty of disaggregating the data for the 18 month construction period, most of the estimated tax collections are based on the full period. The total amount collected would range from $23,079 to $32,511. Over three-fifths of the revenue would be received by Danville and the remainder by Pittsylvania County.

Major state level secondary taxes are estimated in Table 2.15. In order to develop our estimate, we calculated the ratio of selected state taxes to personal income and then applied that ratio to our earnings estimates. Using this method, taxes during the 18 month period would range from $173,810 to $260,680.

TABLE 2.14

MAJOR SECONDARY TAXES[a] DURING THE CONSTRUCTION PHASE--
REGIONAL STUDY AREA

Tax	Base	Rate	Amount
Ten employee households[c]			
Real property tax			
Danville	$ 75,000[d]	$0.0060[e]	$ 450
Pittsylvania County	675,000[d]	0.0033[e]	2,228
			2,678
Other local taxes			
Danville	30,000[f]	0.017[g]	510
Pittsylvania County	270,000[f]	0.008[g]	2,160
			2,670
All other employee households			
Sales tax			
Danville			
Low	1,359,953[h]	0.01	13,600
Middle	1,721,654[h]	0.01	17,217
High	2,083,356[h]	0.01	20,834
Pittsylvania County			
Low	413,128[h]	0.01	4,131
Middle	523,006[h]	0.01	5,230
High	632,884[h]	0.01	6,329
Totals, all employee households, RSA			
Low			$23,079
Middle			$27,795
High			$32,511

TABLE 2.14 (continued)

MAJOR SECONDARY TAXES[a/] DURING THE CONSTRUCTION PHASE--
REGIONAL STUDY AREA

---

a/ Restricted to taxes paid by Marline-Umetco employees.

b/ With the exception of the ten households, the taxes apply to an 18 month period.

c/ Based on Marline-Umetco assumptions, one household from outside the area would locate in Danville and nine would locate in Pittsylvania. See Marline-Umetco p.I.4-40 and Table I.4-15.

d/ According to the company, the average house value would be $75,000. See Marline-Umetco, Table I.4-20.

e/ Rates based on 1984 nominal rates and assessment/sales ratios as estimated by the Virginia Department of Taxation in its 1982 Assessment/Sales Ratio Study. (Danville: $0.76x.793=$0.60; Pittsylvania: $0.35x.944=$0.33.)

f/ According to the company, the average salary of the ten employee households will be $30,000. See Marline-Umetco, Table I.4-14.

g/ Ratio of local taxes other than real property taxes (1981-82) to personal income (1982). Sources: taxes--Auditor of Public Accounts, Comparative Report of Local Government Revenues and Expenditures Year Ended June 30, 1982 (Richmond: Auditor of Public Accounts, 1983); personal income--Survey of Current Business 64:1 (April 1984).

h/ (Wages of Marline-Umetco employees - Wages of 10 households) x 0.38 x S where 0.38 = the ratio of taxable sales to personal income in the combined Danville-Pittsylvania Area and where S = the share of 1982 total taxable sales in each jurisdiction (23.3% in Pittsylvania County and 76.7% in Danville). Sources: wages-- Table 2.1; Sales--Eleanor G. May, Retail Sales in Virginia, 1983 (Charlottesville: Tayloe Murphy Institute, May 1984).

TABLE 2.15

**MAJOR SECONDARY TAXES DURING THE CONSTRUCTION PHASE--
VIRGINIA**

	Base (1981$)[a/]	Rate[b/]	Amount
Low	$4,966,000	0.035	$173,810
Middle	6,207,000	0.035	217,245
High	7,448,000	0.035	260,680

a/ Earnings of Marline-Umetco employees during 18 month period. Source: Table 2.1.

b/ Ratio of selected state taxes in 1981-82 to 1982 personal income. The taxes selected were general sales and gross receipts taxes and individual income taxes. Sources: taxes--U.S. Bureau of the Census, State Government Finances in 1982, GF82 No. 3 (Washington, D.C.: U.S. Government Printing Office, October 1983); personal income--Survey of Current Business 64:4 (April 1984).

Secondary Taxes, Operations Phase

The RSA estimates in Table 2.16 share the methodology used to develop Table 2.14. We followed Marline-Umetco's assumption that there would be 45 new employee households. Total annual taxes are estimated to range from $37,063 to $46,351, depending upon which earnings estimate is used. Slightly over one-half of the revenue would be collected by Pittsylvania County with the remainder going to Danville.

The state of Virginia annual secondary taxes are shown in Table 2.17. The estimates are based on the same methodology used to develop Table 2.15. State tax collections range from $171,150 to $256,690 depending upon which earnings estimate is used.

TABLE 2.16

MAJOR ANNUAL SECONDARY TAXES[a/] DURING THE OPERATIONS PHASE--REGIONAL STUDY AREA

Tax	Base	Rate	Amount
45 employee households[b/]			
Real property tax			
Danville	$ 375,000[c/]	$0.0060[d/]	$ 2,250
Pittsylvania County	3,000,000[c/]	0.0033[d/]	9,900
			12,150
Other local taxes			
Danville	135,300[e/]	0.017[f/]	2,300
Pittsylvania County	1,082,400[e/]	0.008[f/]	8,659
			10,959
All other employee households			
Sales tax			
Danville			
Low	1,070,329[g/]	0.01	10,703
Middle	1,426,493[g/]	0.01	14,265
High	1,782,657[g/]	0.01	17,827
Pittsylvania County			
Low	325,145[g/]	0.01	3,251
Middle	433,341[g/]	0.01	4,333
High	541,537[g/]	0.01	5,415
Totals, all employee households			
Low			$37,063
Middle			$41,707
High			$46,351

TABLE 2.16 (continued)

MAJOR ANNUAL SECONDARY TAXES[a] DURING THE OPERATIONS PHASE--
REGIONAL STUDY AREA

a/ Restricted to taxes paid by Marline-Umetco employees.

b/ Based on Marline-Umetco assumptions, five households from outside the area would locate in Danville and 40 would locate in Pittsylvania County. See Marline-Umetco, Table I.4-15.

c/ According to the company, the average house value would be $75,000. See Marline-Umetco, Table I.4-20.

d/ Rates based on 1984 nominal rates and assessment/sales ratios as estimated by the Virginia Department of Taxation in its 1982 Assessment/Sales Ratio Study. (Danville: $0.76 x .793 = $0.60; Pittsylvania County: $0.35 x .944 = $0.33.)

e/ According to the company, the average salary of the 45 employee households will be $27,060. See Marline-Umetco Table I.4-14.

f/ Ratio of local taxes other than real property taxes (1981-82) to personal income (1982). Sources: taxes--Auditor of Public Accounts, Comparative Report of Local Government Revenues and Expenditures Year Ended June 30, 1982 (Richmond: Auditor of Public Accounts, 1983); personal income-- Survey of Current Business 64:4 (April 1984).

g/ (Wages of Marline-Umetco employees - Wages of 45 households) x 0.38 x S where 0.38 = the ratio of taxable sales to personal income in the combined Danville-Pittsylvania Area and where S = the share of 1982 total taxable sales in each jurisdiction (23.3% in Pittsylvania County and 76.7% in Danville). Sources: wages--Table 2.1; sales--Eleanor G. May, Retail Sales in Virginia, 1983 (Charlottesville: Tayloe Murphy Institute, May 1984).

TABLE 2.17

MAJOR ANNUAL SECONDARY TAXES DURING THE OPERATIONS PHASE--
VIRGINIA

	Base (1981$)[a]	Rate[b]	Amount
Low	$4,890,000	0.035	$171,150
Middle	6,112,000	0.035	213,920
High	7,334,000	0.035	256,690

a/ Earnings of Marline-Umetco employees. Source: Table 2.1.

b/ Ratio of selected state taxes in 1981-82 to 1982 personal income. The taxes selected were general sales and gross receipts taxes and individual income taxes. Sources: taxes--U.S. Bureau of the Census, State Government Finances in 1982, GF82 No. 3 (Washington, D.C.: U.S. Government Printing Office, October 1983); personal income--Survey of Current Business 64:4 (April 1984).

Unemployment Insurance

The company would be subject to the unemployment insurance tax. New employers must pay a rate of 3.4 percent of the first $7,000 of each employee's annual wage until they establish their experience rating in three years. Rates based on experience ratings now range from 1.0 percent to 7.1 percent of the first $7,000 of taxable wages. According to the U.S. Department of Labor, employers in Virginia are paying an average tax rate of 1.0 percent of total wages for 1984.[1] Assuming that Marline-Umetco was treated as a new employer at the onset of construction and that it later paid the average rate on total wages, its taxes would be as shown in Table 2.18.[2] Based on a discount rate of 6.5 percent, the present value of the taxes paid over the 15-year period would be $635,487.

1/ Peggy M. Ware, Virginia: An Outline of State and Local Taxes (Richmond, VA: Division of Industrial Development, June 1984), p. 11.

2/ We have assumed that construction would be performed by Marline-Umetco employees. If this were not the case, the unemployment insurance tax would still be paid, but the rate would depend on the average employer rating of the contractors involved.

TABLE 2.18

ESTIMATED UNEMPLOYMENT TAXES DURING CONSTRUCTION AND OPERATIONS

	Employment	Wage Base	Rate	Tax
Construction				
Year 1	305	$2,135,000	3.4%	$ 72,590
Year 2	305	2,067,000a/	3.4	70,278
Operations				
First year	468	3,276,000	3.4	111,384
Next 12 years (per year)	468	6,117,000	1.0	61,170

Source: Tables 2.1.

a/Since total wages for the 18-month construction period were estimated to be $6,207,000 in 1981 dollars, it was assumed that in six months one-third of that amount would be paid. Because the average wage per worker for six months of $6,777 would be below the $7,000 taxable wage limit, the entire $6,777 would be subject to the 3.4% rate.

Unemployment insurance taxes are earmarked for the Unemployment Insurance Trust Fund. This fund is used to finance payments to workers eligible for unemployment insurance. The fund will incur costs on behalf of eligible Marline-Umetco employees laid off during the construction, operations, and closing phases of the project. We have no basis for forecasting layoffs during construction and operation, but it is quite likely that some construction workers will be eligible and, if the mine/mill does not operate at full capacity, periodic unemployment could occur during operations. If, at the end of 13 years of operation, the facility were shut down, then most of the 468 employees would be eligible for 26 weeks of regular unemployment insurance benefits. According to the Virginia Employment Commission, the average laid off worker draws ten weeks of benefits. Thus, if all were eligible for the maximum benefit ($150 per week) and the average period were ten weeks, the total cost to the Unemployment Insurance Trust Fund would be $702,000. Adjusted to present value, the figure would be $272,461. If the present value of the benefit payments is subtracted from the present value of the unemployment taxes, then the net benefit to the state is $429,039. This benefit is probably overstated because it contains no allowance for layoffs during construction and operations.

CHAPTER 3

COSTS

INTRODUCTION

In this chapter, we consider costs that the Swanson project would create under various given assumptions. The major costs considered are expenditures by state and local governments, environmental degradation, and the possible negative impact on existing and potential industry. The distribution of costs will vary depending on their nature and geographic coverage. For example, local government costs will be borne by taxpayers in the RSA, and environmental health costs will be borne by the individuals who suffer ill effects. As previously mentioned in the introduction to Chapter 2, although these distributional issues are important, they are beyond the scope of this analysis and therefore not discussed.

STATE AND LOCAL GOVERNMENT EXPENDITURES

Introduction

Marline-Umetco will have direct and secondary effects on local and state government expenditures. For example, if the company's trucks require a heavier roadbase and wider roads, then the increased expenditures on roads by the Virginia Department of Highways and Transporation will be a direct expenditure effect of the project. The direct effects that we analyze are the following: 1.) expenditures by state and local governments for the approval process, monitoring, and protection; 2.) outlays by the state government for road improvements necessitated by the existence of the mine/mill complex; and 3.) loss of revenue to local governments caused by the future removal of land from the tax base. The secondary effects that we analyze are outlays by local and state governments for services provided to Marline-Umetco employees (as residents) during construction and operation phases. Secondary or indirect effects are those additional government outlays caused by the company's employees and by suppliers and residents benefiting from the multiplier effects of the mine/mill activity. Because of the difficulty of quantifying the multiplier effects on government outlays, we limit the estimation of secondary expenditure effects to government outlays attributable to the company's employees. (We treated secondary taxes in a similar manner.)

Expenditures by the State for Approval Process, Monitoring, and Protection

Introduction

As part of the review process for considering mining and milling at the Swanson site in Pittsylvania County, the Commonwealth has devoted many man-hours of agency time and has paid for consulting studies. The total amount of the expenditures is not determined; however, Ms. Georgia Herbert of the Piedmont Environmental Council has compiled some cost figures. Such expenditures represent the state's commitment to attract new industry consistent with protecting the environment and health of its citizens. These expenditures, while acknowledged, are considered "sunk costs" and do not depend on the legislature's decision to either ban or allow uranium mining and milling. Therefore, it is inappropriate to include them in the analysis that follows.

According to the Institute for Environmental Negotiation, Virginia will undertake steps to become an agreement state if uranium mining and milling are approved by the General Assembly. Therefore, the following estimates and analyses are based on the assumption that Virginia will seek and be granted agreement status. Our information was taken from the report, "Agreement or Non-Agreement Status: Options for Virginia," presented to the Uranium Administrative Group by the Agreement/Non-Agreement Subcommittee. Information concerning non-agreement status and the corresponding regulatory cost estimates for non-agreement status can be found in the same report.

Agreement Status

The Nuclear Regulatory Commission's (NRC) Agreement State Program enables states to assume regulatory control over one or more areas in the atomic energy and radioactive materials field that would otherwise be regulated by the NRC. A state that assumes such regulatory control is considered an agreement state and must fund and staff its programs. Standards set by agreement states must be at least as stringent as standards adopted by the NRC and the Environmental Protection Agency (EPA). It is expected that Virginia will seek and be granted control over uranium milling and tailings site licensing.

Costs of Regulation

Various state agencies made estimates of developing and maintaining a regulatory program for uranium.1/ Tables 3.1 and 3.2 show the estimated costs of regulating uranium milling, which are divided into initial or infrequent costs and annual costs. One time or infrequent costs are estimated to be $405,750 to $539,300. Annual costs are estimated to be $248,731 to $444,425. We did not include costs associated with regulating exploration, mining, and reclamation because the information is not available. The NRC currently exempts mining from their regulations.

1/ Because state agencies made estimates of required resources independently, some have suggested that there may be duplication of required state expenditures. Also, some costs may have been omitted because it is not possible to determine specific figures for each agency until regulations are in effect and responsibilities assigned to the relevant agencies.

TABLE 3.1

ONE TIME OR INFREQUENT COSTS ASSOCIATED WITH THE REGULATION OF URANIUM MILLING BASED ON AGREEMENT STATUS

Program and Regulation Development	Total (1983 dollars)
Laboratory method development	$ 12,000
Training trip to federal and state laboratories	2,000
P.S.D. permit	1,650- 10,200
Attorney (contract)	50,000
Subtotal	65,650- 74,200
Equipment	
Sampling devices	20,000
TLD's and reader	14,000
4 wheel drive vehicle	10,500
Total suspended particulate sampling monitors (2)	1,800
Oven, ball mill, other sampling prep. equipment	1,000
Platinum ware for fusions	10,000
Alpha spectrometry detectors and electronics	10,000
Pulse height analyzer system	40,000
Radon counter and cells	5,000
Subtotal	112,300
Preoperational Analysis	
Analysis for samples as outlined in Reg.Guide 4.14	35,000
Additional agricultural sampling	17,800
Subtotal	52,800
Licensing Expenditures	
Environmental Impact Study	175,000-300,000
Total	$405,750-539,300

Source: Tables F-1-1 and F-1-2, "Agreement or Non-Agreement Status: Options for Virginia", Presented to the Uranium Administrative Group by the Agreement/Non-Agreement Subcommittee, November 18, 1983; and discussions with Dr. Bernard Caton and Mr. Michael Ward, Division of Legislative Services.

TABLE 3.2

ANNUAL COST OF REGULATING URANIUM MILING DURING OPERATIONS BASED ON AGREEMENT STATUS

		Total Annual Cost (1983 dollars)
Personnel		
Radiation safety specialist		$ 23,500
Radiation safety technicians	($19,239/person)	38,460
Radiation safety supervisor		31,860
Clerk-stenographer		12,600
Water sampling technician	($30,000/person)	60,000-240,000
Agricultural inspector		467-827
Subtotal		166,887-347,247
Sampling Program		
TSP (1-2)		6,000- 12,000
Agriculture sampling		296- 762
Transportation		5,000
Inspections	(frequency depends on compliance)	188- 2,256
Enforcement actions	(frequency depends on compliance)	1,520- 6,240
Subtotal		13,004- 26,258
Analysis		
Analysis for samples as outlined in Reg.Guide 4.14		27,800[a/]
Additional agricultural sampling		8,000
T.S.P. sample analysis		4,160- 6,240
Subtotal		39,960- 42,040
Overhead and Operation Expenses		
Lead agency		28,880
Total		$248,731-444,425

Source: Table F-1-2, "Agreement or Non-Agreement Status: Options for Virginia," November 18, 1984, Presented to the Uranium Administrative Group by the Agreement/Non-Agreement Subcommittee; and discussions with Dr. Bernard Caton and Mr. Michael Ward, Division of Legislative Services.

a/ $33,000 for the first year of operations; $27,800 for subsequent years.

If the General Assembly allows the Swanson project to proceed, then the Commonwealth will incur these costs. The magnitude of such costs will depend upon the regulations that are put into effect, which are presently undetermined.

Cost Recovery

Almost all existing agreement states rely on a combination of funding such as appropriations and user fees, for their budgets. License, renewal, amendment, and inspection fees are charged by the NRC and some agreement states. The NRC provides funding for its activities with agreement states; for example, it provides monies for the training of state personnel. User fees usually do not cover all of the costs of permitting and regulation. However, it is probable that a state with uranium development could recover the additional regulatory costs associated with agreement status. The extent to which Virginia would be able to recover these costs would depend upon the regulations passed by the Virginia legislature.

In non-agreement states, the NRC requires milling facilities to provide financial assurance that decommissioning will be accomplished and to make funds available for annual surveillance for 1,000 years after closure. Neither amount can be used to cover damages if an accident occurs during or after operations. The first requirement is satisfied by the company's purchase of a surety bond prior to licensing for the amount required for decommissioning. This amount is based on engineering studies and is negotiated by the NRC and the company. The second requirement is satisfied by the company's transfer to the federal government of a minimum of $250,000 in 1978 dollars prior to the termination of the mill license. The amount can exceed $250,000 if the federal government determines that annual costs of surveillance will exceed 1 percent of the fund ($2,500 in 1978 dollars). Virginia as an agreement state would impose these requirements and would be free to strengthen them if it desired. Based on preliminary analysis, we think that the $250,000 requirement would not provide sufficient income to cover surveillance costs.

Road Improvements and Maintenance

The Virginia Department of Highways and Transportation (VDHT) has a six-year plan to upgrade one entrance and a bridge, which will lead into the Swanson site. State road 691 (from 685 to U.S. 29) and state road 685 (from 691 to the site) will be upgraded as a direct result of the proposed uranium mining and milling operations. If current plans do not change, the first section of road will be upgraded by 1989, the second section by 1990, and the last section after 1990. A total of four miles will be affected and will meet industrial access road standards after the planned improvements. Although there are no current plans, state road 676 could be upgraded in the future in order to allow two entrances into the site from route U.S. 29.

The initial cost to the state in 1984 dollars will be $1,135,000; the first section will cost $475,000, the second section $360,000, and the third section $300,000. In addition to the above figures, current annual maintenance costs are $1,500 per mile and, once improvements are made, are projected to be $3,500 per mile. Thus, the additional annual maintenance cost due to the uranium mining and milling project will be $2,000 per mile.1/

According to Marline-Umetco's plans, state road 690 and three miles of 683 will be closed. This closing will increase traffic on alternate routes and possibly increase traveling time, although we do not know what patterns will emerge. The Virginia Department of Highways and Transportation does not presently have plans to upgrade the roads that will have heavier traffic, but it is likely that alternate routes may need improvements or additional maintenance due to increased usage.

Increased traffic on primary roads to the site is estimated at 190 passenger vehicles at peak hours during operations. During a typical 24-hour period, 6 to 24 additional trucks will be on the primary roads due to the Swanson project.2/ The Marline-Umetco report assumes that there will be two entrances into the site; at this time, VDHT plans one entrance.

Forgone Revenue

After the mine is decommissioned, land devoted to the lake and tailings pile will not be usable for agricultural production. According to Marline-Umetco, 44 percent of the 1,460 acre Swanson site would not be usable. The current real estate tax per acre in the vicinity of the site is $1.67.3/ Therefore, the annual tax loss after the mine/mill closes will be (1,460 acres) ($1.67 tax per acre) (.44) = $1,073. The present value of this annual forgone revenue discounted at 6.5 percent for 1000 years is $4,680.

Secondary Outlays

Marline-Umetco assumes that its employees will add relatively little to the costs of local and state governments because most of its employees

---

1/ Road improvement and maintenance costs are based on the assumption that the 40 ton weight restriction will not be exceeded. For example, if 100 tons were allowed on the roads, then the annual maintenance cost would be approximately $10,000 per mile.

2/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County, Virginia, vol. 3, (15 October 1983), p.I.4-52.

3/ Information provided to John L. Knapp by John A. Yellich, Marline Uranium Company, letter dated July 17, 1984 and phone conversation on August 2, 1984.

TABLE 3.3

SECONDARY OUTLAYS BY LOCAL AND STATE GOVERNMENTS DURING THE CONSTRUCTION PHASE[a]

RSA	Increased Population[b]	Per Capita Expenditures from Own Sources 1981-82	Amount (1981 $)
Danville	3	$452[c]	$1,356
Pittsylvania County	27	113[c]	3,051
Total			$4,407
State	30	806[d]	$24,180

a/ For simplicity, we show only one year, even though construction is planned to require 18 months.

b/ The increased population is based on Marline-Umetco's assumption of ten worker households hired from outside the RSA (Marline-Umetco, p. I.4-40) and a population per household of 3.0 (Table I.4-15).

c/ "Local expenditures funded from own sources" are defined as: (maintenance and operation expenditures + transfers to general government capital projects + transfers to general government debt service + enterprise activity transfers and contributions) - (revenue from the Commonwealth + pass-through revenue from the federal government + direct revenue from the federal government). Source: Auditor of Public Accounts, Comparative Report of Local Government Revenues and Expenditures Year Ended June 30, 1982, (Richmond,VA: Auditor of Public Accounts, 1983).

d/ "State general expenditures from own sources" are defined as total general expenditures minus intergovernmental revenue. Source: U.S. Department of Commerce, Bureau of the Census, State Government Finances in 1982, GF83, No. 3 (Washington, D.C.: U.S. Government Printing Office, October 1983).

TABLE 3.4

SECONDARY OUTLAYS BY LOCAL AND STATE GOVERNMENTS DURING THE OPERATIONS PHASE

RSA	Increased Population[a/]	Per Capita Expenditure from Own Sources 1981-82	Amount (1981 $)
Danville	10	$452[b/]	$ 4,520
Pittsylvania County	126	113[b/]	14,238
Total			$ 18,758
State	136	806[c/]	$109,616

a/ The increased population is based on Marline-Umetco's assumption of 45 worker households hired from outside the RSA (Marline-Umetco, p. I.4-40) and a total household population of 136 (Marline-Umetco, Table I.4-15).

b/ "Local expenditures funded from own sources" are defined as: (maintenance and operation expenditures + transfers to general government capital projects + transfers to general government debt service + enterprise activity transfers and contributions) - (revenue from the Commonwealth + pass-through revenue from the federal government + direct revenue from the federal government). Source: Auditor of Public Accounts, Comparative Report of Local Government Revenues and Expenditures Year Ended June 30, 1982, (Richmond, VA: Auditor of Public Accounts, 1983).

c/ "State general expenditures from own sources" are defined as total general expenditures minus intergovernmental revenue. Source: U.S. Department of Commerce, Bureau of the Census, State Government Finances in 1982, GF83, No. 3 (Washington, D.C.: U.S. Government Printing Office, October 1983).

will already be living in the RSA and therefore will not require new services. We agree with this assumption. It seems reasonable to assume that the firm will draw most of its labor from the RSA, either by inducing higher labor force participation, reducing unemployment, or attracting commuters. Therefore, we have based our estimates on Marline-Umetco's assumptions about the number, size, and geographic distribution of new employee households from outside the RSA.

Secondary Government Outlays During the Construction Phase

The estimates are shown in Table 3.3. Based on average per capita outlays,[1/] the total expenditures are estimated to be $4,407 at the RSA level and $24,180 at the state level.

Secondary Government Annual Outlays During the Operation Phase

The estimates are shown in Table 3.4. Based on the same methodology used to develop the construction phase outlays in Table 3.3, the annual outlays are estimated to be $18,758 at the RSA level and $109,616 at the state level.

EFFECTS ON CURRENT INDUSTRY

Agriculture

It has been rumored that uranium mining and milling at the Swanson site might have a negative effect on the agricultural industry in the RSA, particularly the dairy and tobacco subsectors. The demand for the products grown in the area depends upon their perceived quality by consumers and producers. If some consumers and producers believe that the existence of a uranium mine and mill will contaminate agricultural products, whether directly or indirectly, then the demand for these products will decline leading to lower prices and/or fewer sales. The demand will depend not only on actual contamination but also on perceived contamination. For example, if mining and milling do not degrade the environment, but consumers and producers believe that the contrary is true, then agricultural products from the area will not be valued as highly as those produced elsewhere. Conversely, contaminated products could retain their value if consumers perceive them as being of a sufficiently high quality.

The demand for agricultural products will be affected by the regulations and their enforcement. We assume that the stricter the regulations and enforcement, the smaller the probability that contamination will

---

1/ Marginal cost analysis is an alternative method for forecasting outlays, but as the time span lengthens and all costs become variable, the two techniques will yield similar results. See Robert W. Burchell and David Listokin, The Fiscal Impact Handbook (New Brunswick, NJ: The Center for Urban Policy, 1978), p. 4.

occur, and the greater the probability that consumers will perceive the regulations as being sufficient to ensure the quality of the products they consume. Because regulations are not in effect, the full impact of uranium mining and milling on agriculture cannot be accurately determined at this time.

The size and form of agriculture in the RSA are changing. From 1978 to 1982, the market value of locally grown tobacco products sold declined from $83,622,220 to $63,092,000 (in 1982 dollars).1/ There is a current worldwide glut of tobacco due to decreased U.S. demand and increased foreign supply. Congress may also remove protection currently received by the tobacco industry. Some agricultural experts are recommending supplementation or replacement of tobacco crops with vegetable crops, particularly cantaloupe and broccoli.2/ In contrast, the market value of dairy products sold rose from $5,465,138 in 1978 to $6,173,000 in 1982; however, many dairies in the RSA are experiencing financial difficulties.3/ Due to the changing market, we are unable to predict accurately the effects of a uranium industry on local agriculture and are only able to consider what the possible impact might be.

If, for whatever reasons, the existence of the mine/mill complex were to cause a reduction in demand for agricultural products, there would be effects on earnings and employment in the RSA and the state. As a hypothetical case, let us assume that the market value of tobacco produced in the RSA declines by 1 percent during the period of operations.4/ This decline in agriculture can be used in the RIMS II model to show the impact on state earnings and employment; the average estimated increase in earnings for the Commonwealth attributed to the Swanson project drops by $400,000, a decline of 3.8 percent, and the average estimated increase in employment attributable to the Swanson project drops

---

1/ U.S. Department of Commerce, Bureau of Census, 1982 Census of Agriculture, Virginia, AC82-A-46 vol.1, pt. 46 (Washington, D.C: U.S. Government Printing Office, 1984), pp. 151,155; and U.S. Department of Agriculture, Crop Reporting Board, Agricultural Prices, Annual Summary 1982 (Washington, D.C: Crop Reporting Board Publications, June 1983), p.7.

2/ Charles W. Coale, Jr. A Report of the Fresh Vegetable Marketing Study Conducted for Southside and Southwestern Virginia Vegetable Growers by the USDA, Department of Agricultural Economics, (Blacksburg, VA.: Virginia Polytechnic Institute and State University, March 1983).

3/ U.S. Department of Commerce, Bureau of the Census, 1982 Census of Agriculture, Virginia, vol. 1, pt. 46, pp. 164,168; U.S. Department of Agriculture, Crop Reporting Board, Agricultural Prices Summary 1982, p. 7.

4/ The potential impact on the dairy sector could also be shown using the RIMS II model. The tobacco sector was chosen because it is the largest subsector of the agricultural industry in the RSA.

from 810 to 780, a decrease of 3.7 percent. This example is purely illustrative and depends on precise information about the effect of the mine/mill operation on the demand for agricultural products. Although such information is currently unavailable, we have not found any evidence to indicate that there will be a change in the tobacco sector due to the existence of a uranium mine and mill. It is also possible to transfer tobacco allotments to other land sites; in other words, in case of property contamination the near Swanson site, tobacco could be grown elsewhere in the RSA.

In summary, we wish to emphasize the following five points:

1. The uranium mine and mill could alter the sale of local agricultural goods based on perceived rather than on actual environmental effects.

2. The stricter the environmental regulations and enforcement, the smaller the probability that the mine and mill complex will have a negative impact on agriculture.

3. Because the size and composition of the agriculture industry are changing, it is difficult to isolate the impact of uranium mining and milling on the agriculture of the RSA.

4. The RIMS II model can be used to estimate the effects of a change in the agriculture industry if the direction and magnitude of the change are known.

5. Some effects could be contained within the RSA. For example, resources used to grow crops near the site may simply be transferred to other areas within the RSA.

Nonagriculture

In sectors where the quality of water and local raw materials are important, nonagricultural production could be adversely affected, for example, in the food processing industry. In such sectors, contamination could.disrupt production processes and require extensive product testing before production or distribution could resume; an example is the accident at Three Mile Island. When the accident occurred, there was concern that local food products would be contaminated, and food products were not shipped until testing showed that federal standards were met.

Food processing is the industry that would be most severely affected by any environmental degradation. In the RSA, the food processing industry is small in size; first quarter 1983 employment data show that firms classified as food processing account for approximately 0.5 percent of all employment in the RSA.1/ In spite of their relatively small size, food processing industries in the RSA were examined because of their

---

1/ Virginia Employment Commission first quarter of 1983 ES-202.

vulnerability to environmental degradation. Of those individuals contacted about the possible problem, none felt that his business would be injured by the Swanson project.

In addition to the effects on supply, we must consider the demand for nonagricultural products, which could also be affected by a change in the actual or perceived quality of goods. A change in the perception of the quality of commodities would most likely be felt by food processing firms and by those businesses providing health and educational services. In spite of mixed opinions about what these effects may be, we have not found any evidence to indicate that there will be a decrease in demand.

The response of businesses and consumers will depend on their perceptions of the risk associated with environmental changes. Given the complexity of the issue and the lack of examples from which to draw information, the response of businesses and consumers is hard to predict. The uniqueness of the proposed mine and mill complex makes it difficult to draw parallels to existing mines and mills. The uranium mine and mill, located in Cholet, France, is said to be similar to the Swanson site in climate and industrial environment. The limited information that we have about Cholet indicates a favorable response by local industry and consumers to the mine and mill complex. However, the social and political structure in Cholet is different and may affect the perception of risk.

An incident from which we can gain some understanding of individuals' perception of and response to risk is the accident at Three Mile Island. Prior to the accident, the power plant was viewed favorably, partially because it provided jobs at a time when the area had lost a major employer. Six months after the accident, workers were willing to move to the area for jobs. The concern that was mentioned most often by businesses was the possibility that, because of the accident, the cost of power would become prohibitive. Agriculture declined slightly, but that was partially attributed to the gasoline shortage that occurred at the same time.[1/] Although there are many differences between an accident at a nuclear plant and the proposed uranium mine/mill complex, the lack of adverse effects on industrial development after the accident indicates that firms, workers, and customers are willing to accept some risks. Thus, it is reasonable to assume that industries could be attracted to the RSA and consumers could continue to consume local commodities.

In order to compile this section of our study, we polled a sample of food processing firms, other businesses, institutions, and chambers of commerce in the RSA. We wanted to determine their response to the

---

1/ Office of Nuclear Regulatory Research, Division of Safeguards, Fuel Cycle and Environmental Research, The Social and Economic Effects of the Accident at Three Mile Island: Findings to Date, By C.B. Flynn and J.A. Chalmers, (Washington, D.C.: U.S. Government Printing Office, January 1980), p. 76.

proposed project. We recognize that not all respondents were perfectly informed, that some may not have been entirely candid, and that all were unable to acccurately predict the projects' effects because regulations are yet to be determined. Given these limitations, our survey findings show that local businesses and institutions are generally not expecting adverse effects from the proposed mine and mill.

Summary

In order to assess the possible effect of the Swanson project on local nonagricultural industry, we surveyed local businesses, institutions, and chambers of commerce to determine their response to the proposed project. Those surveyed do not anticipate the project will cause any negative effects on nonagricultural industry.

We also examined uranium mining and milling operations in the west, in particular New Mexico and Colorado, and also in France. There have been no discernible negative effects on local nonagricultural industry. However, the fact that the locations of western operations are in isolated regions and that there are differences in the political and social environment in France make any comparisons with the Swanson site tenuous.

Finally, we examined the effects of the accident at Three Mile Island on local industry. We recognize that the effects of an accident at a nuclear power station are likely very different from those of a uranium mining and milling project, but, the situations are similar in that there is a risk of radiological contamination. By examining the accident at Three Mile Island, we obtain some understanding of the response of businesses and residents to this risk.

Based on our survey and an examination of other uranium mining and milling sites and the accident at Three Mile Island, there is insufficient evidence to indicate that the Swanson project will interfere with production or cause a decrease in demand.

ENVIRONMENTAL EFFECTS OF THE SWANSON PROJECT

Introduction

In this section, we examine the major environmental effects that are anticipated as a result of the mining and milling project proposed for Pittsylvania County.

There are three steps crucial to valuing, in monetary terms, environmental changes that occur as the result of a project. First, one must know what is produced as a by-product of the project; an example from the Swanson project is the production of dust or suspended particulates. Marline-Umetco estimates that the Swanson project will cause an increase in suspended particulates of 4.5 ug/m^3 during the operations stage.1/ Second, one must know the effect of the by-product on the environment. In this example, we need to know what effects the increase in suspended particulates has on the local environment, for instance, the damage to vegetation and the health of wildlife and residents. Third, we must be able to place a monetary value on the environmental changes that occur. In our example, we need to know the dollar value of the damage to vegetation and the health of the wildlife and residents.

We have found it impossible to place a monetary value on many of the environmental consequences of the Swanson project because of a lack of data. Where we do not have adequate data to make estimates, we discuss the project's effects in a qualitative manner and attempt to relate environmental changes to current regulatory standards. Again, continuing with our example, Marline-Umetco estimates the increase in total suspended particulates will be 4.5 ug/m^3. Without other information, one cannot determine the relative importance of such an increase. However, by comparing it to the background level of 40ug/m^3,2/ and the Environmental Protection Agency (EPA) standard of 75 ug/m^3,3/ one gets an idea of the relative importance of this increase.

We wish to emphasize at the outset that the absence of a dollar value does not indicate that a particular environmental effect is either more or less important than others that are so valued; it indicates only that limitations on information prevent us from estimating the effect in dollar terms. Also, compliance with all regulatory provisions does not indicate an absence of environmental effects; rather, it indicates that such effects are within guidelines established by regulatory agencies. Regulatory agencies typically set standards based on a reasonable certainty that there will be no adverse health consequences; we assume that if Marline-Umetco meets current or proposed standards for a particular emission, then no adverse health effects will occur.

In the remainder of this section, we examine the project's likely effects on air and water quality and public health.

1/ Marline Uranium Corporation and Umetco Minerals Corporation, Technical Memoranda-1984, Final Draft, vol.1, p. IV-40. Suspended particulates are measured as concentrations in micrograms per cubic meter (ug/m^3). Unless otherwise stated, they are annual averages.

2/ Letter of November 10, 1983 from Mr. Bill Lynott of the Environmental Sciences Division of Gibbs and Hill to Mr. William Park, Director of Monitoring, State Air Pollution Control Board.

3/ 75ug/m^3 is the annual geometric mean for suspended particulates. 40 Code of Federal Regulations, app. A, sec. 50-7 (revised as of 1 July 1983): 542.

Air Quality

The effects of the Swanson project on air quality can be divided into two categories: increases in total suspended particulates and increases in toxic trace elements and contaminants.

Total Suspended Particulates

Total suspended particulates (TSPs) are dust and other solid particles that are suspended in the air for relatively long periods of time. Particulates are measured as concentrations in micrograms per cubic meter (ug/m^3). The current EPA standards for total suspended particulates are:1/

150 ug/m^3 maximum 24-hour concentration
75 ug/m^3 annual geometric mean
60 ug/m^3 guideline (annual geometric mean)

As previously mentioned, the background level of particulates at the Swanson site is 40 ug/m^3. Marline-Umetco estimates that the increase in TSPs will be 4.5 ug/m^3 at downwind receptors near the site. Given the background level, TSPs will certainly remain below the EPA guideline of 60ug/m^3. Even if the actual increase exceeds Marline-Umetco's estimate, the total should still be well within the EPA guideline. We emphasize that, except for the EPA 24-hour standard of 150 ug/m^3, all data on TSPs are stated in terms of annual averages. The peak concentration of TSPs could be substantially above the estimated annual average increase of 4.5 ug/m^3. Although peak concentrations may be above Marline-Umetco's estimate, it does not appear that fugitive dust particles will be a problem provided permit conditions are met.2/

It should be noted that the EPA is in the process of developing a new standard for suspended particulates called PM-10, which focuses on extremely fine particulate matter (the proposed rules focus on particles less than ten microns in size; one micron equals one-millionth of a meter or 0.000039 inches). The State Air Pollution Control Board (SAPCB) thinks that Marline-Umetco will be able to meet PM-10 standards as they are currently proposed.3/

1/ 40 Code of Federal Regulations, app. A., sec. 50.7 (revised as of 1 July 1983): 542.

2/ Conservation with Mr. William Park, Director of Monitoring, State Air Pollution Control Board, August 24, 1984.

3/ Ibid.

Toxic Trace Elements and Contaminants

Uranium mining and milling operations may release a number of other contaminants into the air. Table 3.5 shows a list of contaminants that are expected to be produced by the Swanson project along with current state and federal standards.1/

Based on the data provided to us, air pollution should not be a serious problem. We emphasize the following caveats:

1. Our conclusions are based on the assumption that the State Air Pollution Control Board will insure Marline-Umetco's use of an adequate dust suppressant system. We also assume "continuous" reclamation so that only one-tenth of the tailings are exposed at any given time.

2. Our data pertain only to the operations phase of the project. Air pollution will likely be a more serious problem during the 18-month construction phase.2/ Also, peak concentrations of these pollutants will be higher than the annual concentrations indicated.

Radiation

A great deal of controversy surrounds the health effects of long-term exposure to low-level radiation. It is difficult to detect and assess the health effects of radiation because of long latency periods and very small increases in the probabilities of adverse health effects.3/ The EPA states that "...lung cancer caused by the short-lived decay products of radon is the dominant radiation hazard from tailings."4/ Radon is a radioactive gas with a relatively short half-life. (Half-life is a term that describes the length of time required for half the atoms in a sample of radioactive material to undergo decay. Half-lives vary from fractions of seconds to millions of years; radon has a half-life of 3.82 days). We base our estimates of the health effects of radiation on

---

1/ Estimates of background levels are not given by Marline-Umetco, but we can assume they are low in the vicinity of the site due to the absence of industry and the rural nature of the area. Marline-Umetco, Technical Memoranda-1984, Final Draft, vol. 1, p. III-3.

2/ Based on conservations with representatives of the State Air Pollution Control Board at a meeting on July 16, 1984.

3/ Donald E. Dunning Jr.; Richard W. Leggett; and Robert E. Sullivan, "An Assessment of Health Risk from Radiation Exposure," Health Physics 46 (May 1984): p.1050.

4/ Federal Register, vol. 48, no. 196, (7 October 1983): 45929

TABLE 3.5

STATE AND FEDERAL AIR QUALITY STANDARDS[a]

	Estimated Increase	State Standard[b]	Federal Standard[c]
TSPs	4.0 ug/m^3	75 ug/m^3	75 ug/m^3
Ammonia	d/	f/	g/
Sulfuric acid mist	d/	f/	g/
Insoluable uranium	e/	f/	g/
Sulfur dioxide	0.005 ug/m^3	80 ug/m^3	80 ug/m^3
Nitrogen dioxide	4.6 ug/m^3	100 ug/m^3	100 ug/m^3
Carbon monoxide	d/	10,000 ug/m^3	10,000 ug/m^3
Hydrocarbons	d/	160 ug/m^3	160 ug/m^3

a/ Marline-Umetco gives a background concentration only for TSPs. Background concentrations of other compounds can be assumed to be very low because of the absence of major industry and the rural nature of the area. Marline-Umetco, Technical Memoranda, vol.1, p.III-3.

b/ State Air Pollution Control Board, Regulations for the Control and Abatement of Air Pollution (Richmond, VA: State Air Pollution Control Board, 31 July 1981), pp. 47-49.

c/ 40 Code of Federal Regulations, app. A, sec. 50.7, (Revised as of 1 July 1983): p. 542.

d/ Marline-Umetco states that some minor emissions are possible but provides no specific estimate for these compounds. Marline-Umetco, Technical Memoranda, vol.1, p.IV-40.

e/ Marline-Umetco does not provide any information with respect to emissions of insoluable uranium. They do, however, state that 500 pounds of uranium oxide will be emitted per year. This constitutes .025 percent of production (assumed production is 2,000,000 pound per year). Marline Uranium Company and Union Carbide, An Evaluation of Uranium Development in Pittsylvania County, Virginia, vol.2 (15 October 1983), p. H.3-9.

TABLE 3.5 (continued)

STATE AND FEDERAL AIR QUALITY STANDARDS

f/ The state does not have standards for these compounds. It has, however, issued guidelines for maximum one-hour concentrations as follows:

Ammonia	1,750	ug/m^3
Sulfuric acid mist	50	ug/m^3
Insoluable uranium	1.25	ug/m^3

State Air Pollution Control Board, Regulations for the Control and Abatement of Air Pollution (Richmond, VA: State Air Pollution Control Board, 31 July 1981), p.171.

g/ The federal government does not have ambient air quality standards for these compounds. It does, however, have standards for these compounds in the workplace. The following represent the maximum eight-hour concentrations permitted:

Ammonia	35,000	ug/m^3
Sulfuric acid mist	25	ug/m^3
Insoluable uranium	1,000	ug/m^3

29 Code of Federal Regulations 1910.1000, subpart Z (Revised as of 1 July 1983): tables Z1-Z3, pp. 667-672.

information from various sources. We estimate only the loss caused by the increased probability of death from cancer. We emphasize, therefore, that our estimates are low because we ignore nonfatal cancers, cancers caused by other possible sources of radiation, and other types of adverse health effects. We feel, however, that the possible adverse effects of radon are the most significant health issue associated with the Swanson project.

Valuing the Incremental Risk of Death from Cancer

We estimate the loss associated with the incremental risk of contracting a fatal cancer for two different size areas. First, we estimate the loss expected within a radius of 1,500 meters (approximately one mile) of the site. We feel this represents the area that will be most strongly affected by the project. Second, we estimate the loss expected within a 50-mile radius of the site. Beyond 50 miles, there should be no discernible increase in cancer risk.

1,500-Meter Radius (roughly one mile)

SENES Consultants Limited states that radon concentrations decrease rapidly with distance from the source, and, in fact, typically become lost in the background level of radon within one kilometer of the source.2/ This suggests that any adverse health effects caused by radon would be concentrated within a small area surrounding the site. For this reason, we examine an area of 1,500-meters radius from the site.

Data

The EPA has provided us with estimates of the lifetime risk of a fatal cancer to an individual living within 1,500 meters of the site. They have provided these estimates for the operations, post-operations, and post-closure phases of the project.3/

We have estimated the population within one mile of the site to be approximately 200.4/

1/ Federal Register, vol. 48, no. 196, (7 October 1983): 45929.

2/ Letter of July 25, 1984, from Dr. D.G. Chambers, Executive Vice President of SENES Consultants Limited to Dr. Robert Straube, Assistant Commissioner of Health Protection and Environmental Management: p.4-5.

3/ EPA, "Health Risk Estimates for Radon Emissions from Proposed Swanson Project and from an Average Commercial Western Uranium Mill Tailings Pile," enclosed in the letter of April 12, 1984 from Mr. Glen Sljoblom, Director of the Office of Radiation Programs of the EPA to Ms. Mary Spain, Staff Attorney of the Coal and Energy Commission.

4/ This estimate is based on census block data from the 1980 Census.

Using the EPA's estimates of the increase in the lifetime risk to individuals within 1,500 meters of the site and the estimated population of 200, we have calculated the expected number of deaths within 1,500 meters of the site during the operations, post-operations, and post-closure phases of the project as shown in Table 3.6. We then use the expected number of deaths to estimate the expected loss.

Sample Calculation of Expected Increase in Cancer Deaths

During the operations phase, the additional lifetime risk of contracting a fatal cancer to an individual living within 1,500 meters of the site is 1.5×10^{-4} = (0.00015). The population of the area is 200.

$$\text{Expected deaths during operations} = (1.5 \times 10^{-4}) \times 200 = 3 \times 10^{-2} = 0.03$$

TABLE 3.6

EXPECTED INCREASE IN CANCER DEATHS
1,500-METER RADIUS

Phase	Population	Risk	Expected Deaths
Operations	200	0.00015	0.03
Post-operations	200	0.000000005	0.000001
Closure	200	0.00000007	0.000014

From the calculated increase in cancer deaths within 1,500 meters given in Table 3.6, we can derive the expected loss within 1,500 meters due to the project, shown in Table 3.7. We make the following assumptions.

Assumptions

1. The discount rate is 3 percent (see Appendix E on the use and selection of discount rates).

2. The period of latency of cancer is 20 years.1/

1/ The latency period of cancer is long and variable. Hard tumors seldom appear before ten years after exposure, and can occur long after 30 years. While 20 years is arbitrary, it is reasonable considering the difficulty involved in predicting exactly what the latency period is. Committee on the Biological Effects of Ionizing Radiation, Effects on Populations of Exposure to Low Levels of Ionizing Radiation (Washington, D.C.: National Academy Press, 1980), p. 185.

TABLE 3.7

PRESENT VALUE OF LOSS DUE TO THE INCREASED RISK OF A CANCER DEATH 1,500-METER RADIUS

Value of a Life[a]	Loss During Operations[b]	Loss During Post-Operations[c]	Loss During Post-Closure[d]
$ 380,000	$ 6,312.00	$ 0.21	$ 2.95
560,000	9,302.00	0.31	4.34
600,000	9,966.00	0.33	4.65
1,000,000	16,610.00	0.55	7.75

a/ See Appendix D for a discussion of the literature and the sources for the value of a life.

b/ A 15-year exposure is assumed during the operations phase. The expected number of cancer deaths resulting from the project in the operations phase is 3×10^{-2} = (0.03).

c/ We assume a five-year exposure during the post-operations phase. The expected number of cancer deaths resulting from the project in the post-operations phase is 1×10^{-6} = (0.000001).

d/ Lifetime exposure is assumed after closure of the site. The expected number of deaths per century is 1.4×10^{-5} = (0.000014).

3. Our range of estimates for the value of a life (for a discussion of the literature and the source of our estimates, see Appendix D) are as follows:

   $ 380,000

   560,000

   600,000

   1,000,000

<u>Sample Calculation of Loss Caused by Increased Cancer Deaths 1,500 Meter Radius</u>

The loss caused by the increased risk of a cancer death is equal to the value of a life multiplied by the expected number of deaths from cancer, discounted 20 years to allow for a long period of latency.

Suppose the value of a life is \$380,000. Then, since the discount rate is 3 percent and the estimated number of deaths is 3×10^{-2}, it follows that the value of the increased risk of cancer death within 1,500 meters of the site is

$$\$380,000 \times (3 \times 10^{-2}) \times (1.03)^{-20} = \$6,312.00$$

The estimates for the expected loss within a 1,500-meter radius are small relative to the value of a life. Even when the value of a life is placed at \$1,000,000, the expected loss due to increased cancer deaths is only \$16,610. In comparison with the value of a life, the loss is small because the expected increase in cancer deaths is also small.

50-Mile Radius

As noted previously, the majority of health effects will be concentrated close to the site; however, we have included an estimate for the expected loss caused by the increased risk of cancer death for a larger area of 50-miles radius from the site. Beyond 50 miles, there should be no discernible increase in the risk of cancer.

Data

The EPA has provided us with estimates for the expected increase in cancer deaths that will occur within a 50-mile radius of the site for the operations, post-operations, and post-closure phases of the project.1/ We, therefore, have used this information directly in the calculation of expected loss for the 50-mile radius.

Using these figures and the range of estimates for the value of a life and assumptions used in the calculations for the 1,500-meter radius, we have estimated the loss associated with the increased risk of cancer death imposed on local inhabitants by the project. These estimates are shown in Table 3.8.

Sample Calculation of Loss Caused by Cancer Deaths 50-Mile Radius

The loss caused by the increased risk of cancer death is equal to the value of a life multiplied by the expected number of deaths from cancer, discounted 20 years to allow for a long period of latency. Suppose the value of a life is \$380,000. Because the discount rate is 3 percent and the estimated increase in cancer deaths is 0.3, it follows that the loss caused by the increased risk of cancer death is

$$\$380,000 \times 0.3 \times (1.03)^{-20} = \$63,118.00$$

1/ EPA, "Health Risk Estimates for Radon Emissions from Proposed Swanson Project and from an Average Commercial Western Uranium Mill Tailings Pile," enclosed in the letter of April 12, 1984 from Mr. Glen Sljoblom, Director of the Office of Radiation Programs of the EPA to Ms. Mary Spain, Staff Attorney of the Coal and Energy Commission.

TABLE 3.8

PRESENT VALUE OF LOSS DUE TO THE INCREASED RISK OF CANCER DEATH
50-MILE RADIUS

Value of Life[a/]	Loss During Operations[b/]	Loss During Post-Operations[c/]	Loss During Post-Closure[d/]
$ 380,000	$ 63,119.00	$2.10	$ 42.08
560,000	93,018.00	3.10	62.01
600,000	99,662.00	3.32	66.44
1,000,000	166,104.00	5.54	110.74

a/ See Appendix D for a discussion of the literature and the sources for the value of a life.

b/ A 15-year exposure is assumed during the operations phase. The expected number of cancer deaths resulting from the project in the population within 50 miles is 0.3.

c/ A 5-year exposure is assumed during the post-operations phase. The expected number of cancer deaths resulting from the project in the population within 50 miles is 1×10^{-5} = (0.00001).

d/ Lifetime exposure is assumed after closure of the site. The expected number of deaths per century is 2×10^{-4} = (0.0002).

A brief examination of Table 3.8 reveals several things. First, the vast majority of the losses associated with the project are anticipated to occur as a result of the operations phase. Losses attributable to the post-operations phase are very small because of the relatively short period of exposure (five years of exposure assumed) involved and a decrease in radon emissions compared to the operations phase. Losses attributable to the post-closure phase are small primarily because of the decrease in radon emissions after the mine tailings are fully encapsulated. Second, as one would anticipate, the expected loss due to the operations phase varies widely depending on the selection of the value of a life. Third, the expected loss is small relative to the value of a life used in the calculations because the small increase in the expected number of deaths and the loss must be discounted by the factor 1.03^{-20} to arrive at the present value of the loss.

We would once again emphasize the following points:

1. We include only radon emissions from the tailings in our estimates of losses due to cancer.

2. We assume that workers voluntarily accept any increase in risk when they agree to work and so include only effects on residents of the area, not workers at the site.

3. We do not include estimates of the costs of non-fatal cancers or other radiological health effects.

Water Resources

We divide the effects of the Swanson project on water resources into two categories: groundwater and surface water.

Groundwater

The proposed uranium mining and milling project can have two types of effects on groundwater; the water table may be lowered in the vicinity of the mine as water is pumped from the mine pit or the quality of groundwater may be affected as compounds used at the site "leach" through the soil.

Quantity

Because the bottom of the mine pit will be below the water table, groundwater will flow into the mine and must then be pumped out. As water is pumped out of the mine, more water will flow in, and the water table in the immediate area will be drawn down. The area in which the water table is affected is called the cone of depression, the size of which is determined by the geophysical characteristics of the area. Marline-Umetco states that the drop in the water table will be limited to the area immediately adjacent to the site and that only three wells will be affected, two of which are within the perimeter of the site.[1/]

The State Water Control Board (SWCB), however, has expressed some concern. They point out that there are no data concerning the effects of deep (200 - 800 feet) open pit mines on groundwater and that claims of negligible effects on the water table are based on shallow (less than 200 feet) pump testing and professional opinion, not on deep mine pits or deep pump tests.[2/]

1/ Marline-Umetco, Technical Memoranda, vol.1, p.IV 40-41.

2/ Communication with Thomas Felvey, Director of Division of Ecological Studies, State Water Control Board, August 30, 1984.

Quality

A variety of proposed rules and current regulations designed to protect the quality of groundwater are listed below:

1. The SWCB is proposing the requirement that "...there shall be no degradation of groundwater from any portion of a uranium operation".1/

2. The EPA requires that liners be used in the tailings management area to prevent groundwater degradation and that "...the disposal of uranium tailings be designed to maintain its integrity, in most cases, for at least 1,000 years."2/

3. The EPA also requires corrective actions "...to restore groundwater to its background quality..." in the event of noncompliance with groundwater quality regulations.3/ The problem with such a regulation is that of establishing the background quality. In this case, the SWCB has already determined background quality levels for the physiographic province of the Piedmont.4/

Surface Water

New Source Performance Standards (NSPS) require that there be no discharge from the uranium mill. We can assume that this standard will be met and that there will be no change in surface water quality due to discharges from the mill during normal operations. There will be discharge from the mine that is regulated by the National Pollutant Discharge Elimination System (NPDES) standards. The SWCB feels that (NPDES) permit limits and procedures for addressing water quality considerations will be adequate to protect the environment.5/

1/ "Preliminary Proposed Laws and Regulations for Uranium Mining and Milling in Virginia," unpublished outline presented to the Uranium Task Force on July 17, 1984.

2/ There are two types of liners; synthetic and clay. They both have shortcomings. Synthetic liners are impermeable, but fragile, and are subject to rupture because of poor installation or uneven loading. Clay liners are permeable to some compounds and may require additional measures, such as partial neutralization of the tailings, to adequately protect groundwater. They are, however, expected to retain their effectiveness for a long period of time. Federal Register, vol. 48, no. 196 (7 October 7, 1983), pp. 45927-45931.

3/ Federal Register, vol.48, no.196 (October 1983), pp. 45927.

4/ State Water Control Board, Water Quality Standards, RB-1-80, revised ed., (Richmond, VA: SWCB, April 1982): p.9, Groundwater Standards.

5/ Communications with Thomas Felvey Director of Division of Ecological Studies, State Water Control Board, 30 August 1984.

Other Considerations

Diversion of Mill Creek

Mill Creek will be diverted south of its present course into Dry Branch. After closure, it will be rediverted into the mine pit in order to minimize the time required to fill the mine pit with water.1/ Because we have no way of valuing the destruction caused by the diversion of Mill Creek, we give a brief description of some of the anticipated effects. Clearly, the diversion of Mill Creek will destroy much of its aquatic life. Marline-Umetco also mentions that the passage of water from Mill Creek through a newly excavated channel would cause an increase in sedimentation in Whitethorn Creek and the Banister River. This increase in sedimentation "...would have localized effects on invertebrate production, fish spawning success, and fish vitality."2/

Also, recent research indicates that headwater creeks are a major contributor of nutrients to the entire river basin. Hence, the diversion of Mill Creek and the consequent destruction of habitat may have much more widespread effects than in just the immediate area.3/ The rediversion of Mill Creek to its original course would involve a second disruption of habitat and its consequent effects on downstream areas.

Accidents

In discussing the effects of the Swanson project on the environment, we have concentrated on normal operations of the mine/mill complex. One should not, however, be lulled into thinking that there will be no adverse effects on the environment. The Swanson project, just as any other mining operation, has the potential for an accident that could cause environmental damage to exceed projections based on the analysis of normal operations. We have not attempted to determine the costs of every conceivable accident. Instead, we give an example of a calculation done for one type of accident that has occurred during western uranium operations--a retention dike failure in the tailings management area. Based on a hypothetical value for clean-up costs, we demonstrate how the dollar value of the damage would be estimated.

1/ Marline-Umetco, Technical Memoranda, vol.1, p.IV-44

2/ Ibid.

3/ K.W. Cummins, and G.L. Spengler, "Stream Ecosystems," Water Spectrum (Fall 1978): 1-9; and Robin L. Vannate; G.W. Minshall; K.W. Cummins; J.R. Sedell; and E.E. Cushing, "The River Continuum Concept," Canadian Journal of Fisheries and Aquatic Sciences 37, 1 (1980): 130-137.

Example of a Retention Dike Failure

Marline estimates the probability of a retention dike failure at some point during the operations phase to be 0.03.[1/] With the probability that there would be a failure equal to 0.03 over the 13-year lifespan of the operations phase of the project, the probability of failure in any one year is equal to 0.0023.[2/] (This assumes that the probability of failure in any one year is independent of the probability of failure in any other year. It also assumes that the probability of failure and the extent of damage would be the same in any year). If we have the hypothetical value for the damage that results from a retention dike failure, we can calculate the present value of the expected damage. Unfortunately, no one has reliable information on what clean-up costs might be. Nonetheless, to illustrate the method for establishing such costs, we can use a hypothetical example. This sample calculation is done two ways: by assuming that the cost of the accident falls on the residents and by assuming that the cost falls on state and local governments. (See Exhibit 3.1 and Exhibit 3.2). Again, we emphasize that the values used for damage in these examples are hypothetical and intended only to demonstrate how such calculations can be made. They are not intended to show the actual value of expected damage.

As illustrated in Exhibits 3.1 and 3.2, if the hypothetical cost of an accident were $1,000,000 and the probability of an accident were 0.03 over the project's lifetime, then the present value of damage would be $23,041 if the cost were borne by residents and $17,439 if the cost were borne by state and local governments.[3/] This example shows that the expected damage from relatively costly accidents may be low due to the combination of very low probabilities of occurrence and because of the discounting of future costs.

1/ This estimate is based on historical data from western uranium operations. Due to changes in legislation concerning the construction of tailings management areas and differences in climate, it is not clear that this estimate is applicable to the Swanson site. The actual probability may be substantially different.

2/ If the probability that a failure occurs at sometime during the project is 0.03 and the project lasts 13 years, then the probability of a failure during any one year is 0.03/13=0.0023.

3/ Different discount rates are used for costs accruing to state and local government and for those accruing to residents. For this reason, the present value of costs differ depending on whether costs are borne by state and local governments or residents.

Summary

1. Provided that the General Assembly implements the SWCB's proposed standard of zero degradation, we can conclude that there will be no adverse effects on groundwater quality. Even if the SWCB's proposed standards are not implemented, it appears that federal regulations, if enforced, will prevent significant degradation of groundwater.

2. There will likely be some localized depression of the water table associated with the mine pit. Marline-Umetco estimates that this will be minimal. The SWCB is concerned that the effect may be more widespread than Marline-Umetco believes.

3. Except for some increase in sedimentation due to the diversion of Mill Creek, no significant degradation of surface waters is expected during normal operations, assuming enforcement of current state and federal regulations.

4. The diversion of Mill Creek will cause the destruction of its aquatic habitat and may also have adverse effects on the ecology of downstream areas. We have no way of valuing the losses associated with the environmental changes accompanying the diversion of Mill Creek.

5. Our analysis has emphasized the costs and benefits associated with this project during normal operations. We recognize the possibility for accidents during operations, but because of difficulties in establishing the probability of different events, and the damage they cause, we have not attempted to estimate the loss due to accidents. We do, however, give a hypothetical example to illustrate how such calculations could be performed if reliable data concerning probabilities and damages were available.

EXHIBIT 3.1

SAMPLE CALCULATION OF THE COST OF A RETENTION DIKE FAILURE ASSUMING ENVIRONMENTAL COSTS ACCRUE TO RESIDENTS

If the costs of the accident accrue to residents of the area, then the appropriate discount rate is 3 percent. (See Appendix E for a discussion of discount rates.) Since future income (and costs) is not valued as much as income received today, future income (and costs) must be discounted so that they are comparable to income (and costs) received today.

Assumptions:

Probability of a retention dike failure during any given year: 0.0023

Value of damage that results if an accident does occur: $1,000,000

Discount rate: 3 percent

Operations begin in 1987

With the cessation of operations, the probability of a retention dike failure goes to zero.

To calculate the present value of the expected damage due to a retention dike failure, we calculate the expected damage in any one year and then sum over the number of years the project is operated.

The expected value of damage in any one year is

$$(\$1{,}000{,}000 \times 0.0023)/\ (1.03)^{-n}.$$

where n is the number of years from the present, for example the present value of damage in year 10 (7 years after the project begins) is

$$(\$1{,}000{,}000 \times 0.0023)/\ (1.03)^{-10} = \$1{,}711.$$

The present value of the expected damage during the entire lifetime of the project is equal to the sum of the expected damages during any given year. (Again this assumes that the probabilities of an accident in any one year are independent.)

$$\sum_{i=3}^{15} (\$1{,}000{,}000 \times 0.0023)/\ (1.03)^{-i} = \$23{,}041.$$

EXHIBIT 3.2

SAMPLE CALCULATION OF THE COST OF A RETENTION DIKE FAILURE ASSUMING COSTS ACCRUE TO STATE AND LOCAL GOVERNMENTS

If the costs of the accident accrue to state and local governments, then the appropriate discount rate is 6.5 percent (see Appendix E for a discussion of discount rates). Since future income (and cost) is not valued as much as income received today, future income (and cost) must be discounted so that it is comparable to income (and cost) received today.

Assumptions:

Probability of a retention dike failure during any given year: 0.0023

Value of damage that results if an accident does occur: $1,000,000

Discount rate: 6.5 percent

Operations begin in 1987

With the cessation of operations, the probability of a retention dike failure goes to zero.

To calculate the present value of the expected damage due to a retention dike failure, we calculate the expected damage in any one year and then sum over the number of years the project is operated.

The expected value of damage in any one year is

$$(\$1{,}000{,}000 \times 0.0023) / (1.065)^{-n}.$$

Where n is the number of years from the present, for example, the present value of damage in year 10 (7 years after the project begins) is

$$(\$1{,}000{,}000 \times 0.0023) / (1.065)^{-10} = \$1{,}225.$$

The present value of the expected damage during the entire lifetime of the project is equal to the sum of the expected damages during any given year. (Again this assumes that the probabilities of an accident in any one year are independent.)

$$\sum_{i=3}^{15} (\$1{,}000{,}000 \times 0.0023) / (1.065)^{-i} = \$17{,}439.$$

CHAPTER 4

SUMMARY OF COSTS AND BENEFITS

The analysis of costs and benefits requires a conceptual framework. For this study, we employ the following approach:

1. We examine the costs and benefits of the Swanson project from the viewpoint of the Commonwealth and its citizens.

2. Costs and benefits that occurred in the past should be of only peripheral interest to decision-makers because such dollar amounts have already been spent and will not be changed by the future of the Swanson project. These sunk amounts do, however, convey an idea of the commitment of Marline-Umetco and the concern of government officials and other groups and individuals.

3. The future costs and benefits of the project are the basis of our evaluation and conclusion.

4. To compare costs and benefits that occur over a long time period or at different points in time, we value the dollar amounts by discounting them to present values, which is known as present value analysis. In order to engage in such analysis, we must establish and quantify costs and benefits, date them, and select appropriate discount rates.

5. Our estimates of costs and benefits are based on an assumed level of regulations. The state government obviously can revise regulations before or after operations commence. Revised regulations most likely would change the costs and benefits set forth in this study.

6. Although the profitability of the project is not considered directly, it could influence the size of costs and benefits. The level of profitability, the regulatory framework, and the quantity of costs and benefits are all interrelated. If relatively more stringent regulations were set, then benefits from the viewpoint of the Commonwealth and its citizens would be increased because the firm would be forced to spend more on environmental safeguards; also, costs would fall because environmental degradation would be reduced. However, with more stringent regulations, the firm's profits would be reduced, thus increasing the probability that the site would remain undeveloped.

In Table 4.1, we present a summary of our results. For those estimates that are assigned dollar values, we also indicate the present value of the benefit or cost during the lifetime of the project. For example, the estimated annual earnings in the RSA during the operations phase are $8,435,100. The present value of the sum of annual earnings for 13 years (the assumed length of operations) is $63,954,928.[1]

The present value of all measurable benefits is $101,024,000 for the low range of estimates, $125,358,000 for the middle range, and $149,692,000 for the high range. The majority of these benefits are attributable to the increased earnings of workers and increased tax revenues to state and local governments.

The present value of all measurable costs is $4,046,000 for the low range of estimates, $4,828,000 for the middle range, and $5,611,000 for the high range. The largest measurable costs are the regulatory costs incurred by state and local governments.

Using the middle range of estimates, the benefit to cost ratio is 26:1. The extremes of the benefit to cost ratio are 18:1 (low benefit estimate divided by high cost estimate) and 37:1 (high benefit estimate divided by low cost estimate).

Although these favorable ratios are certain to be of interest to readers, we caution that they are based on incomplete and rough information and that certain costs and benefits have not been quantified. As a result, our estimates do not include all costs and benefits, only those which we were able to quantify. The problem of valuation was more severe for costs than benefits. Specifically, for one large section of costs, environmental costs, we were unable to obtain any dollar estimates. Therefore, in comparison with benefits, costs are underrepresented in our estimates. Despite this, we feel that with precise estimates for all costs and benefits, the benefits would still be larger than costs, but the difference would be narrowed. We encourage a careful reading of the full study and the review of additional information provided by other consultants.

1/Except as noted, our estimates are in 1981 dollars. Thus the $63,954,928 represents the present value (in 1981 dollars) of all future earnings received by residents of the RSA as a result of the Swanson project. The present value would be approximately 14 percent higher if it were adjusted to 1984 dollars using the Consumer Price Index.

TABLE 4.1
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimate	Present Value During the Lifetime of the Project
BENEFITS		
Total Earnings		
RSA construction	$ 12,975,400 low	$ 11,440,134 low
	16,219,300 middle	14,300,212 middle
	19,463,200 high	17,160,289 high
RSA operations	6,748,100 low	51,164,094 low
	8,435,100 middle	63,954,928 middle
	10,122,100 high	76,745,762 high
State construction	25,102,300 low	22,132,164 low
	31,377,900 middle	27,665,227 middle
	37,653,500 high	33,198,290 high
State operations	9,706,900 low	73,597,716 low
	12,133,600 middle	91,996,955 middle
	14,560,300 high	110,396,195 high

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimate	Present Value During the Lifetime of the Project
BENEFITS (cont.)		
Total Employment		
RSA construction	521 low	a/
	652 middle	a/
	782 high	a/
RSA operations	496 low	a/
	620 middle	a/
	744 high	a/
State construction	625 low	a/
	782 middle	a/
	938 high	a/
State operations	648 low	a/
	810 middle	a/
	972 high	a/

a/ Present value cannot be calculated for estimates not in dollar terms.

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimate	Present Value During the Lifetime of the Project
BENEFITS (cont.)		
Taxes during construction--RSA		
Real property		
year 1	$ 11,790	$ 11,070
year 2	236,280	208,323
Machinery and tools		
year 1	36,000	33,803
year 2	36,000	31,740
Tangible personal property		
year 1	10,455	9,817
year 2	10,455	9,218
Sales		
year 1	46,327	43,500
year 2	46,327	40,845

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimates	Present Value During the Lifetime of the Project
BENEFITS (cont.)		
Taxes during construction--State		
Sales		
year 1	$250,710	$235,408
year 2	250,710	221,041
Motor vehicle sales and use tax	16,400	15,400
Taxes during operations--RSA		
Real property	236,280	1,791,475
Machinery and tools	36,000	272,952
Tangible personal property	10,455	79,270
Sales	2,040	15,467

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimates	Present Value During the Lifetime of the Project
BENEFITS (cont.)		
Taxes during operations--State		
Corporate income	No estimate	No estimate
Sales	$ 12,300	$ 93,259
Secondary taxes during construction--RSA	23,079 low 27,795 middle 32,511 high	20,348 low 24,506 middle 28,664 high
Secondary taxes during construction--State	173,810 low 217,245 middle 260,680 high	153,245 low 191,540 middle 229,839 high

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimate	Present Value During the Lifetime of the Project
BENEFITS (cont.)		
Secondary taxes during operations--RSA	$ 37,063 low 41,707 middle 46,351 high	$ 281,062 low 316,222 middle 351,433 high
Secondary taxes during operations--State	171,150 low 213,920 middle 256,690 high	1,297,659 low 1,621,941 middle 1,946,224 high
Unemployment insurance taxes	429,039 (present value)	429,039
COSTS		
State outlays in manpower and consultant charges for review of proposal to allow mining/milling and to license it	No estimate	No estimate

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimate	Present Value During the Lifetime of the Project
COSTS (cont.)		
Regulatory costs		
One time/infrequent costs based on agreement status	$ 405,750 to 539,300 a/	$ 326,581 to 434,074
Costs for exploration, mining, and reclamation	No estimate	No estimate
Costs during operations	248,731 to 444,425 a/	1,721,622 to 3,076,139
Cost recovery	No estimate	No estimate
Road expenditures		
Improvements	1,135,000 b/	877,348

a/ The estimates are given in 1983 dollars and were adjusted to 1984 dollars before discounting to make them comparable to the other estimates.

b/ This estimate is given in 1984 dollars and was adjusted to 1981 dollars before discounting to make it comparable to the other estimates.

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item		Present Value During the Lifetime of the Project
COSTS (cont.)		
Annual maintenance	$ 8,000[a/]	$ 53,863
Forgone annual local government revenue	1,073	4,681
Local government secondary expenditures during construction--RSA	4,407	3,886
State government secondary expenditures during construction--State	24,180	21,319
Local government secondary expenditures during operations--RSA	18,758	142,223

a/ This estimate is given in 1984 dollars and was adjusted to 1981 dollars before discounting to make it comparable to other estimates.

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimate	Present Value During the Lifetime of the Project
COSTS (cont.)		
State government secondary expenditures during operations--State	$ 109,616	$ 831,108
Air quality		
Increase in total suspended particulates	4.0 ug/m^3	a/
Increase in airborne ammonia concentrations	No estimate	No estimate
Increase in sulfuric acid mist concentrations	No estimate	No estimate
Increase in airborne insoluable uranium concentrations	No estimate	No estimate
Increase in sulfur dioxide concentrations	0.005 ug/m^3	a/
Increase in nitrogen dioxide concentrations	4.6 ug/m^3	a/

a/ Present value cannot be calculated for estimates not in dollar terms.

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimate	Present Value During the Lifetime of the Project
COSTS (cont.)		
Increase in Carbon Monoxide concentrations	No estimate	No estimate
Increase in airborne hydrocarbons concentration	No estimate	No estimate
Radiation exposure		
Total body	16.4 mrem/yr	a/
Bone	94.6 mrem/yr	a/
Gastrointestinal	0.1 mrem/yr	a/
Average lung	41.0 mrem/yr	a/
Increase in cancer deaths from radon exposure	0.3	a/
Value of the increased risk of fatal cancers	$ 63,119 to 166,104 (present value)	$ 63,119 to 166,104

a/ Present value cannot be calculated for estimates not in dollar terms.

TABLE 4.1(continued)
SUMMARY OF BENEFITS AND COSTS AS ESTIMATED BY THE TAYLOE MURPHY INSTITUTE

Item	Estimate	Present Value During the Lifetime of the Project
COSTS (cont.)		
Water resources		
Groundwater quantity	No estimate	No estimate
Groundwater quality	No estimate	No estimate
Surface water	Diversion of Mill Creek	a/
Accidents	No estimate	No estimate

a/ Present value cannot be calculated for estimates not in dollar terms.

APPENDIX A

INPUT-OUTPUT MODELS

This appendix provides a brief introduction to input-output (I-O) analysis, discusses its general application to regional impact studies, and concludes with a detailed explication of the assumptions and methodology of our own I-O model.

WHAT IS I-O ANALYSIS?[1/]

"The input-output method," says its creator, Wassily Leontif, "is an adaptation of the neoclassical theory of general equilibrium to the empirical study of the quantitative interdependence of interrelated economic activities."[2/] Although the association with neoclassical economics may be misplaced,[3/] I-O is nonetheless unique among the tools of the economist in its attempt to capture quantitatively the complex interaction among the myriad sectors and industries of the economy.

To see how I-O models work, suppose that there are N industries in the economy, each of which produces a homogeneous good X_i.[4/] Let X_{ij} be the amount of industry i's output used in the production of industry j's output, and let Y_i be the "final demand" for industry i's output, that is to say, the amount of X_i that is either consumed, exported, invested or used by the government. Clearly, the total output of the jth industry must either be used to produce more outputs or be absorbed into "final demand." Thus

(1) $$X_i = X_{ij} + Y_i \quad \text{for all } i,j = 1,2,\ldots,N$$

1/ Two excellent introductions to I-O analysis are William H. Miernyk, The Elements of Input-Output Analysis (New York: Random House, 1957); and Chapter 22 of William J. Baumol, Economic Theory and Operations Research, 4th ed. (Englewood Cliffs, New Jersey: Prentice-Hall, 1965). The locus classicus of I-O analysis is Wassily W. Leontief, Studies in the Structure of the American Economy (New York: Oxford University Press, 1953).

2/ Wassily W. Leontief, "Input-Output Analysis" in Input-Output Economics (New York: Oxford University Press, 1966): 134.

3/ Misplaced for at least two reasons: First, outputs determined by the model need not satisfy any market equilibrium conditions (see Baumol, Economic Theory and Operations Research, p. 538); second, the structure of the model has no direct link with the optimizing behavior of firms and households. See Carl C. Christ, "A Review of Input-Output Analysis" in Input-Output Analysis: An Appraisal (Princeton: Princeton University Press, 1955): 143.

4/ This rules out the possibility of "joint production," the simultaneous production of more than one output by a given set of inputs.

Equation (1) is merely an accounting identity, however, and is not very useful by itself. In order to generate hypotheses about the relation of "final demands" to total outputs, I-O analysis imposes two restrictions on the X_{ij}:

First, inputs are assumed to expand in proportion to output; that is, the production process is characterized by "constant returns to scale."

Second, substitution between inputs is prohibited so that a manufacturing process that is currently labor-intensive does not have the option of becoming more capital-intensive if the wage rate increases.1/ This implies that

(2) $$X_{ij} = a_{ij}X_j \quad \text{for all } i,j = 1,2,\ldots,N$$

where a_{ij} is defined to be the fixed amount of output i required to produce a unit of output j.

Substituting (2) into (1) we arrive at the system of equations

(3) $$X_i = \quad a_{ij}X_j + Y_i \quad \text{for all } i,j = 1,2,\ldots,N$$

Now let $X = [X_1,X_2,\ldots,X_N]$ be the N-element column vector of outputs; similarly, let $Y = Y[Y_1,Y_2,\ldots,Y_N]$ be the N-element column vector of "final demands." Define A as the NxN "structural" matrix of the a_{ij}. Then the system of equations in (3) can be expressed in matrix notation as

(3a) $$X = AX + Y$$

or collecting terms

$$X(I - A) = Y$$

where I is the (NxN) identity matrix. Provided certain mathematical conditions are met,2/ this system can be solved for the vector of outputs as

---

1/ In the literature, production technologies with this property are known as "fixed coefficient" or "Leontief" technologies. See Hal Varian, Microeconomic Analysis (New York: W.W. Norton & Co., 1978), p. 5..

2/ Specifically, all of the a_{ij}'s must be non-negative. For the derivation of these so-called Hawkins-Simons stability conditions see D. Hawkins and H.A. Simons, "Some Conditions of Macroeconomic Stability," Econometrica 17 (July-October, 1949).

(4) $$X = (I - A)^{-1} Y$$ [1]

Equation (4) tells us how much of each output is necessary to support a given level of final demand. Conversely, by forecasting an increase in final demand, we can estimate the resulting increase in output[2]--which is precisely how I-O models are applied to impact analysis.

Note that in this simple model consumption appears in the vector of demands, a specification that precludes feedback between output and income. A rudimentary[3] method of capturing "induced expenditure" effects, however, is to include a vector of consumption coefficients in the structural matrix, A.[4] If we call this new, augmented matrix A^*, our fundamental result becomes

(4a) $$X = (I - A^*)^{-1} Y$$

Note also that the X vector in (4) and (4a) is measured in dollars of output. For the purposes of impact analysis, however, it is often useful to denominate the results in dollars of earnings,[5] rather than dollars of output. This is a straightforward transformation, given the ratio of earnings to output for each industry.[6] Another extension of

---

1/ For large matrices, this inversion can be prohibitively time consuming, even for large computers. Often, therefore, an approximation to the inverse is used. See Alpha C. Chiang, Fundamental Methods of Mathematical Economics, 2nd ed. (New York: McGraw-Hill Book Company, 1974), pp. 238-239. A variety of "shortcut" techniques are also available. See Joseph V. Cartwright, Richard M. Beemiller, and Richard D. Gustely, RIMS II: Regional Input-Output Modelling System (Washington, D.C.: U.S. Government Printing Office, April 1981), pp. 28-34.

2/ Norman J. Glickman, Econometric Analysis of Regional Systems (New York: Academic Press, 1977), p. 30.

3/ This method is rudimentary because it in effect treats households as firms with fixed coefficient production functions.

4/ I-O models that treat consumption as an exogenous element in the final demand vector are known as "open" models. In contrast, models that treat consumption as an endogenous element by tacking a consumption vector onto the structural matrix are "closed."

5/ Earnings are defined by the BEA as the sum of wages, salaries, other labor income, and proprietors' income.

6/ Cartwright, et al, RIMS II: Regional Input-Output Modeling System, pp. 34-38.

the model involves the translation of the earnings vector into units of employment. This is most commonly done by multiplying each industry's earnings by the ratio of employment to earnings of that industry.1/

REGIONAL I-O MODELS2/

The task of collecting the data needed to estimate the structural matrix is truly Herculean; it requires, in principle, the determination of both the industrial origin and destination of sales and purchases of all firms in the economy.3/ Most regional economists have therefore eschewed the time consuming and inordinately expensive activity of primary data collection, adopting instead less expensive "non-survey" techniques of generating regional I-O coefficients. Generally, "non-survey" techniques generate regional I-O coefficients by adjusting the national I-O table (produced periodically by the BEA) to allow for differences between the regional and national economies.4/ There are several ways of adjusting national coefficients. Because the Regional Industrial Multiplier Systems (RIMS I and II) of the BEA have effectively standardized the use of I-O models in impact studies we can focus our attention on their method of adjustment, known as the Simple Location Quotient (SLQ) technique.5/

1/ This is essentially the "Moore-Petersen Method," though Moore and Petersen dealt with income and employment, rather than earnings and employment. See Frederick T. Moore and James W. Petersen, "Regional Analysis: An Inter-industry Model of Utah," Review of Economics and Statistics 37 (November 1955): 368-383. Another approach to generating employment figures from the model is described in Walter Isard and Robert E. Kuenne, "The Impact of Steel Upon the Greater New-York-Philadelphia Industrial Region," Review of Economics and Statistics 35 (November 1953): 289-301.

2/ Discussions of the application of I-O models to regional economics are found in Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science (Cambridge, MA: The M.I.T. Press, 1963); Norman J. Glickman, Econometric Analysis of Regional Systems (New York: Academic Press, 1977); and Floyd K. Harmston and Richard E. Lund, Application of an Input-Output Framework to a Community Economic System (Columbia, MO: University of Missouri Press, 1967).

3/ Glickman, Econometric Analysis of Regional Systems, p. 35.

4/ Cartwright, et al, RIMS II: Regional Input-Output Modeling System, p. 5.

5/ This discussion follows Cartwright. See pp. 15-16.

The simple location quotient of regional industry i is defined as

(5) $$SLQ_i = \frac{Q_{ir}/T_r}{Q_{in}/T_n}$$

where Q_{ir} is a measure of output of the industry in the region; Q_{in} is a measure of its national ouput; T_r is a measure of aggregate economic activity in the region; and T_n is a measure of aggregate economic activity at the national level. Earnings or employment can be used as proxies for the Q_i's, while income, population, earnings, or employment can be used as proxies for the T's.

How is SLQ_i to be interpreted? If it is less than one, then the industry provides a smaller proportion of economic activity in the region than in the nation, so the region must import some of output i. Conversely, if it is greater than one, the industry provides a greater proportion of economic activity in the region than in the nation, so the region must export some of output i. In short, SLQ_i is a summary measure of the self-sufficiency of the region in the production of output i. A simple method of regionalizing the national I-O coefficients suggests itself. If we let a_{ij} be the ijth national I-O coefficient, and if we define

(6) $$SLQ_i' = \begin{cases} SLQ_i \text{ if } SLQ_i < 1 \\ 1 \text{ if } SLQ_i > 1 \end{cases}$$

then the ijth regional I-O coefficient r_{ij} will be

(7) $$r_{ij} = SLQ_i' \times a_{ij}$$

Cartwright provides convincing statistical evidence that the coefficients estimated using this method are reasonably close to those estimated with survey techniques.1/

APPLICATION TO THE SWANSON PROJECT

Following Marline-Umetco, we have developed four analytical categories, each of which uses RIMS II to model the impacts of a particular phase of the Swanson project on a given study area. These are:

1. RSA/Construction
2. RSA/Operations
3. State/Construction
4. State/Operations

1/ Cartwright, RIMS II: Regional Input-Output Modeling System, Chapter 5.

The final estimates of earnings and employment for these categories, bounded by intervals of plus and minus 20 percent, are reported in Tables 2.6 and 2.7 of the text. Our object here is to demonstrate with a sample I-O table how these results were generated.

Table A.1 reproduces the I-O Table for the RSA/Construction scenario. The 39x7 sub-matrix in the upper left of this table shows the industry earnings multipliers generated by RIMS II for each of the seven categories of regional final demand that will be affected by the construction phase of the project. The elements of this sub-matrix show how much earnings will increase in any given industry as a result of a dollar's increase in a specific category of final demand. For example, if Marline-Umetco spends $1.00 on ready-mixed concrete, earnings in the Agricultural Production and Services industry will increase by $.0018.

The third row from the bottom of Table A.1 reports the increases in regional final demand (in 1981 dollars) associated with the project.1/ These are simply the expenditures by Marline-Umetco summarized in Table A.9 of the text. Because the RIMS II coefficients are based on 1972 data it is necessary to deflate these expenditures to 1972 dollars. The deflators are shown in the penultimate row, while the deflated final demands are shown in the final row.2/

Total earnings generated in each industry appear in the third column from the right. These industry totals are calculated by summing the products of each element in a row by the associated increase in final demand. This is best seen by example: The total increase in earnings in Agricultural Production and Services is (3029 x .0051) + (441 x .0006) + (3380 x .0026) + (2714 x .0018) + (1721 x .0018) + (1966 x .0022) = 36.7. Total earnings in the RSA is then simply the sum of the elements in this column (= $8,311,600).

Total employment generated in each industry is shown in the final column. These figures are calculated by multiplying each industry's projected earnings by an employment-earnings ratio,3/ shown in the penultimate column. To continue our previous example, the increase in employment in the Agricultural Production and Services industry is 36.7 x .1383 = 5.1. The total increase in employment in the RSA is therefore

---

1/ For details of the derivation of these expenditures, see the Table A.2 of Section III.

2/ For details, see the Table A.2, Section IV.

3/ For details, see Tables A.2 and A.4.

the sum of the elements in the final column (= 977.7).1/

DETAILS OF THE I-O MODEL AND COMPARISONS WITH THE I-O MODEL OF GIBBS AND HILL

Throughout the preceding section, we have footnoted detailed explanations of the assumptions, data, and calculations of our I-O model. In order to facilitate what must inevitably be tedious reading, we have organized these details in an outline. The general headings of this outline are:

I. Earnings Multipliers

II. Employment-Earnings Ratios2/

III. Expenditures

IV. Deflators

Since some readers may be interested in comparing our model with that of Gibbs and Hill, the outline is set in tabular form so that our treatment of each of these issues can be juxtaposed against theirs.

1/ Because the construction phase will last 18 months, the earnings figures calculated here are also for an 18-month period. The employment-earnings ratios, calculated from OBERS data, are for a 12-month period. To make these figures consistent, it is necessary to divide the earnings estimate by 1.5. This yields a final column of annual employment estimates.

2/ Marline-Umetco uses the term employment/earnings multipliers. This is misleading because these ratios bear no theoretical relationship to multipliers of any sort.

TABLE A.1

SAMPLE I-O TABLE FOR THE CONSTRUCTION PHASE--
REGIONAL STUDY AREA

	RIMS II Earnings Multipliers									
	Labor	Personal Consumption	Real Estate	Wholesale Trade	Stone, Clay Mining & Quarrying	R.M. Concrete	Misc. Professional Services	Total Earnings	Employment-Earnings Ratio	Jobs
Agr. Prod. & Services	0.0000	0.0051	0.0006	0.0026	0.0018	0.0018	0.0022	36.7	0.1383	3.4
Forestry & Fishery Prod.	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.6	0.1538	0.1
Coal Mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0	0.0481	0.0
Crude Petrol. & Nat. Gas	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0	0.0403	0.0
Other Mining	0.0000	0.0001	0.0001	0.0000	0.3137	0.0252	0.0000	895.4	0.0790	47.1
New Construction	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2926.0	0.1510	305.0
Maint. & Repair Const.	0.0000	0.0072	0.0254	0.0060	0.0067	0.0064	0.0042	90.5	0.0896	5.4
Food & Kindred Prod.	0.0000	0.0008	0.0001	0.0004	0.0003	0.0003	0.0003	5.7	0.1219	0.5
Textile Mill Prod.	0.0000	0.0035	0.0003	0.0017	0.0013	0.0012	0.0014	24.7	0.1341	2.2
Apparel	0.0000	0.0087	0.0008	0.0042	0.0032	0.0030	0.0035	61.4	0.2096	8.6
Paper & Allied Prod.	0.0000	0.0005	0.0001	0.0013	0.0013	0.0008	0.0003	11.4	0.0781	0.6
Printing & Publishing	0.0000	0.0016	0.0010	0.0036	0.0008	0.0012	0.0019	25.4	0.1183	2.0
Chemicals & Ref. Petrol.	0.0000	0.0000	0.0000	0.0000	0.0003	0.0001	0.0000	1.0	0.0781	0.1
Rubber & Leather Prod.	0.0000	0.0021	0.0004	0.0013	0.0025	0.0012	0.0010	21.7	0.0977	1.4
Lumber & Furn. Prod.	0.0000	0.0013	0.0004	0.0007	0.0005	0.0010	0.0005	10.5	0.1279	0.9
Stone, Clay & Glass Prod.	0.0000	0.0005	0.0003	0.0004	0.0005	0.2300	0.0003	401.0	0.0996	26.6
Primary Metals	0.0000	0.0000	0.0000	0.0000	0.0006	0.0001	0.0000	1.8	0.0700	0.1
Fabricated Metals	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.3	0.0893	0.0
Non-elect. Machinery	0.0000	0.0001	0.0000	0.0002	0.0004	0.0003	0.0001	2.8	0.0944	0.2
Electrical Machinery	0.0000	0.0001	0.0000	0.0001	0.0001	0.0000	0.0001	1.1	0.0924	0.1
Motor Vehicles & Trans.	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.3	0.0682	0.0
Other Trans. Equipment	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.0846	0.0
Instruments	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0	0.1221	0.0
Misc. Manufacturing	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0001	1.0	0.1453	0.1
Trans. Loc. Govt., Trans. Post	0.0000	0.0121	0.0027	0.0146	0.0087	0.0566	0.0121	231.7	0.0595	9.2
Communication	0.0000	0.0039	0.0013	0.0062	0.0018	0.0025	0.0046	51.5	0.595	2.1
Utilities	0.0000	0.0019	0.0007	0.0014	0.0027	0.0012	0.0009	21.9	0.0595	0.9
Wholesale Trade	0.0000	0.0111	0.0020	0.4307	0.0089	0.0090	0.0054	1541.0	0.0748	76.9
Retail Trade	0.0000	0.0658	0.0079	0.0326	0.0239	0.0229	0.0271	468.5	0.1847	57.7
Eating & Drinking Est.	0.0000	0.0158	0.0026	0.0013	0.0060	0.0069	0.0109	102.4	0.1847	12.6
Finance	0.0000	0.0054	0.0020	0.0041	0.0036	0.0028	0.0041	53.6	0.0905	3.2
Insurance	0.0000	0.0047	0.0018	0.0031	0.0024	0.0022	0.0023	40.2	0.0694	1.9
Real Estate	0.0000	0.0007	0.0518	0.0006	0.0007	0.0004	0.0008	31.1	0.1131	2.3
Lodging & Amusements	0.0000	0.0024	0.0003	0.0018	0.0010	0.0012	0.0030	24.1	0.1916	3.1
Personal Services	0.0000	0.0117	0.0021	0.0073	0.0046	0.0044	0.0053	91.2	0.1112	6.7
Business Services	0.0000	0.0018	0.0010	0.0034	0.0026	0.0023	0.3736	763.2	0.0849	43.2
Health Services	0.0000	0.0253	0.0023	0.0118	0.0088	0.0084	0.0102	175.1	0.0849	9.9
Other Services	0.0000	0.0164	0.0036	0.0144	0.0102	0.0090	0.0105	163.3	0.1033	11.3
Households	0.0000	0.0048	0.0004	0.0023	0.0017	0.0016	0.0019	33.4	0.2961	6.6
Column Sum	1.0000	0.2157	0.1120	0.5583	0.4217	0.4041	0.4886			
Expenditure $1981	6207	6207	802	6618	4581	4008	3659	8311.6		651.8
Deflator	2.1210	2.1210	1.8180	1.9570	1.6870	2.3280	1.8600			
Expenditure $1972	3029	3029	441	3380	2714	1721	1966			

TABLE A.2

DETAILS OF THE I-O MODEL AS USED BY THE TAYLOE MURPHY INSTITUTE AND GIBBS AND HILL

Gibbs & Hill	Tayloe Murphy Institute
I. Earnings Multipliers	I. Earnings Multipliers
A. Earnings multipliers provided by RIMS II[a/]	A. Earnings multipliers provided by RIMS II[a/]
II. Employment-Earnings Ratios	II. Employment-Earnings Ratios
A. Reconciliation of RIMS II and OBERS industrial classifications	A. Reconciliation of the RIMS II and OBERS industrial classifications
1. The BEA[b/] industry classifications used in the RIMS II model do not match those of OBERS.[c/] In order to link the earnings figures of RIMS II with the employment-earnings ratios of OBERS, however, it was necessary to effect a rough reconciliation of the two methods of classification.	1. TMI adopts the G&H reconciliation, with one exception:
	a. G&H approximates RIMS II Industry 39 (Other Services) with the aggregate OBERS category of 'Services.' TMI instead defines 'Other Services' as the OBERS 'Services' minus the categories 'Hotels and Other Lodging Places,' 'Personal and Miscellaneous Business and Repair Services,' and 'Medical and Other Health Services.'
2. The OBERS industry categories chosen by G&H to approximate the BEA categories are reported in Table A.3.[d/]	2. TMI's choice of industries is reported next to that of G&H in Table A.3.
B. State Employment-Earnings Ratios	B. State Employment-Earnings Ratios
1. For most industry classifications, the G&H state employment-earnings ratios can be closely approximated by the ratio of OBERS 1985 projections for employment to OBERS 1985 projections for earnings.[e/]	1. For most industry classifications, the TMI state employment-earnings ratios are defined as the ratio of the OBERS 1985 projections for employment and earnings.
2. Exceptions to the rule in II.A.[f/]	2. Exception to the rule in II.A.
a. Whether intentionally or inadvertently, Industry 4 (Crude Petroleum and Natural Gas) and Industry 5 (Other Mining) were merged into a single industry and thus share a common ratio of 0896.	a. The ratio for Industry 5 (Other Mining) is set equal to the ratio of earnings estimated by RIMS II (given the expenditure assumptions described in section III) to the level of employment projected by Marline.
b. The OBERS ratio of Industry 8 (Food and Kindred Products) has been replaced with the OBERS ratio for Tobacco.	
c. The OBERS ratios for Industries 31 (Finance), 32 (Insurance), and 33 (Real Estate) have a common ratio which is equal to the ratio of 1978 employment to the OBERS projection of earnings in 1985.	
3. G&H's state employment-earnings ratios are reported in Table A.4.	3. TMI's state employment-earnings ratios are reported next to those of G&H in Table A.4.

TABLE A.2 (continued)

DETAILS OF THE I-O MODEL AS USED BY THE TAYLOE MURPHY INSTITUTE AND GIBBS AND HILL

Gibbs & Hill

C. Regional Employment-Earnings Ratios

1. Marline's regional employment-earnings ratios are based primarily on OBERS data for the state and non-SMSA Region 21 (1985 projections), but have been "calibrated" in some unknown manner with data from Region 22[g] (which includes Halifax County and South Boston).[h]

2. The regional ratios of Industries 1-5 (Agriculture and Mining) are identical to the state ratios for these industries.

3. The regional ratios for Industries 8-28, 30 and 34-39 can be approximated by adjusting the state ratios in the follwing manner: The ratio of state employment in manufacturing to state (labor and proprietors') income from manufacturing is .0929; the ratio of regional employment in manufacturing to regional income from manufacturing is .1047. The ratio of these ratios is .0929/.1047 = .8873. The regional employment-earnings ratio for any industry is then the state ratio for that industry divided by .8873.

   a. Note that this method is used for such disparate industrial classifications as services and wholesale trade, as well as manufacturing.

4. The regional ratios for Industries 6 and 7 (Construction) can be calculated from unadjusted state data for 1978, rather than 1985; possibly, however, these ratios were generated with the method in G&H II.C.3., but using 1985 data from Region 22 as well as from Region 21 and the state.[i]

5. The regional ratio for Industry 29 (Retail Trade) was calculated directly from regional OBERS data; this is one of the few cases where it is possible to avoid approximating regional ratios from the state ratios.

6. G&H's ratio of .0782 for Industries 31 (Finance), 32 (Insurance) and 33 (Real Estate) is much lower than the OBERS figure of .1019 (calculated using the method in B.3). This is an inexplicable inconsistency.[j]

7. G&H's regional employment-earnings ratios are reported in Table A.5.

Tayloe Murphy Institute

C. Regional Employment-Earnings Ratios

1. TMI's regional employment-earnings ratios are based solely on data for OBERS non-SMSA Region 21 and the state. The rationale for excluding data from Region 22 is that Halifax County projects geographically into Region 21 and has more in common economically with that Region than with Region 22, which includes Richmond as well as the South Side.

2. The regional ratios for Industries 2-7, 25-28, and 29-39 were calculated by adjusting the state ratios for these industries in the following manner: The ratio of total state employment to total state (labor and proprietors') income is .1069 (as always, the 1985 projection); the ratio of total regional employment to total total regional income is .0939. The ratio of these ratios is .1069/.0939 = 1.1384. Then the regional employment-earnings ratio for the industry is the state ratio for that industry divided by 1.1384.

3. The regional ratios for Industries 8-24 (Manufacturing) were calculated using the method described in G&H II.C.3., that is, by dividing the state ratio by .8873.

4. The regional ratios of Industry 1 (Agricultural Products and Services) and Industry 29 (Retail Trade) were calculated directly from unadjusted OBERS data for Region 21. These are the only two disaggregated industrial categories for which regional data exists.

5. As in TMI II.B.2.a., the ratio for Industry 5 (Other Mining) is set equal to the ratio of earnings generated by the RIMS II model to the level of employment projected by Marline.[k]

6. TMI's regional employment-earnings ratios are reported next to those of G&H in Table A.5.

TABLE A.2 (continued)

DETAILS OF THE I-O MODEL AS USED BY THE TAYLOE MURPHY INSTITUTE AND GIBBS AND HILL

Gibbs & Hill	Tayloe Murphy Institute
III. Expenditures	III. Expenditures
A. Wholesale expenditures	A. Wholesale Expenditures
1. The wholesale expenditures used in the G&H I-O tables (1.4-7 through 1.4-10)l/ are 15 percent of the wholesale expenditures reported in the G&H Expenditure tables 1.4-2 , and 1.4-4 through 1.4-6).m/	1. TMI accepts the lower figure for wholesale expenditures used by G&H.
a. G&H made this reduction because most of the dollars received by the wholesale agents will be passed through to manufacturers without impacting the regional economy.	
B. Expenditures on Tailings Management	B. Expenditures on Tailings Management
1. G&H do not include expenditures on tailings management in their I-O models.	1. The TMI I-O models include $16 million for tailings management during the construction phase of the project, and $4.8 million annually during the operations phase.n/
	2. Allocation of expenditures on tailings management
	a. Distribution between labor and non-labor expenditures
	i. 4 percent of expenditures on tailings management are allocated to labor ($640,000 during construction, $192,000 during operations); the remainder is allocated to non-labor expenditures ($15,360,000 during construction, $4,608,000 during operations.o/
	b. Distribution between the RSA and Virginia
	i. Both the RSA and Virginia are assumed to receive 100 percent of the labor expenditure for tailings management.
	ii. Non-labor expenditures for tailings management for the RSA (Virginia) are calculated from the ratios of RSA (Virginia) non-labor expenditure to total non-labor expenditure reported in Marline's Table I.4-1.p/ (Example: the RSA ratio for the operations phase is 8.8/24.9 = .3534, so that the non-labor expenditure in the RSA for tailings management is .3534 x $4,608,000 = $1,628,000

TABLE A.2 (continued)

DETAILS OF THE I-O MODEL AS USED BY THE TAYLOE MURPHY INSTITUTE AND GIBBS AND HILL

Gibbs & Hill	Tayloe Murphy Institute
	c. Distribution of non-labor expenditures among industries
	i. The distribution of total non-labor tailings management expenditures among industries is assumed to be identical to the distribution non-labor construction expenditures among industries.[s] (Example: from Table A.7, total non-labor expenditures in the RSA during the construction phase are $12,744,000 (= $18,264,000 - $5,520,000. Since Wholesale Trade receives $4,288 of this total, its proportionate allocation is .3365. Thus from from TMI III.B.2.b.ii. the wholesale expenditure in the RSA during operations is .3365 x $1,628,000 = $548,000 which is the value reported in Table A.12)
C. Omitted Industries	C. Omitted Industries
1. G&H Expenditure Table I.4-6[q] for State Operations includes the industrial categories Electric Services, Gas Production and Distribution, Industrial Inorganic and Organic Chemicals, and Explosives. These industries are inexplicably omitted from the G&H I-O model.	1. TMI includes in its State Operations I-O model the industries omitted by G&H.[t]
D. Labor Expenditures	D. Labor Expenditures
1. Deriving the Wage Bills	1. Deriving the Wage Bills
a. The wage bills reported by G&H in Table I.3-6[r] are calculated by multiplying the estimated number of man-years of employment by the estimated average annual salary.	a. In 1982 the average annual salary for construction workers in Pittsylvania County was $12,068[u] (1981 dollars),[v] which is approximately 7.43 percent larger than the figure given by G&H. TMI therefore increased the construction wage bill from G&H's $5,138,000 to $5,520,000.
	b. There is no evidence to support changing the labor expenditures given by Marline for the operations phase of the project.[w]
2. Discrepanciesin the G&H Data	2. Discrepancies in the G&H Data
a. The wage bill reported for regional construction in Marline's I-O Table I.4-7 is $5,148,000; the wage bill reported for state construction in I-O Table I.4-9 is $5,348,000. According to Table I.3-6, however, both should be equal to $5,138,000.	a. TMI has used the correct figure of $5,138,000 (prior to the adjustment decribed in III.D.1.b.) in the construction scenarios of the I-O model.
	i. Tables A.6-A.10 and A.14-A.17 have beeen adjusted for this lower figure by reducing each industry's allocation of labor.

TABLE A.2 (continued)

DETAILS OF THE I-O MODEL AS USED BY THE TAYLOE MURPHY INSTITUTE AND GIBBS AND HILL

Gibbs & Hill	Tayloe Murphy Institute
IV. Deflators	IV. Deflators
A. Since the RIMS II model uses 1972 I-O coefficients, it was necessary to deflate Marline's estimated expenditures, which are reported in 1981 dollars.	A. TMI uses an updated series of BLS deflators which allows the reported expenditures to be directly deflated into 1972 dollars.y/
B. When G&H undertook its analysis of the project in mid 1983, the most current I-O deflators available from the Bureau of Labor Statistics (BLS) were from 1976. G&H therefore seems to have adopted the two-step procedure of deflating the 1981 values back to 1976 dollars with industry deflators from the Bureau of Economic Analysis (BEA), and then deflating these values again with the BLS deflators. That is, the deflators reported in the G&H I-O Tables are equal to a BEA 1981 Deflator (base 1976) times the BLS 1976 Deflator (base 1972).x/	B. Table A.22 compares the TMI deflators with those of G&H.
C. Table A.22 reports the G&H deflators.	

Table A.2 (continued)

DETAILS OF THE I-O AS USED BY TAYLOE MURPHY INSTITUTE AND GIBBS AND HILL

a/ Unpublished printouts from the Bureau of Economic Analysis, provided to the Tayloe Murphy Institute by Gibbs & Hill.

b/ U.S. Department of Commerce, Bureau of Economic Analysis, Regional Analysis Division Regional Input-Output Modeling System, Estimation, Evaluation, and Application of a Disaggregated Regional Impact Model (Washington, D.C.: U.S. Government Printing Office, April 1981): 69.

c/ U.S. Department of Commerce, Bureau of Economic Analysis 1980 OBER Regional Forecasts vol. 8, Region 5, Southeast (Washington, D.C.: U.S. Government Printing Office, July 1981): 180.

d/ Source: photocopy of an annotated worksheet used by Gibbs & Hill.

e/ OBERS: 180.

f/ These exceptions were deduced by the Tayloe Murphy Institute and summarized in a letter of July 3, 1984 from Dr. John Knapp of the Institute to Mr. Joseph Nagy of Gibbs and Hill; they were confirmed in Mr. Nagy's written reply to Dr. Knapp, dated July 13, 1984.

g/ Quoted from Mr. Nagy's letter of July 13.

h/ OBERS: 190.

i/ Mr. Nagy's letter of July 13.

j/ Mr. Nagy's letter of July 13.

k/ See, for example, the employment-earnings ratios reported in the sample I-O Table A.1 for RSA Construction on page 87.

l/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County (October 15, 1983): I.4-16 to I.4-31.

m/ Ibid., I.4-3 to I.4-5, I.4-8 and I.4-10 to I.4-14.

n/ Letter of July 30, 1980 from Mr. John Yellich of Marline Uranium Corporation to Dr. John Knapp of the Tayloe Murphy Institute.

o/ Mr. Yellich's letter of July 30.

p/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation: I.4-3.

q/ Ibid., I.4-13 and I.4-14.

r/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation: I.3-14.

Table A.2 (continued)

DETAILS OF THE I-O AS USED BY TAYLOE MURPHY INSTITUTE AND GIBBS AND HILL

s/ The proportionality assumption was accepted by Mr. John Yellich of Marline Uranium Corporation and Mr.Joseph Nagy of Gibbs and Hill in a telephone conference with John L. Knapp and William T. Smith II, on July 25, 1984.

t/ See the Expenditure Tables for State Operations, A.18--A.21.

u/ Virginia Employment Commission, Covered Employment and Wages (Richmond, 1982).

v/ Deflated with the Consumer Price Index, U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index.

w/ 55 percent of the General and Administrative jobs listed by Marline Uranium Corporation and Union Carbide Corporation (An Evaluation, Table I.3-10, p.I.3-19), were comparable to manufacturing jobs in the RSA. (Jim Heilman, Mary Lynn Dubler, John L. Knapp, and Julia H. Martin. Virginia Occupational Demand, Supply and Wage Information. (Charlottesville, Virginia: Tayloe Murphy Institute, 1983): Table A.6). Averaging those salaries gives a wage bill that is 2.25 percent higher than the wage bill given by Marline for General and Administrative jobs. On the other hand, only 33 perecent of the mining jobs listed by Marline Uranium Corporation and Union Carbide Corporation (An Evaluation, Table I.3-8, p. I.3-16 and Table I.3-9, pp. I.3-16 I.3-18) were comparable to manufacturing jobs in the RSA. Averaging those salaries yields a wage bill that is 8.8 percent lower than the wage bill given by Marline for mine workers. Given the paucity of information and the closeness of the wage bills given the available information, there seems no reason to revise the Gibbs & Hill estimate.

x/ Our discussion of Gibbs & Hill's use of the two-step procedure is based upon a telephone conversation with Ms. Zoe Amargis of the Bureau of Economic Analysis.

y/ U.S. Department of Commerce, Bureau of Labor Statistics. "Time Series Data for Input-Output Industries - Output, Price, and Employment," unpublished printout (May 22, 1984).

TABLE A.3

COMPARISON OF RIMS II INDUSTRY CLASSIFICATIONS AND OBER INDUSTRY CLASSIFICATIONS AS SELECTED BY GIBBS AND HILL AND THE TAYLOE MURPHY INSTITUTE TO GENERATE EMPLOYMENT-EARNINGS MULTIPLIERS

RIMS II Classification	Gibbs and Hill's Choice of OBER Classification	Tayloe Murphy Institute's Choice of OBER Classification
1. Agriculture	Agricultural production	Agricultural production
2. Forestry and fisheries	Agricultural services, forestry and fisheries	Agricultural services, forestry and fisheries
3. Coal mining	Coal mining	Coal mining
4. Petroleum and natural gas mining	Oil and gas extraction	Oil and gas extraction
5. Other mining	Nonmetallic mining excluding fuels	Nonmetallic mining excluding fuels
6. New construction 7. Maintenance and repair	Construction	Construction
8. Food and kindred products	Food and kindred products	Food and kindred products
9. Textiles	Textile mill products	Textile mill products
10. Apparel	Apparel and other fabricated textile products	Apparel and other fabricated textile products
11. Paper	Paper and allied products	Paper and allied products
12. Printing and publishing	Printing and publishing	Printing and publishing
13. Chemicals	Chemicals and allied products	Chemicals and allied products
14. Rubber and leather	Rubber and miscellaneous plastics products	Rubber and miscellaneous plastics products
15. Lumber and furniture	Lumber products excluding furniture and fixtures	Lumber products excluding furniture and fixtures
16. Stone, clay, and glass	Stone, clay and glass products	Stone, clay and glass products
17. Primary metals	Primary metals	Primary metals
18. Fabricated metals	Fabricated metals	Fabricated metals
19. Nonelectrical machinery	Machinery excluding electrical machinery	Machinery excluding electrical machinery
20. Electrical machinery	Electrical machinery	Electrical machinery
21. Motor vehicles	Motor vehicles and equipment	Motor vehicles and equipment
22. Other transporation equipment	Transportation equipment excluding motor vehicles	Transporation equipment excluding motor vehicles
23. Instruments	Instruments	Instruments
24. Miscellaneous manufacturing	Miscellaneous manufacturing	Miscellaneous manufacturing
25. Transportation 26. Communication 27. Utilities	Transportation, communication, and utilities	Transporation, communication and utilities

TABLE A.3 (continued)

COMPARISON OF RIMS II INDUSTRY CLASSIFICATIONS AND OBER INDUSTRY CLASSIFICATIONS AS SELECTED BY GIBBS AND HILL AND THE TAYLOE MURPHY INSTITUTE TO GENERATE EMPLOYMENT-EARNINGS MULTIPLIERS

RIMS II Classification	Gibbs and Hill's Choice of OBER Classification	Tayloe Murphy Institute's Choice of OBER Classification
28. Wholesale trade	Wholesale trade	Wholesale trade
29. Retail trade 30. Eating and drinking establishments	Retail trade	Retail trade
31. Finance 32. Insurance 33. Real estate	Finance, insurance and real estate	Finance, insurance and real estate
34. Lodging and amusement	Hotels and other lodging places	Hotels and other lodging places
35. Personal services 36. Business services	Personal and miscellaneous business and repair services	Personal and miscellaneous business and repair services
37. Health services	Medical and other health services	Medical and other health services
38. Other services	Services	Services (minus hotels and other lodging places, personal and miscellaneous business and repair services, medical and other health services
39. Household	Private household	Private household

Source: Bureau of Economic Analysis, Regional Economic Analysis Division, Regional Input-Output Modeling System, Estimation, Evaluation, and Application of a Disaggregated Regional Impact Model, April 1981, p. 69; and Bureau of Economic Analysis, 1980 OBERS BEA Regional Projections, vol. 8, region 5, Southeast, July 1981, p. 180.

TABLE A.4

EMPLOYMENT-EARNINGS RATIOS, GIBBS AND HILL VS. TAYLOE MURPHY INSTITUTE--VIRGINIA

Industry	Gibbs & Hill[a]	Tayloe Murphy Institute[b]
1. Agricultural Products & Services	.1432	.1434
2. Forestry and Fishery Products	.1746	.1751
3. Coal Mining	.0548	.0548
4. Crude Petroleum and Natural Gas	.0896	.0459
5. Other Mining	.0896	.0899
6. New Construction	.1020	.1020
7. Maintenance and Repair Construction	.1020	.1020
8. Food and Kindred Products Tobacco	.0631	.1082
9. Textile Mill Products	.1189	.1190
10. Apparel	.1865	.1860
11. Paper and Allied Products	.0700	.0693
12. Printing and Publishing	.1037	.1050
13. Chemicals and Refined Petroleum	.0693	.0693
14. Rubber and Leather Products	.0868	.0867
15. Lumber and Furniture Products	.1145	.1135

TABLE A.4 (continued)

EMPLOYMENT-EARNINGS RATIOS, GIBBS AND HILL VS. TAYLOE MURPHY INSTITUTE--VIRGINIA

	Industry	Gibbs & Hill[a/]	Tayloe Murphy Institute[b/]
16.	Stone, Clay, and Glass Products	.0885	.0884
17.	Primary Metals	.0612	.0621
18.	Fabricated Metals	.0793	.0792
19.	Non-electrical Machinery	.0837	.0838
20.	Electrical Machinery	.0820	.0820
21.	Motor Vehicles and Equipment	.0603	.0605
22.	Other Transportation Equipment	.0757	.0751
23.	Instruments	.1075	.1083
24.	Miscellaneous Manufacturing	.1292	.1298
25.	Trns., Loc. Gov't Transt, Post.	.0676	.0677
26.	Communication	.0676	.0677
27.	Utilities	.0676	.0677
28.	Wholesale Trade	.0853	.0853
29.	Retail Trade	.1684	.1683
30.	Eating and Drinking Establishments	.1684	.1683
31.	Finance	.0782	.1030
32.	Insurance	.0782	.0790
33,	Real Estate	.0782	.1288
34.	Lodging and Amusements	.2185	.2181

TABLE A.4 (continued)

EMPLOYMENT-EARNINGS RATIOS, GIBBS AND HILL VS. TAYLOE MURPHY INSTITUTE--VIRGINIA

Industry		Gibbs & Hill[a/]	Tayloe Murphy Institute[b/]
35.	Personal Services	.1267	.1266
36.	Business Services	.0967	.0967
37.	Health Services	.0967	.0967
38.	Other Services	.1250	.1176
39.	Households	.3375	.3371

a/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County (October 1983), Table I.4-9, pp. I.4-22 to I.4-24.

b/ Calculated from data in U.S. Department of Commerce, Bureau of Economic Analysis, 1980 OBERS BEA Regional Projections (July 1981), Tables 3 and 4, pp. 180-181.

TABLE A.5

EMPLOYMENT-EARNINGS RATIOS, GIBBS AND HILL VS. TAYLOE MURPHY INSTITUTE--REGIONAL STUDY AREA

	Industry	Gibbs & Hill[a/]	Tayloe Murphy Institute
1.	Agricultural Products & Services	.1432	.1383
2.	Forestry and Fishery Products	.1746	.1538
3.	Coal Mining	.0548	.0481
4.	Crude Petroleum and Natural Gas	.0896	.0403
5.	Other Mining	.0896	.0790
6.	New Construction	.1189	.0896
7.	Maintenance and Repair Construction	.1189	.0896
8.	Food and Kindred Products Tobacco	.0712	.1219
9.	Textile Mill Products	.1341	.1341
10.	Apparel	.2104	.2096
11.	Paper and Allied Products	.0790	.0781
12.	Printing and Publishing	.1170	.1183
13.	Chemicals and Refined Petroleum	.0782	.0781
14.	Rubber and Leather Products	.0979	.0977
15.	Lumber and Furniture Products	.1292	.1279

TABLE A.5 (continued)

EMPLOYMENT-EARNINGS RATIOS, GIBBS AND HILL VS. TAYLOE MURPHY INSTITUTE--REGIONAL STUDY AREA

Industry		Gibbs & Hill[a/]	Tayloe Murphy Institute
16.	Stone, Clay and Glass Products	.0998	.0996
17.	Primary Metals	.0690	.0700
18.	Fabricated Metals	.0895	.0893
19.	Non-electrical Machinery	.0944	.0944
20.	Electrical Machinery	.0925	.0924
21.	Motor Vehicles and Equipment	.0680	.0682
22.	Other Transportation Equipment	.0847	.0846
23.	Instruments	.1213	.1221
24.	Miscellaneous Manufacturing	.1457	.1463
25.	Trns., Loc. Gov't Transt, Post.	.0763	.0595
26.	Communication	.0763	.0595
27.	Utilities	.0763	.0595
28.	Wholesale Trade	.0962	.0748
29.	Retail Trade	.1845	.1847
30.	Eating and Drinking Establishments	.1845	.1847
31.	Finance	.1019	.0905
32.	Insurance	.1019	.0694
33.	Real Estate	.1019	.1131
34.	Lodging and Amusements	.2465	.1916

TABLE A.5 (continued)

EMPLOYMENT-EARNINGS RATIOS, GIBBS AND HILL VS. TAYLOE MURPHY INSTITUTE--
REGIONAL STUDY AREA

	Industry	Gibbs & Hill[a/]	Tayloe Murphy Institute
35.	Personal Services	.1429	.1112
36.	Business Services	.1429	.0849
37.	Health Services	.1091	.0849
38.	Other Services	.1410	.1033
39.	Households	.3807	.2961

a/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County (October 1983), Table I.4-7, pp. I.4-16 to I.4-18.

TABLE A.6

ALLOCATION OF CONSTRUCTION EXPENDITURES DURING THE CONSTRUCTION PHASE--REGIONAL STUDY AREA

Marline Classification	Total Allocation	% Allocation	Industry Classification	Allocation
Mill Process Equip.	$ 279,000	100%	Wholesale Trade	$ 279,000
Plant Concrete and Excavation	7,552,000	26	Labor	1,989,000
		39	Stone and Clay Mining and Quarrying	2,968,000
		35	Ready-mixed Concrete	2,597,000
Building, Structural Painting	1,532,000	64	Labor	982,000
		36	Wholesale Trade	550,000
Electrical	1,274,000	70	Labor	897,000
		30	Wholesale Trade	377,000
Instrumentation	110,000	70	Labor	77,000
		30	Wholesale Trade	33,000
Site Preparation	1,182,000	92	Labor	1,081,000
		8	Wholesale Trade	101,000
Piping	770,000	64	Labor	494,000
		36	Wholesale Trade	276,000
Indirect Costs	2,891,000	82	Miscellaneous Professional Services	2,371,000
		18	Real Estate	520,000
Mobile Equipment	123,000	100	Wholesale Trade	123,000
Open Pit Mine Equip.	2,550,000	100	Wholesale Trade	2,550,000
Total	$18,265,000		Total	$18,265,000

Source: Marline-Umetco Table I.4-2 with adjustments by TMI.

TABLE A.7

SUMMARY OF THE ALLOCATION OF CONSTRUCTION EXPENDITURES DURING THE CONSTRUCTION PHASE--REGIONAL STUDY AREA

Industry Classification	Allocation
Wholesale Trade	$ 4,289,000
Labor	5,520,000
Stone and Clay Mining and Quarrying	2,968,000
Ready-mixed Concrete	2,597,000
Miscellaneous Professional Services	2,371,000
Real Estate	520,000
Total	$18,265,000

Source: Marline-Umetco Table I.4-2 with adjustments by TMI.

TABLE A.8

ALLOCATION OF TAILINGS MANAGEMENT EXPENDITURES DURING THE CONSTRUCTION PHASE--REGIONAL STUDY AREA

Industry Classification	Allocation
Wholesale Trade	$2,330,000
Labor	687,000
Stone and Clay Mining and Quarrying	1,613,000
Ready-Mixed Concrete	1,411,000
Miscellaneous Professional Services	1,288,000
Real Estate	282,000
Total	$7,611,000

Source: Marline-Umetco Table I.4-2 and letter from John A Yellich to John L. Knapp, July 30,1984.

TABLE A.9

SUMMARY OF THE ALLOCATION OF CONSTRUCTION AND TAILINGS MANAGEMENT EXPENDITURES DURING THE CONSTRUCTION PHASE--REGIONAL STUDY AREA a/

Industry Classification	Allocation
Wholesale Trade	$ 6,619,000
Labor	6,207,000
Stone and Clay Mining and Quarrying	4,581,000
Ready-mixed Concrete	4,008,000
Miscellaneous Professional Services	3,659,000
Real Estate	802,000
Total	$25,876,000

Source: Tables A.6, A.7 and A.8.

a/ This Table is also shown as Table 2.2 in the text.

TABLE A.10

ALLOCATION OF ANNUAL OPERATING EXPENDITURES DURING THE OPERATIONS PHASE--REGIONAL STUDY AREA

Marline Classification	Total Allocation	% Allo- cation	Industry Classification	Allocation
Labor	$5,920,000	100%	Labor	$5,920,000
Diesel Fuel, Gas- oline, Lubricants	599,000	100	Wholesale Trade	599,000
Maintenance/Repair, Parts	339,000	100	Wholesale Trade	339,000
Electricity	671,000	100	Electrical Services	671,000
Natural Gas	1,264,000	100	Gas Production and Distribution	1,264,000
Office Supplies, Rental, Leases	144,000	100	Real Estate	144,000
Replacement Capital Costs	53,000	100	Wholesale Trade	53,000
Mine/Mill Operating	18,000	100	Wholesale Trade	18,000
Total	$9,008,000		Total	$9,008,000

Source: Marline-Umetco Table I.4-4 with adjustments by TMI.

TABLE A.11

SUMMARY OF THE ALLOCATION OF ANNUAL OPERATING EXPENDITURES DURING THE OPERATIONS PHASE--REGIONAL STUDY AREA

Industry Classification	Allocation
Wholesale Trade	$1,009,000
Labor	5,920,000
Electrical Services	671,000
Gas Production and Distribution	1,264,000
Real Estate	144,000
Total	$9,008,000

Source: Marline-Umetco Table I.4-4 with adjustments by TMI.

TABLE A.12

ALLOCATION OF TAILINGS MANAGEMENT EXPENDITURES DURING THE OPERATIONS PHASE--REGIONAL STUDY AREA

Industry Classification	Allocation
Wholesale Trade	$ 548,000
Labor	192,000
Stone and Clay Mining and Quarrying	379,000
Ready-Mixed Concrete	332,000
Miscellaneous Professional Services	303,000
Real Estate	66,000
Total	$1,820,000

Source: Marline-Umetco Table I.4-4 and letter from John A. Yellich to John L. Knapp, July,30,1984.

TABLE A.13

SUMMARY OF THE ALLOCATION OF ANNUAL OPERATING AND TAILINGS MANAGEMENT EXPENDITURES DURING THE OPERATIONS PHASE--REGIONAL STUDY AREA a/

Industry Classification	Allocation
Wholesale Trade	$ 1,557,000
Labor	6,112,000
Stone and Clay Mining and Quarrying	379,000
Ready-Mixed Concrete	332,000
Electrical Services	671,000
Gas Production and Distribution	1,264,000
Miscellaneous Professional Services	303,000
Real Estate	210,000
Total	$10,828,000

Source: Tables A.10, A.11, and A.12.

a/ This table is also shown as Table 2.3 in the text.

TABLE A.14

ALLOCATION OF CONSTRUCTION EXPENDITURES DURING THE CONSTRUCTION PHASE--VIRGINIA

Marline Classification	Total Allocation	% Allo- cation	Industry Classification	Allocation
Mill Process Equip.	$ 834,000	100%	Wholesale Trade	$ 834,000
Plant Concrete and Excavation	7,480,000	26	Labor	1,915,000
		40	Stone and Clay Mining and Quarrying	2,968,000
		34	Ready-mixed Concrete	2,597,000
Building, Structural Painting	6,959,000	13	Labor	945,000
		11	Paints and Allied Products	752,000
		76	Concrete Block and Brick	5,262,000
Electrical	2,721,000	32	Labor	864,000
		68	Electrical Industrial Apparatus	1,857,000
Instrumentation	683,000	11	Labor	74,000
		89	Electrical Industrial Apparatus	609,000
Site Preparation	1,919,000	65	Labor	1,247,000
		35	Gas Production and Distribution	672,000
Piping	3,695,000	13	Labor	475,000
		87	Pipes, Valves, and Pipe Fittings	3,220,000

TABLE A.14 (continued)

ALLOCATION OF CONSTRUCTION EXPENDITURES DURING THE CONSTRUCTION PHASE--VIRGINIA

Marline Classification	Total Allocation	% Allo-cation	Industry Classification	Allocation
Indirect Costs	7,282,000	90	Miscellaneous Professional Services	6,589,000
		10	Real Estate	693,000
Mobile Equipment	123,000	100	Wholesale Trade	123,000
Open-pit Mine Equip.	8,590,000	50	Construction Machinery and Equipment	4,295,000
		50	Mining Machinery	4,295,000
Total	$40,286,000		Total	$40,286,000

Source: Marline-Umetco Table I.4-5 with adjustments by TMI.

TABLE A.15

SUMMARY OF THE ALLOCATION OF CONSTRUCTION EXPENDITURES DURING THE CONSTRUCTION PHASE--VIRGINIA

Industry Classification	Allocation
Wholesale Trade	$ 957,000
Labor	5,520,000
Stone and Clay Mining and Quarrying	2,968,000
Ready-Mixed Concrete	2,597,000
Paints and Allied Products	752,000
Concrete Block and Brick	5,262,000
Electrical Industrial Apparatus	2,466,000
Gas Production and Distribution	672,000
Pipes, Values, and Pipe Fittings	3,220,000
Miscellaneous Professional Services	6,589,000
Real Estate	693,000
Construction Machinery and Equipment	4,295,000
Mining Machinery	4,295,000
Total	$40,286,000

Source: Marline-Umetco Table I.4-5 with adjustments by TMI.

TABLE A.16

ALLOCATION OF TAILINGS MANAGEMENT EXPENDITURES DURING THE CONSTRUCTION PHASE--VIRGINIA

Industry Classification	Allocation
Wholesale Trade	$ 194,000
Labor	687,000
Stone and Clay Mining and Quarrying	601,000
Ready-mixed Concrete	526,000
Paint and Allied Products	152,000
Concrete Blocks and Brick	1,066,000
Electrical Industrial Apparatus	499,000
Gas Production and Distribution	136,000
Pipes, Values, and Pipe Fittings	652,000
Miscellaneous Professional Services	1,335,000
Real Estate	140,000
Construction Machinery and Equipment	871,000
Mining Machinery	871,000
Total	$7,730,000

Source: Marline-Umetco Table I.4-5 and letter from John A. Yellich to John L. Knapp, July,30,1984.

TABLE A.17

SUMMARY OF THE ALLOCATION OF CONSTRUCTION AND TAILINGS MANAGEMENT EXPENDITURES DURING THE CONSTRUCTION PHASE--VIRGINIA[a/]

Industry Classification	Allocation
Wholesale Trade	$ 1,151,000
Labor	6,207,000
Stone and Clay Mining and Quarrying	3,569,000
Ready-mixed Concrete	3,123,000
Paints and Allied Products	904,000
Concrete Block and Brick	6,328,000
Electrical Industrial Apparatus	2,965,000
Gas Production and Distribution	808,000
Pipes, Values, and Pipe Fittings	3,872,000
Miscellaneous Professional Services	7,924,000
Real Estate	833,000
Construction Machinery and Equipment	5,166,000
Mining Machinery	5,166,000
Total	$48,016,000

Source: Tables A.14, A.15, and A.16.

a/ This table is also shown as Table 2.4 in the text.

TABLE A.18

ALLOCATION OF ANNUAL OPERATING EXPENDITURES DURING THE OPERATIONS PHASE--VIRGINIA

Marline Classification	Total Allocation	% Allo-cation	Industry Classification	Allocation
Labor	$ 5,920,000	100%	Labor	$ 5,920,000
Diesel Fuel, Gasoline, Lubricants	3,991,000	100	Gas Production and Distribution	3,991,000
Maintenance/Repair Parts	695,000	100	Wholesale Trade	695,000
Electricity	671,000	100	Electrical Services	671,000
Natural Gas	1,264,000	100	Gas Production and Distribution	1,264,000
Office Supplies, Rentals, Leases	144,000	100	Real Estate	144,000
Chemicals	3,020,000	60	Industrial Inorganic and Organic Chemicals	1,812,000
		40	Explosives	1,208,000
Replacement Capital Costs	53,000	100	Wholesale Trade	53,000
Mine/Mill Operating Supplies	18,000	100	Wholesale Trade	18,000
Total	$15,776,000		Total	$15,776,000

Source: Marline-Umetco Table I.4-6 with adjustments by TMI.

TABLE A.19

SUMMARY OF THE ALLOCATION OF ANNUAL OPERATING EXPENDITURES DURING THE OPERATIONS PHASE--VIRGINIA

Industry Classification	Allocation
Wholesale Trade	$ 766,000
Labor	5,920,000
Electrical Services	671,000
Gas Production and Distribution	5,255,000
Real Estate	144,000
Industrial Inorganic and Organic Chemicals	1,812,000
Explosives	1,208,000
Total	$15,776,000

Source: Marline-Umetco Table I.4-6 with adjustments by TMI.

TABLE A.20

ALLOCATION OF TAILINGS MANAGEMENT EXPENDITURES DURING THE OPERATIONS PHASE--VIRGINIA

Industry Classification	Allocation
Wholesale Trade	$ 72,000
Labor	192,000
Stone and Clay Mining and Quarrying	224,000
Ready-mixed Concrete	196,000
Paint and Allied Products	57,000
Concrete Block and Brick	398,000
Electrical Industrial Apparatus	186,000
Gas Production and Distribution	52,000
Pipes, Values, and Pipe Fittings	243,000
Miscellaneous Professional Services	498,000
Real Estate	52,000
Construction Machinery and Equipment	325,000
Mining Machinery	325,000
Total	$2,820,000

Source: Marline-Umetco Table I.4-6 and letter from John A. Yellich to John L. Knapp July 30,1984.

TABLE A.21

SUMMARY OF THE ALLOCATION OF ANNUAL OPERATING AND TAILINGS MANAGEMENT EXPENDITURES DURING THE OPERATIONS PHASE--VIRGINIA[a/]

Industry Classification	Allocation
Wholesale Trade	$ 838,000
Labor	6,112,000
Stone and Clay Mining and Quarrying	224,000
Ready-mixed Concrete	196,000
Paint and Allied Products	57,000
Concrete Block and Brick	398,000
Electrical Services	671,000
Electrical Industrial Appliances	186,000
Gas Production and Distribution	5,307,000
Pipes, Value, and Pipe Fittings	243,000
Miscellaneous Professional Services	498,000
Real Estate	196,000
Industrial Inorganic and Organic Chemicals	1,812,000
Explosives	1,208,000
Construction Machinery and Equipment	325,000
Mining Machinery	325,000
Total	$18,596,000

Source: Tables A.18, A.19, and A.20.

a/ This table is also shown as Table 2.5 in the text.

TABLE A.22

DEFLATORS USED BY TAYLOE MURPHY INSTITUTE AND GIBBS AND HILL IN THE I-O MODEL

Category of Final Demand	Gibbs and Hill[a/]	Tayloe Murphy Institute[b/]
Wholesale Trade	2.05	1.957
Personal Consumption	1.96	2.121
Stone and Clay Mining and Quarrying	1.64	1.687
Ready-mixed Concrete	2.09	2.790
Paint and Allied Products	2.01	1.790
Concrete Block and Brick	2.06	2.328
Electrical Services	2.70	2.519
Electrical and Industrial Appliances	2.07	2.324
Gas Production and Distribution	2.86	3.666
Petroleum Refining	6.80	6.829
Pipes, Values, and Pipe Fittings	2.42	2.136
Miscellaneous Professional Services	1.92	1.860
Real Estate	1.80	1.813
Industrial Inorganic Chemicals	...	3.648
Explosives	...	2.434
Construction Machinery	1.92	2.647
Mining Machinery[c/]	...	2.647
Tobacco	...	1.949

a/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County, October 15, 1983, Table I.4-7 through I.4-10.

b/ U.S. Department of Labor, Bureau of Labor Statistics, "Time Series Data for Input-Output Industries-Output, Price, and Employment," unpublished printout, May 22, 1984.

c/ Marline does not include mining machinery, tobacco, industrial inorganic chemicals, or explosives as categories of final demand in the I-O tables, and hence reports no deflators for them.

APPENDIX B

BASE ANALYSIS

INTRODUCTION

Economic base theory separates a local economy into two sectors--the basic and nonbasic sectors. Those activities associated with providing goods and services to consumers located outside the local economy comprise the basic sector; conversely, those associated with providing goods and services to consumers located within the local economy comprise the nonbasic sector. The theory postulates that growth in the basic sector stimulates growth in the nonbasic sector.

This approach considers a local economy to be open, in the sense that resources flow into and out of the economy. Raw materials, food, services, and manufactured products that the locality does not produce itself are imported. Goods and services that the locality produces in excess of local demand are exported. Consequently, the basic sector provides the means to pay for the area's imports and supports the nonbasic sector.

The primary purpose of basic sector analysis is to understand how economic activities at the local level interact and affect the economic well-being of the area. Particularly applicable to this study, base analysis can help to assess a new firm's impact on the economy.

It is assumed that there is a relationship between the basic sector and the total economy that can be measured. The basic/nonbasic relationship is represented in the multiplier, which is the ratio of total economic activity to basic sector activity. Not only can the relationship be measured but it is assumed that the relationship does not change much over time or that the rate of change is predictable. Local economic activity can be analyzed using various units of measure; two of the most common are employment and income, popular because of their ready availability and relatively detailed geographic breakdown.

TYPES OF MULTIPLIER

The aggregate multiplier is defined as the ratio of total economic activity to basic sector activity.

$$\text{Aggregate multiplier} = \frac{\text{Total Employment}}{\text{Basic Employment}}$$

The aggregate multiplier provides a picture of the total/basic relationship at a particular point in time.

The marginal multiplier is computed in the same way as the aggregate multiplier but relates <u>changes</u> in total or nonbasic employment to

<u>changes</u> in basic employment. It attempts to measure the changes taking place in the total-basic relationship over time. Because the marginal multiplier is estimated for changes over a span of time, it reflects trends in the total-basic relationship that develop during a time period.

Differential multipliers are derived through analysis of the relationship between total economic activity and the various components of basic sector activity, such as manufacturing. For example, these multipliers can relate the change in total employment to changes in a subset of basic employment over a period of time. Differential multipliers enable the user to separate the effects of different subsectors, such as manufacturing, and measure a specific multiplier for each subsector making up the basic sector.

At any point in time, it may not be possible to observe or measure the relationship between the basic and nonbasic sectors. The economy does not instantaneously respond to changes in the basic sector. Therefore, since employment and earnings in the basic sector continually alter, the true basic-nonbasic relationship may never be observed because adjustments are always in process.

The most readily available data can also give a distorted view of the relationship between the basic and the nonbasic sectors. For example, employment may be too crude a measure to pick up all changes in economic activity. Employment data only indicate if a job exists; they do not show if the facilities and employees are being utilized at full capacity. If, however, the nonbasic firms are operating at less than worker capacity, an increase in basic employment could similarly affect the nonbasic sector's level of operation and yet not be accurately depicted by employment data or multipliers.

Employment statistics do not capture all economic activity that is basic to the local economy. For example, unemployed workers may decrease their demand for goods and services, but continue consuming due to society's system of transfer payments such as unemployment compensation, welfare payments, and food stamps. Transfer payments affect the local economy in the same way as basic sector jobs; the person who receives either a job or a transfer payment demands and consumes local goods and services, thereby creating nonbasic jobs. In our model, we take transfer payments into consideration.

Because each industry affects the economy differently, using a multiplier for the entire basic sector could yield erroneous results when forecasting economic growth arising from developments in a particular industry. We would have liked to derive differential multipliers to determine the effects of a uranium mine and mill on the economy of the RSA but were unable to for two reasons. First, the few firms classified as mining in the RSA are unlike uranium mining. Multipliers derived for mining based on these firms would not be representative of the effect of the proposed uranium mine and mill. Second, there were insufficient data to solve the problem of multicollinearity among the explanatory

explanatory variables.[1] Multicollinearity occurs when data for individual sectors are so interrelated that individual trends cannot be separated. Therefore, we combine the individual sectors to derive marginal multipliers for the RSA.

SOURCE OF DATA

The Bureau of Economic Analysis, U.S. Department of Commerce, published the employment and earnings data used to derive the multiplier. Annual data by county and independent city are reported by broad industrial sector. We use 1969-1981 proprietors' and laborers' employment data and 1965-1981 earnings data. We classify firms in the RSA as basic or nonbasic according to their four digit Standard Industrial Classification (SIC) code, previous base analyses conducted by the Department of Planning and Budget, and conversations with local businesses and institutions. Total employment in agriculture, mining, and state and local government, and a portion of employment in manufacturing, transportation and public utilities, retail trade, and services are allocated to the basic sector. To control for the impact of transfer payments on total employment, we include transfer payments as part of the basic sector.[2]

ALLOCATION OF DATA

1. Farm (proprietor and nonproprietor): We classify all farm employment as basic sector employment. Some farm employment may serve the RSA; however, information is not available to allow detection of nonbasic farm employment.

2. Mining: The limited mining that occurs in the RSA is unlike uranium mining. According to the major employer, a producer of crushed and broken limestone, most of the product is consumed within the RSA. Therefore, we classify mining as nonbasic.

3. Federal Government, Civilian: We allocate all federal civilian government with the exception of the postal service to the basic sector.

4. Federal Government, Military: We classify all military as basic.

5. State and Local Government: We allocate state and local government to the nonbasic sector. Available information shows that governmental institutions and agencies provide services only within the local area.

1/ Using the test derived by D. Farrar and R. Glauber, severe multiple and bivariate correlations between the employment of the individual sectors indicated multicollinearity.

2/ Employment and some categories of transfer payments are determined together. Therefore, there is a simultaneity problem that is corrected by using a regression technique called two stage least squares.

6. Agricultural Services: Based on four digit SIC codes, we classify agricultural services as nonbasic.

7. Construction: We allocate construction to the nonbasic sector.

8. Transportation and Public Utilities: We divide transportation and public utilities between the basic and nonbasic sectors. The Virginia Electric and Power Company office located in South Boston serves as a regional office. Based on the proportion of total customers served who reside outside the RSA, we allocate part of that office to the basic sector.

9. Wholesale Trade: We classify wholesale trade as nonbasic.

10. Retail Trade: We divide retail trade employment between the basic and nonbasic sectors. The base study conducted by the Department of Planning and Budget classified Danville-Pittsylvania as a regional shopping area and allocated 5 percent of retail trade as basic. Since our base analysis considers the RSA local economy rather than Danville-Pittsylvania, we allocate only 2.5 percent of retail trade in the Danville-Pittsylvania area to the basic sector.

11. Finance, Insurance and Real Estate: Finance, insurance, and real estate employment serve only the RSA, and we classify them as nonbasic.

12. Services: We divide services employment between the basic and nonbasic sectors. We consider service categories such as hotels and other lodging places, and museums and art galleries as basic. We allocate health services and residential care social services to the basic sector based on the number of patients/residents originating from outside the RSA.

13. Manufacturing: We classify all manufacturing with the exception of newspaper publishing as basic.

REGIONAL MULTIPLIERS

Employment

Total employment (EMPLOYt) is regressed on total basic sector employment (BASEt) and transfer payments (TRANSt).1/ The results are:

1/ "Regression analysis may be broadly defined as the analysis of relationships among variables. It is one of the most widely used statistical tools because it provides a simple method for establishing a functional relationship among variables." See Samprit Chatterjee and Bertram Price, Regression Analysis by Example (New York: John Wiley & Sons, 1977), p.1. In this study, employment is "regressed on" basic sector employment and transfer payments in order to estimate how much of the variation in employment can be explained by changes in these two variables. Note the explanation of the regression results in the following paragraphs.

EMPLOYt = 8323 + 1.51BASEt + 0.107TRANSt
(0.88) (5.15) (6.21)

Adjusted R^2 = 0.905
F-Statistic = 58.25
DW = 1.37[1/]

The equation and the coefficients of BASEt and TRANSt are significant at the 99 percent level. T-statistics are in parentheses.

The estimated employment multiplier, the coefficient on basic employment, is 1.51. That means there are approximately 1.5 total jobs in the economy for every job in the basic sector. Thus, every two jobs in the basic sector support one job in the nonbasic sector. According to this multiplier, if Marline-Umetco employs 305 people during construction, approximately 152 additional jobs in the RSA nonbasic sector will be created for a total employment of 457. If Marline-Umetco employs 468 during operations, an additional 234 jobs will be supported for a total employment of 702.

Earnings[2/]

Total earnings (EARNt) are regressed on total basic sector earnings which includes transfer earnings (BASEt). The results are:

EARNt = 18649 + 1.43BASEt
(3.77) (94.77)

Adjusted R-2 = 0.998
F-Statistic = 8982.23
DW = 1.14[3/]

Both the coefficient and the equation are significant at the 99 percent level. T-statistics are in parentheses.

1/ The value of the Durbin-Watson statistic (1.37) is above the upper bound at the .01 significance level, but within the standard bounds at the .05 level. The Cochrane-Orcutt iterative technique is employed to correct for (first order) serial correlation. The estimated coefficient on the lagged disturbance term is not significantly different from zero, and therefore the final regression is run without any correction factor.

2/ The Marline-Umetco report only estimated wages and salaries, not earnings. However, earnings are primarily composed of wages and salaries.

3/ The value of the Durbin-Watson statistic (1.14) is above the upper bound at the .01 significance level, but within the standard bounds at the .05 level. As with the employment equation, the Cochrane-Orcutt iterative technique is employed to correct for (first order) serial correlation. The estimated coefficient on the lagged disturbance term is not significantly different from zero, and so again the final regression is run without any correction factor.

The estimated earnings multiplier, which is the coefficient on earnings, is 1.43. It indicates that every dollar increase in basic sector earnings (including transfer payments) generates $1.43 in total earnings, and $0.43 in nonbasic sector earnings.

This multiplier, which is a pure earnings multiplier, is not analogous to the multiplier in the RIMS II model, which is an earnings-expenditure multiplier. If Marline-Umetco workers earn $6,207,000 during construction, additional earnings of $2,669,000 would be generated in the RSA, for a total of $8,876,000 in earnings attributable to construction of the proposed uranium mine and mill. Earnings of $6,117,000 during operations would lead to additional earnings of $2,630,000 for a total of $8,747,000 in earnings attributable to the Swanson site.

STATE MULTIPLIERS[1/]

Employment

The state multipliers are estimated analogously to the regional multipliers. The multiplier for total basic sector employment (the coefficient of total basic employment) is 2.57. An increase in basic employment results in an increase in total employment 2.57 times as great. At the state level, an increase in 305 jobs during construction leads to 783 total jobs statewide. During operations, the expected 468 jobs leads to 1,203 total jobs statewide.

At the state level, data are available to allow an estimate for differential multipliers. The differential multiplier for mining does not completely relate to the proposed project because mining in Virginia is mostly coal mining. However, if the coefficient for mining, 2.38, is taken as a proxy, then an increase of 468 jobs during operations will lead to an increase of 1,114 jobs for the state. A differential multiplier for construction was not estimated; therefore, we only give figures for operations.

Earnings

As previously noted, this multiplier is a pure earnings multiplier and not analogous to the RIMS II earnings-expenditure multipliers. The earnings multiplier, estimated from regressing total earnings on total basic sector earnings,including transfer payments, is 1.71. Thus, earnings of $6,207,000 during construction would result in total earnings for the state of $10,614,000; earnings of $6,117,000 during operations would result in total earnings of $10,460,000.

1/ State multipliers were estimated by Philip J. Grossman and taken from his publication, Economic Base Analysis: Theory and Application, (Charlottesville, VA: Tayloe Murphy Institute, June 1984).

Regressing total earnings on basic earnings for each basic industry results in a differential multiplier of 2.79 for the mining sector. Earnings of $6,117,000 during operations would result in earnings of $17,066,000. A differential multiplier for construction was not estimated; therefore, we only give figures for operations.

The Tables below summarize our results.

TABLE B.1

ESTIMATED INCREASES IN EARNINGS[a/] FROM THE SWANSON PROJECT, BASED ON ECONOMIC BASE THEORY

	Multiplier	Earnings
RSA Construction	1.43	$ 8,876,000
State Construction	1.71	10,614,000
RSA Operations	1.43	8,747,000
State Operations	1.71	10,460,000
State Operations[b/]	2.79	17,066,000

a/ In 1981 dollars.

b/ As noted in the text, two multipliers were derived at the state level. This multiplier is a differential multiplier.

TABLE B.2

ESTIMATED INCREASES IN EMPLOYMENT[a/] FROM THE SWANSON PROJECT, BASED ON ECONOMIC BASE THEORY

	Multipliers	Employment
RSA Construction	1.51	457
State Construction	2.57	783
RSA Operations	1.51	702
State Operations	2.57	1,203
State Operations[b/]	2.38	1,114

a/ Average number of jobs at an annual rate.

b/ As noted in the text, two multipliers were derived at the state level. This multiplier is a differential multiplier.

APPENDIX C

EFFECTS OF THE SWANSON PROJECT ON LOCAL PROPERTY VALUES

The economics profession has long recognized that many investment projects have effects on others that are not felt by those involved in the project. Such effects, referred to as externalities or spillovers, may be beneficial, positive externalities, or harmful, negative externalities. One of our tasks is to identify externalities and include an estimate of their value in the study. Often, a precise dollar valuation of externalities is not possible. In such situations, we identify and discuss the relative importance of such externalities.

An externality can affect either the consumption opportunities of individuals or the production possibilities of firms. If it affects individuals' consumption opportunities, then the satisfaction individuals receive from consumption will either be enhanced, if it is a positive externality, or decreased, if a negative externality. If it affects the production possibilities of firms, then the output that firms can produce from a given quantity of inputs is changed; positive externalities increase while negative externalities decrease the quantity of output that can be produced.

In competitive markets, the amount a resource contributes to output determines the price firms are willing to pay for it. The greater the contribution to output, the more a firm is willing to pay for the use of a resource. Because the presence of negative externalities reduces their productivity, firms will not be willing to pay as much for resources when such externalities are present. In some cases, resources can be transferred so that the externality can be avoided. Take, for example, a farm located near a newly opened coal-fired power plant. Assume that the emission of sulfur compounds from the smoke stack reduces crop yields. It is relatively inexpensive to transfer some resources such as fertilizer, machinery, and labor to another location not affected by the sulfur compounds. We would not expect their value to fall very much because these resources are readily moved and can be expected to be nearly as productive in the new location as in the previous one.

Unlike fertilizer and machinery, some resources are not easily moved from one location to another. The most obvious example of such a resource is land, which is immobile. While it can be transferred between uses readily, land cannot be transferred between locations. To return to the example of the farm, the land used for the farm is a resource that cannot be transferred to a new location. Because of the sulfur compounds emitted by the power plant, crop yields are reduced. Therefore, the amount farmers are willing to pay for the use of this land falls because it is not as productive as it had been. In this example, the presence of a negative externality caused the value of agricultural property to fall because of a reduction in the productivity of the land. More generally, since land is an immobile resource, any externality that affects its flow of services, either in consumption or production, also causes a change in its value.

For more than 20 years, economists have been studying the relation between externalities and property values. Most of these efforts have focused on the effect of negative externalities, particularly air and noise pollution, on residential property values. As might be expected in studying an issue this complex, researchers have had difficulty isolating the effect of externalities from other factors that determine residential property values, but they have found statistically significant changes in property values attributable to negative externalities. The magnitude of these effects varies widely for reasons listed below:

1. Differences in the geographical area studied: Researchers have studied a wide variety of locations. These include large metropolitan areas such as Washington, D.C.,1/ surburban areas within large metropolitan areas such as Winnetka, Illinois (a suburb of Chicago),2/ and small towns such as Toledo, Oregon.3/

2. Differences in the externality studied: As mentioned above, most studies examine the influence of a negative externality on property values. However, the externality actually examined and the method of measurement varies from study to study. Thus, we expect that the magnitude of the effects varies depending on the source of the externality.

3. Differences in the specification of the models used: The specific empirical models used differ in terms of factors controlled for, assumptions concerning the linearity of relationships, and size of the affected area.

Virtually all of the previous work has involved ex post studies. For the most part, these studies do not compare the value of property before and after the appearance of an externality. Instead, they examine the value of property in the vicinity of what is presumed to be a negative externality (airport, power station, etc.) and compare it to the value of similar property not subject to the externality. Differences in the market conditions of the various locations and in the specification of the models make it difficult to draw general conclusions from the results to date.

1/ Robert Anderson and Thomas Crocker, "Air Pollution and Residential Property Values," Urban Studies 8 (October 1971): 171.

2/ Glen Blomquist, "The Effect of Electric Utility Power Plant Location on Area Property Value," Land Economics 50 (February 1974): 97.

3/ John Jaksch, "Air Pollution: Its Effects on Residential Property Values in Toledo, Oregon," Annals of Regional Science 4 (December 1970): 43.

While researchers have reported widely differing magnitudes for the effects of negative externalities on property values, the consistency with which these effects are found indicates that negative externalities are related to declines in property values. Though differences between studies make it difficult to generalize, several broad conclusions can be made on the basis of previous studies.

There is little doubt that air pollution has a negative effect on property values; it has been the most extensively studied externality and has consistently been associated with lowered property values, regardless of the method of measuring air pollution or the location examined.

Second, researchers have been unable to establish any effect on property values for some activities that are widely believed to have negative externalities. An example is nuclear power reactors. While it has been shown that coal-fired power stations do cause a decline in property values,[1/] several studies examining the effect of nuclear power reactors on property values have failed to show any relation between the presence of such facilities and property values.[2/] Other research has indicated that there were no measurable adverse effects on property values in the wake of the accident at Three Mile Island.[3/] This is significant considering the widespread prediction that property values would decline in areas adjacent to the Three Mile Island nuclear facility after the accident of March 1979.

Finally, there is some evidence that the effects of an externality attributable to a specific source diminish rapidly as the distance from the source increases, for example, airport noise and soot from smoke stacks. Blomquist's study, illustrating this point, found that the effect of a coal-fired power plant on property values diminished rapidly and that it was limited to a distance of approximately 2.2 miles from the plant.[4/]

1/ Blomquist, "The Effect of Electric Utility Power Plant Location on Area Property Value," p.97.

2/ Hays Gamble and Roger Downing, "Effects of Nuclear Power Plants on Residential Property Values," Journal of Regional Science 22 (November 1982): 457.; Jon Nelson, "Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications," Land Economics 57 (August 1981): 370.

3/ Gamble and Downing, "Effects of Nuclear Power Plants on Residential Property Values," p.457.; Nelson, "Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications," p.363.; U.S. Nuclear Regulatory Commission, The Social and Economic Effects of The Accident at Three Mile Island, by C.B. Flynn and J.A. Chalmers, NUREG/CR-1215 (January 1980), p.77.

4/ Blomquist "The Effect of Electric Utility Power Plant Location on Area Property Value," p.97.

While we can draw general conclusions from previous studies, we think that differences between the proposed uranium mining and milling operation at the Swanson site and other externalities studied make it difficult to predict whether the project will, in fact, have any effects on property values and, if it does, what their magnitude would be. The most important differences between the proposed project at the Swanson site and past studies are:

1. Previous studies have concentrated on the effects of externalities on residential property values. In the vicinity of the Swanson project, the majority of the effects will be on agricultural property rather than residential property. Externalities likely have different effects on agricultural property compared to residential property. With the Swanson project, the important question is what effects the project will have on the productive capacity of the land. We would expect a negative effect on property values to the extent that it reduces the productivity of the land. In other studies the question has been what effect does the disamenity (any factor perceived as unpleasant or unattractive) have on the satisfaction that consumers (homeowners) derive from their property. The answers to these two questions are most likely different, even if the source of the externality is the same. This is not to say that there would be no effects on residential property values in the area, only that because of the low population density in the vicinity of the site, we would anticipate that declines in residential property values will account for only a small part of the total decline in property values that might occur.

2. A second difference is that one of the potential externalities of the Swanson project is radiological in nature. Most researchers investigating the effects of externalities on property values have looked at non-radiological pollutants. The reaction to radiological compared to non-radiological pollutants may be very different. There is evidence that the possibility of radiological pollution does not adversely affect property values. In their study of property values in the vicinity of four different nuclear power plants, Gamble and Downing found no evidence that the presence of the nuclear power plants caused any change in property values.[1/] This is interesting, particularly in light of Blomquist's finding of significant declines in property values near a coal-fired power plant. Also, Gamble and Downing found no decline in property values in the vicinity of the Three Mile Island power plant even after the accident of March 1979.[2/] This is notable because one of the widely predicted effects of that accident suggested that property values would decline. (Another prediction, sharp declines in

---

1/ See Gamble, Nelson, and U.S. NRC, NUREG/CR-1215 (January 1980).

2/ Gamble and Downing, "Effects of Nuclear Power Plants on Residential Property Values," p. 457.

tourism, also failed to materialize.)[1/] Gamble and Downing's results are an indication that in the absence of accidental releases of radiological materials there should be little or no effect on property values.

3. Projects that are most closely analogous to the Swanson project are other open pit mining operations. We have been unable to find any studies that examine the effects of open pit mining operations on local property values but would expect any effects to be localized. Reasons for declines in property values include dust, noise, degradation of local water resources, and additional local traffic. These effects can be expected to diminish rapidly as the distance from the site increases.

4. Previous studies have not examined the effects of water degradation on property values. One of the possible effects of the Swanson project is a decline in the quality of surface and groundwaters. Past studies of other types of negative externalities indicate that if such degradation occurs it could have an adverse effect on property values. However, in the absence of evidence from other studies, it is not known whether or not a decline in the quality of water would have an effect on property values and, if it does, what its magnitude would be.

Besides possible negative effects on property values, there are two reasons that the Swanson project may cause property values in the area to increase. First, Marline-Umetco has guaranteed to purchase any land on which they hold a (mineral) lease and that is immediately adjacent to the site for 125 percent of market value. Marline-Umetco states that it currently has 75 percent of the land adjacent to the Swanson site under lease.[2/] This purchase guarantee will increase the value of property that is covered. However, due to the limited amount of property covered by the purchase guarantee, the effect on total property values in the RSA will be small.

Second, Marline-Umetco argues that because of rising incomes in the area and an increase in general prosperity, property values will increase.[3/] While possible, it is unlikely that the Swanson project will increase incomes enough to have any significant effect on property values.

1/ U.S. Nuclear Regulatory Commission, The Social and Economic Effects of the Accident at Three Mile Island, p.72.

2/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County, Virginia (15 October 1983), vol.3, p.J.3-3.

3/ Marline Uranium Corporation and Union Carbide Corporation, An Evaluation of Uranium Development in Pittsylvania County, Virginia (15 October 1983), vol.3, p.J.2-8 and J.3-3.

SUMMARY

Previous studies have consistently shown that negative externalities can cause declines in the value of nearby property. In reviewing the literature, we can say several things about the possibility of the Swanson project affecting property values near the site.

1. If the project has a negative effect on property values in the vicinity of the site, the effect is likely to be limited to a relatively small area.

2. Despite widespread claims that the possibility of radiological contamination will cause property values to decline, there does not appear to be any evidence to support this notion. The absence of any decline in property values after the accident at Three Mile Island indicates that fears of declines in property values due to the possibility of radiological pollution are exaggerated.

3. It is unlikely that there will be any significant positive effects on property values. Marline-Umetco's guarantee to buy leased land immediately adjacent to the Swanson site will increase the value of that land slightly; it will have only minor effects overall. Similarly, increases in income in the area are unlikely to have any significant influence on property values.

APPENDIX D

THE VALUE OF A LIFE

INTRODUCTION

Many projects or changes in regulations involve incremental changes in the probability of death, which present special problems when doing cost-benefit studies. Such studies require that a monetary value be placed on the various effects of the project being examined.

The question naturally arises whether or not cost-benefit analysis can adequately deal with situations in which there is an increase in the probability of death. The first reaction may be to say that since the value of any one person's life is infinite, the costs of any program that results in an increase in deaths over the status quo would be infinite and should therefore not be implemented. And indeed, if you ask someone what payment he would accept in return for the forfeiture of his life, the answer would most likely be that there is no payment which is large enough, an indication of infinite costs.

Unlike the previous situation, most programs do not involve the certain death of a person. Rather, most projects involve changes in the <u>probability</u> of someone dying. If you ask someone what payment he would accept in return for a slight increase in the <u>probability</u> of his death, he would likely respond with some positive, non-infinite amount. Say, for example, the probability of death for a single individual increased from one in 100,000 per year to ten in 100,000 per year for a population of 100,000 people. We would then expect, on average, ten deaths per year rather than one death per year. Now, assume that each person is indifferent between the one in 100,000 probability of death with his present income and the ten in 100,000 probability of death with an increase in income of $50 per year. In this situation, the implicit value people have placed on the nine additional lives that are lost, on average, is $555,556. (An increase in income of $50 per year compensates each of the 100,000 people for his increased risk. Thus, total compensation for the increase of an average of nine deaths is five million dollars, or an average of $555,556 per death.) This example illustrates how one can argue that the infinite value of an individual life is logically consistent with an implicit, finite value when that value is based on compensation for risk.

Doubtless, people do, in fact, trade off increases in their risk of death in return for some incremental benefit. For example, the risk of being killed in an automobile accident is much greater than that of being killed in an airplane accident, yet many people choose to drive across country rather than fly. Presumably, the additional benefits they receive from driving (the opportunity to sightsee, the convenience of having an automobile when they arrive, etc.) rather than flying compensates them for the extra risk involved in driving.

Conceptually, there are several ways to measure the value of lives lost as a result of some program. We examine each in turn: 1) the present discounted value of earnings lost due to premature death, 2) wage differentials between jobs of differing riskiness, and 3) revelation through the political process, i.e., what expenditures are made in various programs to decrease the probability of death.

PRESENT DISCOUNTED VALUE

The traditional method of economics would be to calculate the present discounted value of earnings lost as a result of premature death. In a competitive economy, earnings are equal to the value of output produced. Therefore, the value of forgone earnings equals the value of output lost to society as a result of premature death. In order to strictly apply this approach, we must know the future earnings stream of the affected individual and his age at death and then select an appropriate discount rate. In the absence of this specific information, we can use the median income of the relevant population. We can then construct a "worst case" in which the individual dies just at the beginning of his working carreer, thus maximizing his lost earnings. The question then becomes what discount rate should be used. (See Appendix E for a discussion of discount rates.) Using relatively low discount rates, which would tend to increase the value of life, the high range of estimates, using present discounted values, would be on the order of $500,000 to $750,000.

WAGE DIFFERENTIALS

Another possibility for calculating the value of a life is to use the approach of Thaler and Rosen and base the calculations on the marginal valuation workers place on job risk. With this approach, Thaler and Rosen use estimates of the probability of death in different occupations and the wage differentials between them to estimate the increase in wages that compensate workers for the increase in risk of a given occupation. From this information, we can infer the value to the workers of saving a life. From data obtained from the Survey of Economic Opportunity (1967), Thaler and Rosen calculate the value of a life to be $200,000 ± $60,000. Using 1983 prices, as adjusted by the Consumer Price Index (CPI), that would be roughly $600,000 ± $178,000.[1/]

1/ Richard Thaler and Sherwin Rosen, "The Value of Saving a Life," Household Production and Consumption, ed. Nestor E. Terleckyj (New York: National Bureau of Economic Research, 1976), p. 265.

REVELATION THROUGH THE POLITICAL PROCESS

A third possibility is to examine safety and health regulations. These will give an indication of what society is willing to pay to reduce the risk of life-threatening situations, as revealed through the political process. Programs such as medical screening, highway traffic safety, airline safety, and control of radioactive and non-radioactive emissions can be examined, and the cost per life saved can be calculated. Expenditures per death avoided range from a low of about $25,000 up to several millions of dollars; those for radioactive related risks are routinely much greater than for others.

SUMMARY

There does not seem to be a great deal of agreement on how to measure the value of a life, let alone what that value should be. In general, using the present discounted value method will result in a lower value than that obtained by examining wage differentials. The following range of values shows entries for the value of a life from different studies. All dollar amounts are reported in 1983 dollars, as adjusted by the CPI.

$380,000 This estimate is from Cumulative Regulatory Effects on the Cost of Automotive Transportation, a study prepared for the Office of Science and Technology. The authors examined many of the safety and emissions control regulations affecting automobiles. The $380,000 figure they use as the value of a life in their cost-benefit studies is based on the undiscounted future earnings of people who die prematurely.1/

$480,000 This estimate is from cost-benefit studies of hypothetical automobile safety regulations presented before the Senate Subcommittee on Antitrust and Monopoly during hearings concerning automobile liability insurance. This estimate is based on discounted future earnings using a discount rate of 3 percent.2/

$600,000 This estimate, from Thaler and Rosen's study, is based on the marginal valuation of risk as expressed in the market by wage differentials.3/

1/ Ad Hoc Committee, Cumulative Regulatory Effects on the Cost of Automotive Transportation (RECAT): Final Report of the AD HOC Committee, Prepared for Office of Science and Technology, 28 February 1972, app. II-A, p. II-A2.

2/ U.S. Congress, Senate Committee on the Judiciary, Auto Insurance Liability, Hearings before the subcommittee on Antitrust and Monopoly on S. Res. 40 pt.18B, 91st Cong., 1st sess., 1969, p.13802.

3/ Thaler and Rosen, "The Value of Saving a Life," p. 294.

$560,000 This estimate is based on individuals' valuation of risk as expressed by their use of seat belts. In this study, Blomquist corrects one of the major criticisms of Thaler and Rosen's work. In their study, Thaler and Rosen examine wage differentials between occupations of differing risk, which has been criticized because the occupations they examine are much riskier than the "average" job. Therefore, the people in their study are likely to either handle risk better than the average person or be less risk averse than the average. In either case, it would bias their results in a downward direction. It is notable that Blomquist's study, which corrects for this apparent bias, results in an estimate consistent with Thaler and Rosen's.1/

$25,000 - $1,000,000+ Based on life saving expenditures on other programs by the federal government.2/

1/ Glen Blomquist, "Value of Life Saving: Implications of Consumption Activity," Journal of Political Economy 87 (June 1979) p. 540.

2/ U.S. Nuclear Regulatory Commission, Final Generic Environmental Impact Statement on Uranium Milling, NUREG 0706, vol.1 (September 1980). p.12-19.

APPENDIX E

DISCOUNT RATES

In this appendix, we discuss, in a very general manner, the use of discount rates, the major issues involved in selecting an appropriate discount rate, and the implications for this project in particular.

USE OF DISCOUNT RATES

Income received in the future is worth less than income received today because of positive rates of interest. With positive interest rates, one can invest a dollar today and receive more than a dollar in the future. For example, if the interest rate is 5 percent, then one would receive $1.05 next year in return for a dollar invested today. Similarly, a dollar next year is worth only $0.95 today since $0.95 invested at 5 percent would yield $1.00 in one year's time.

The discount rate is the rate of interest used to adjust income received in the future so that it is comparable to presently received income. In this study, we have used discount rates to adjust costs and benefits received in the future in order to make them comparable to current figures.

The formula for converting future costs or benefits to their equivalent present value is:

$$PV = \frac{I}{(1 + r)^n}$$

PV = Present value of the cost or benefit received in year n

I = Dollar value of the cost or benefit in year n

r = Discount rate

n = Number of years from the present

As an example, assume that in 20 years, (n = 20) a project provides a one time benefit of $10,000 (I = $10,000) and that the discount rate is 5 percent (r = .05).

Then, for this example:

$$PV = \frac{\$10,000}{(1 + .05)^{20}} = \$3,769$$

In other words, assuming a discount rate of 5 percent, the value today of $10,000 received in 20 years is $3,769.

SELECTION OF DISCOUNT RATES

The nature of the proposed mining and milling project complicates the issue of the proper discount rate to be used in converting streams of costs and benefits to present values. From a theoretical perspective, it is relatively straightforward to decide on the appropriate discount rate to be used in a private investment project or in one financed by the government. However, in the case of the proposed mining and milling project, there are aspects of both private and public projects. The project itself is a private investment decision since Marline-Umetco ultimately finances and decides whether the project is economically viable. The public aspects of the project are the regulatory framework that will be established by the state to deal with possible adverse side effects and the effect on tax revenues and expenditures by state and local governments. Cost-benefit studies are usually an evaluation of the effects of a transfer of resources from the private to the public sector. The question addressed here is slightly different; we must decide on the proper discount rate to use in calculating the present value of future changes in costs and benefits incurred by governments and by private individuals. In this case, we are evaluating a governmental decision (whether or not to pursue the issue of uranium mining and milling) that has the potential to alter incomes and the environment in the area, rather than a decision involving the allocation of resources between the public and private sectors.

Two broad schools of thought exist concerning the appropriate discount rate to use in the evaluation of the streams of costs and benefits resulting from public project. The first argues that the discount rate should reflect the opportunity cost of the funds used in the project being examined. (By opportunity cost, we mean the value of benefits that are given up by not using the funds in their best alternative use.) According to this school, the opportunity cost of funds can most accurately be represented by the selection of an appropriate market rate of interest. An advantage of this method is that it results in benefits and costs being discounted in the same manner for both public and private projects. This helps avoid distortions in the allocation of resources between the public and private sectors. The second school argues that the appropriate discount rate should reflect the social rate of time preference, that is, the optimal allocation of resources over time from society's point of view. The social rate of time preference has no necessary connection to any market rate of interest. In fact, it is argued that discount rates based on market rates of interest are too high from society's point of view.

Opportunity Cost

The opportunity cost concept of discount rates argues that any investment funds must come at the expense of some other project for which they might have been used. In a fully employed economy, resources can be obtained only from the displacement of investment by firms or from the displacement of consumption activities by consumers. (This assumes that the government will not transfer resources from its own projects.) If the resources for a given project come entirely from the displacement of private investment, then the appropriate discount rate is the before tax return (the rate of return before taxes are paid) on private investment. When the government takes resources away from private investment, the cost to society is the additional output those resources would have produced had they remained in the private sector. The before tax return on private investment represents the additional output available to society as the result of private investments.

If, instead of coming at the expense of investment by firms, the government finances its project at the expense of private consumption, then the private marginal rate of substitution between present and future consumption reflects the appropriate discount rate. (The private margin--al rate of substitution indicates how individuals choose to allocate their consumption between the present and future.) If resources for a government project are drawn entirely from consumption, then the private marginal rate of substitution should be used as the discount rate. By doing so, the government sector allocates resources between the present and future in the same manner as the private sector. An indication of individuals' marginal rates of substitution between current and future consumption is their savings behavior. The after tax return to savings (the rate of return after taxes are paid) indicates how individuals value future consumption compared to present consumption. The after tax return to savings can therefore be used as a measure of the private marginal rate of substitution, and is the appropriate discount rate to use in a situation in which the government finances a project entirely at the expense of private consumption.

Because the appropriate discount rate for government projects varies depending on the source of the funds, some people have argued that the theoretically correct discount rate for public projects is a weighted average of the marginal rate of transformation (before tax return on private investments) and the private marginal rate of substitution (after tax return on savings). The weights should reflect the proportion of funds that come out of private investment and those that come at the expense of private consumption.1/

Social Rate of Time Preference

The social rate of time preference indicates the optimal allocation of resources between the present and future from society's point of view. Those who argue that the correct discount rate should reflect the social rate of time preference feel that there are such large distortions in

---

1/ See William Baumol, "On the Appropriate Discount Rate for Evaluation of Public Projects," in Program Budgeting and Benefit-Cost Analysis, ed. by Harley Hinrichs and Graeme Taylor (Pacific Palisades, CA.: Goodyear. Publishing Co., 1969), p.212.

capital markets that no market rate of interest will accurately reflect the social rate of time preference. They feel that the private marginal rate of substitution (as reflected by after tax returns to savings) must be adjusted downward to accurately reflect the social rate of time preference and the distribution of resources between present and future generations, which is often ignored in policy decisions. Private individuals tend to ignore the welfare of future generations. As a result, the use of the private marginal rate of substitution as the discount rate results in a discount rate that is too high from society's point of view. Because such a discount rate is too high, too much consumption takes place in this generation and too little capital is bequeathed to future generations. However, the government, which should not ignore the welfare of future generations, can correct this market failure, at least for its projects, by using a lower discount rate, insuring that future generations have the stock of physical capital that they are entitled to. In essence, those who favor using the social rate of time preference as the discount rate are arguing that decision-makers should impose their view of the optimal time path of consumption on the project. There does not appear to be any consensus on the basis for the adjustment, only that the appropriate discount rate would be below any market rate of interest.1/

A disadvantage of having the government use a discount rate below market rates of interest is that too many of society's resources will be devoted to government projects because with lower discount rates, benefits will be larger and, hence, more often greater than costs. Even if the government uses the appropriate (lower) discount rate, private firms will still use a discount rate (the before tax return on private investment) that is too high from society's point of view. As a result, private firms will allocate too many resources to projects that have the majority of benefits in the near future and too few to those that have the majority of benefits in the distant future.

DISCOUNT RATES AS THEY APPLY TO THIS PROJECT

One of the major benefits of the proposed project is the increased income accruing to residents of the RSA and the state of Virginia. To these residents, this income is indistinguishable from that of any other source. Therefore, any increase in income attributable to this project should be discounted in the same manner that individuals would discount any other future streams of income. In general, individuals' savings

---

1/ See Richard Tresch, Public Finance: A Normative Theory (Plano, Tx.: Business Publications, Inc., 1981), p. 496; and William Baumol, "On the Discount Rate for Public Projects," Public Expenditure and Policy Analysis, 2nd ed., ed. Robert Haveman and Julius Margolis (Chicago: Rand McNally, 1977), p. 174; and Jacob Stockfisch, "The Interest Rate Applicable to Government Investment Projects," Program Budgeting and Benefit-Cost Analysis, ed. Harley Hinrichs and Graeme Taylor (Pacific Palisades,CA: Goodyear Publishing Co., 1969), p. 190.

behavior is an indication of how they discount future streams of income. The after tax return that individuals receive on their savings is a good measure of their private marginal rate of substitution (the rate at which individuals are willing to exchange current income for future income). Because for other sources of income the after tax return to savings is the appropriate discount rate to use for discounting future income to individuals, it should also be the appropriate discount rate for the additional income accruing to individuals as a result of Marline-Umetco's expenditures.

The appropriate discount rate is a separate issue from the level of benefits to be discounted, and it will not be affected by the level of resource employment. The amount by which Marline-Umetco's spending increases incomes will affect the level of benefits but will not affect the choice of the correct discount rate. There are two extremes to consider with respect to the level of benefits:

1. Substantial unemployment will be present in the absence of the Marline-Umetco project. In this situation, Marline-Umetco will not draw resources from other uses, and income can be expected to increase by the full amount of Marline-Umetco's spending. This income should be discounted just as any other income would be discounted by individuals.

2. No unemployment will be present in the absence of the Marline-Umetco project. In this situation, Marline-Umetco can be expected to compete for resources and, therefore, draw the resources it does use from other employment. Because resources are fully employed, any increase in their employment by Marline-Umetco must be met by drawing resources away from other uses. Hence, any spending by Marline-Umetco will be offset by a reduction in spending by other firms. In this situation, there will be no net increase in spending or income, and, therefore, no benefits to discount.

Obviously, the actual outcome lies somewhere between these two extremes. For the purposes of this study, we assume that Marline-Umetco does not draw its resources from other uses and that the benefits are equal to the full amount of Marline-Umetco's spending. Hence, our estimates represent the largest possible increase in income that can be expected as a result of the Swanson project.

Since any environmental changes that result from the project will fall on the individual residents of the RSA and the state, their cost should be discounted in the same manner as the benefits accruing to individual residents.

The other costs and benefits of the project accrue to the local and state governments. It could be argued that, ultimately, all costs or benefits of the project actually accrue to the residents of the area because the local governments are acting in their behalf. We shall assume, however, that all taxes and revenues accruing to state and local governments are their property. We make this assumption to emphasize the difference in investment opportunities available to governments and individuals. The discount rate for the costs and benefits accruing to state and local governments should be developed in the same manner as it was for costs and benefits accruing to individuals--that is, by examining the investment opportunities available to state and local governments. The returns available to the state and local governments would be reflected by the returns they could receive from investing in some type of low risk, long-term security. The reason we would anticipate that these returns differ from returns available to individuals would be differences in the tax treatment of the two agents.

For discounting costs and benefits to residents of the RSA, we use the interest rate on long term, AAA tax exempt municipal bonds, adjusted for anticipated inflation; for discounting costs and benefits to state and local governments, we use the interest rate on long term Treasury bonds, also adjusted for anticipated inflation. These interest rates are adjusted for inflation to reflect real rates of interest because all costs and benefits are reported in constant dollars.1/ No attempt has been made to adjust these discount rates for risk, but we have considered risk, in terms of ranges of possible outcomes, elsewhere in our report. The Federal Reserve Bank of San Francisco reports that the

---

1/ We recognize that local governments would be unlikely to invest in such long-term securities. However, we feel that the real return on long-term bonds is the appropriate theoretical measure of the opportunity cost of forgone funds to local governments. Another approach to determining discount rates would be to assume that, in the absence of revenues from the Swanson project, state and local governments would have to increase taxes or borrow in the long-term tax exempt bond market. If it is assumed that taxes would increase in the absence of the project, then all costs are ultimately borne by private individuals, and, hence, the same discount rate would be used for all costs and benefits. If it is assumed that state and local governments would increase borrowing in the absence of the Swanson project, then the appropriate discount rate for costs and benefits accruing to state and local governments would be the rate of interest on tax exempt long-term municipal. bonds, adjusted for inflation. If we assume that state and local governments increase borrowing, then, to maintain logical consistency, we must also assume that private individuals would increase their borrowing to finance consumption. In such a situation, the discount rate to private individuals should reflect the long-term cost of funds. One estimate of this would be mortgage rates, adjusted for tax treatment and inflation.

anticipated annual rate of inflation over the next ten years is 6.75 percent.[1/] Recently, the interest rates on high-grade municipal bonds have been between 9.5 and 10 percent. This would indicate a discount rate of between 2.75 and 3.25 percent for costs and benefits accruing to individuals. We use a rate of 3 percent to discount costs and benefits accruing to individuals. The interest rate for 30 year Treasury bonds has been between 13 and 13.5 percent recently. This would indicate a discount rate of between 6.25 and 6.75 percent for costs and benefits accruing to local governments. We use a rate of 6.5 percent to discount costs and benefits accruing to state and local governments.

1/ See "Factors Influencing Long-Term Interest Rates," FRB SF Weekly Letter, Federal Reserve Bank of San Francisco (June 1, 1984), p. 1.

APPENDIX F

COMPARISON TABLES

TABLE F.1

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
BENEFITS			
Total Earnings			
RSA construction	$16,219,300	$12,320,000	TMI included expenditures for tailings management. For additional differences see Appendix A.
RSA operations	8,435,100	8,032,000	
State construction	31,377,900	27,748,000	
State operations	12,133,600	11,913,000	
Total Employment			
RSA construction	652	894	TMI uses average number of jobs at an annual rate. Marline-Umetco uses person years. TMI included expenditures for tailings management. For additional differences see Appendix A.
RSA operations	620	596	
State construction	782	1,645	
State operations	810	765	

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
BENEFITS (cont.)			
Taxes during construction--RSA			
Real property			
year 1	$ 11,790	No estimate	
year 2	236,280	No estimate	
Machinery and tools			
year 1	36,000	No estimate	
year 2	36,000	No estimate	
Tangible personal property			
year 1	10,455	No estimate	
year 2	10,455	No estimate	
Sales			
year 1	46,327	No estimate	
year 2	46,327	No estimate	
Taxes during construction--State			
Sales			
year 1	250,710	No estimate	
year 2	250,710	No estimate	
Motor vehicle sales and use tax	16,400	No estimate	

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
BENEFITS (cont.)			
Taxes during operations--RSA			
Real property	$ 236,280	$ 256,500	Different true tax rate used.
Machinery and tools	36,000	36,000	No difference.
Tangible personal property	10,455	63,570	TMI restricted tax base to mobile equipment.
Sales	2,040	67,000	TMI restricted tax base to one-half of total maintenance and repair parts, allowed tailings management expenditures, and adjusted expenditures to make them consistent with the I-O table.
Taxes during operations--State			
Corp. income	No estimate	1,200,000	TMI did not estimate because of the absence of information for several variables used in the three-factor formula for multi-state corporations.
Sales	12,300	180,000	TMI restricted tax base to one-half of total maintenance and repair parts, allowed for tailings management expenditures, and adjusted expenditures to make them consistent with the I-O table.

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
BENEFITS (cont.)			
Intangible personal property	$ 0	$15,000	Tax has been repealed.
Secondary taxes during construction--RSA	23,079 low 27,795 middle 32,511 high	No estimate	TMI limited all secondary taxes to those paid by Marline-Umetco employees.
Secondary taxes during construction--State	173,810 low 217,245 middle 260,680 high	No estimate	
Secondary taxes during operations--RSA	37,063 low 41,707 middle 46,351 high	53,700	TMI used direct earnings to estimate the sales tax base. Marline-Umetco used total earnings, including the multiplier effect. TMI assumed that 38% of earnings would be used for local purchases subject to the sales tax; Marline-Umetco assumed 50%. TMI used lower effective property tax rates for Danville and Pittsylvania than were used for by Marline-Umetco. TMI estimated non real estate taxes for 45 employee households that are expected to move into the RSA. Marline-Umetco restricted its estimate to the sales tax.

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
BENEFITS (cont.)			
Secondary taxes during operations--State	$171,150 low 213,920 middle 256,690 high	No estimate	
Net benefit to Unemployment Insurance Trust Fund	429,039 (present value)	No estimate	The TMI estimate is probably overstated because it contains no allowance for layoffs during construction and operations.
COSTS			
State outlays for review of proposal to allow and license mining/milling and	No estimate	No estimate	Considered a "sunk cost" by TMI and therefore not included.

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
COSTS (cont.)			
Regulatory costs			
One time/infrequent costs based on agreement status	$ 405,750 to 539,300	No estimate	
Costs for exploration, mining, and reclamation	No estimate	No estimate	
Costs during operations	248,731 to 444,425	No estimate	
Cost recovery	No estimate	No estimate	Amount, if available, would be credited against regulatory costs.
Road expenditures			
Improvements	1,135,000	$720,000	TMI estimate based on Virginia Department of Highways and Transportation (VDHT) estimate of $475,000 by 1989, $360,000 by 1990, and $300,000 after 1990. VDHT did not estimate higher maintenance costs on other roads due to closing of state road 690 and 3 miles of 683. TMI's estimate is for one entrance, not two.

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
COSTS (cont.)			
Annual maintenance	$ 8,000	$120,000	TMI estimate obtained from VDHT, assumes that weight restrictions will not exceed 40 tons
Forgone annual local government revenue	1,073	No estimate	
Local government secondary expenditures during construction--RSA	4,407	No estimate	TMI limited all secondary expenditures to those provided to Marline-Umetco employees.
State government secondary expenditures during construction--State	24,180	No estimate	
Local government secondary expenditures during operations--RSA	18,758	51,181	Marline-Umetco used a population of 148 instead of 136 and a larger number of public school children (58) then previously shown (41). The company also used higher cost per average daily membership and per capita than substantiated by financial reports.a/

a/ See Department of Education, Facing Up-17, Statistical Data on Virginia's Public Schools, 1981-82 School Year. (Richmond, VA: Department of Education, March 1983), and Auditor of Public Accounts, Comparative Report of Local Government Revenues and Expenditures Year Ended June 30, 1982, (Richmond, VA: Auditor of Public Accounts, 1983)

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item.	TMI	Marline-Umetco	Comment
COSTS (cont.)			
State government secondary expenditures during operations--State	$109,616	No estimate	
Air quality			
Increase in total suspended particulates	4.0 ug/m^3	4.0 ug/m^3	Annual Average
Increase in airborne ammonia concentrations	No estimate	No estimate	Marline-Umetco assumes any increase will be minor.
Increase in sulfuric acid mist concentrations	No estimate	No estimate	Marline-Umetco assumes any increase will be minor.
Increase in airborne insoluable uranium concentrations	No estimate	No estimate	Marline-Umetco estimates that 500 pounds of uranium oxide will be lost to the atmosphere annually. This represents .025 percent of production.
Increase in sulfur dioxide concentrations	$0.005ug/m^3$	$0.005ug/m^3$	Annual average.
Increase in nitrogen dioxide concentrations	$4.6ug/m^3$	$4.6ug/m^3$	Annual average.

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
COSTS (cont.)			
Increase in Carbon Monoxide concentrations	No estimate	No estimate	Annual average. Marline-Umetco assumes any increase will be minor.
Increase in airborne hydrocarbons concentration	No estimate	No estimate	Marline-Umetco assumes any increase will be minor.
Radiation exposure			
Total body	16.4 mrem/yr	16.4 mrem/yr	These exposures include exposure from air and water pathways and include radon and its daughter products. As a basis of comparison, the NRC limit for exposure in unrestricted areas is 500 mrem/yr.
Bone	94.5 mrem/yr	94.5 mrem/yr	
Gastrointestinal	0.0 mrem/yr	0.0 mrem/yr	
Average lung	41.0 mrem/yr	41.0 mrem/yr	
Increase in cancer deaths from radon exposure	0.3	No estimate	This is the expected increase in deaths in the population within 50 miles of the site as a result of exposure during the operations phase.
Value of the increased risk of fatal cancers	63,119 $166,104	No estimate	This is the value placed on the increased risk of death for the population with 50 miles of the site as the result of exposure during the operations phase.

TABLE F.1 (continued)

COMPARISON OF TAYLOE MURPHY INSTITUTE RESULTS WITH THOSE PROVIDED BY MARLINE-UMETCO

Item	TMI	Marline-Umetco	Comment
COSTS (cont.)			
Water resources			
Groundwater quantity	No estimate	Slight depression of the water table in the immediate area of the mine pit.	SWCB has expressed some concern that the depression of the water table may be more extensive than estimated by Marline-Umetco.
Groundwater quality	No estimate	No estimate	Marline-Umetco states that potential contaminant concentrations can be reduced to levels that meet Virginia and federal regulatory standards.
Surface water	Diversion of Mill Creek	Diversion of Mill Creek	The major impact of the project on surface water will be the diversion of Mill Creek; Marline-Umetco states that there will be no discharges from the mill during operations and that discharges from the mine will meet all state and federal standards.
Accidents	No estimate	No estimate	Marline-Umetco presents probabilities for a variety of accidents. These probabilities are based on historical data. Because of changes in regulations and large differences between the Swanson site and western sites, the actual probabilities may be different from Marline-Umetco estimates.

APPENDIX G

ACKNOWLEDGMENTS

The following people provided us with information directly or aided us in gathering information. We appreciate and thank them for sharing their expertise with us.

Danville Chamber of Commerce

Charles Pendleton, Executive Director

Danville Extension Office

Doris L. Pritchett, County Agent

Division of Legislative Services

Bernard J. Caton, Jr., Ph.D., Research Associate

Gibbs and Hill Inc.

Environmental Sciences Division, Denver, Colorado
William P. Lynott, Operations Director
Architecture/Urban Development Division, New York
Robert J. Nagy, Director of Planning

Halifax Chamber of Commerce

Nancy L. Poole, Executive Director
Dorothy W. Bradshaw, Secretary

Halifax County Extension Office

Larry L. McPeters, County Extension Agent

Marline Uranium Corporation

John A. Yellich, Vice President for Development
C. Dudley Blancke, Jr., Mining Engineer

Piedmont Environmental Council

Georgia H. Herbert, Director of Development
Tamara A. Vance, Resource Economist

Pittsylvania Chamber of Commerce

Audrey F. Millner, Executive Director
C. D. Bryant, Businessman and Member of Chamber

Pittsylvania County Extension Office

Stephen J. Britt, County Extension Agent
Drury J. Holland III, County Extension Agent
Bobby S. Stump, County Extension Agent

Pittsylvania County Office of Assessments

Hunt Meadows, Commissioner of Revenue

Rodgers, Golden, & Halpern

Phillip R. Hopkins, Senior Resource Planner

Southside Concerned Citizens

Liz George, Chairperson

State Air Pollution Control Board

William R. Meyer, Executive Director
Division of Monitoring
William W. Parks, Director
Division of Planning
Kenneth C. Van Auken, Director

State Water Control Board

Richard N. Burton, Executive Director
Division of Enforcement and Environmental Reasearch
Michael A. Bellanca, Director of Operations
Biological Programs
Thomas M. Felvey, Manager
Catherine S. Turner, Aquatic Biologist
Water Research Programs
J. R. Bell, Water Resources Engineer
Russell P. Ellison, III, Geologist

United Methodist Church, Virginia Annual Conference

Board of Church and Society
Eloise Nenon, President

U.S. Department of Commerce

Bureau of Economic Analysis
Zoe O. Ambargis, Regional Economist
Joseph V. Cartwright, Regional Economist

U.S. Nuclear Regulatory Commission

NRC Contacts
Office of State Programs:
John S. Kendig, Agreement Status Officer
Robert S. Wood, Licensee Relations Analyst

Nuclear Materials Safety and Safeguards Office:
Mary Jo Seemann, Program Analyst

University of Virginia

Department of Economics
William C. Wood, Assistant Professor
Department of Environmental Sciences
H. Grant Goodell, Professor
Department of Nuclear Engineering
Thomas G. Williamson, Professor and Chairman
James L. Kelly, Professor
Institute for Environmental Negotiation
Richard C. Collins, Director
Anthony B. Dotson, Assistant Director
Francis A. Hannigan, Associate
Jason L. Gray, Graduate Assistant
Timothy J. Mealey, Graduate Assistant

Virginia Air Pollution Control Board

Division of Monitoring
William W. Parks, Director

Virginia Coal and Energy Commission

Michael D. Ward, Staff Attorney

Virginia Department of Agriculture and Consumer Services

Product and Industry Regulation Division
Billy W. Southall, Director
Bureau of Plant Protection and Pesticide Regulation
Bernard W. Chudoba, Assistant Supervisor for Field Operations

Virginia Department of Health

Division of Epidemiology
Grayson B. Miller, Director
Division of Radiological Health
Charles R. Price, Director
Office of Health Protection and Environmental Management
Robert B. Stroube, M.D., Assistant Commissioner

Virginia Department of Highways and Transportation

Charles P. Crowder, Assistant Resident Engineer

Virginia Department of Taxation

Tax Policy Division
Danny M. Payne, Director
William R. Warren, Tax Analyst
Joel T. Winks, Legislative Division
Property Tax Division
Otho C. W. Fraher, Assistant Director

Virginia Division of Industrial Development

Marketing Services
James C. McKean, Economist
Peggy M. Ware, Economist

Virginia Employment Commission

Jerry Lawson, Deputy Commissioner

Employees and friends of the following businesses and institutions provided information that was helpful in understanding the local economy. The facts and opinions obtained were used in our economic base analysis in Appendix B and the section on economic impacts on existing industries. The majority of businesses and firms contacted represent services and food-processing. Additional industries, not listed below, were contacted.

Averett College, Danville
Berry Hill Nursing Home, South Boston
Burlington Industries Inc., Halifax
Camelot Hall Nursing Home, Danville
Chatham Hall, Chatham
Coca-Cola Bottling Co., Danville
Danville Community College, Danville
Danville Meat Products, Danville
Farmer's Feed and Supply, Danville
Hargrave Miliatry Academy, Chatham
Neal's Warehouse, Danville
Pepsi-Cola Bottling, Danville
Virginia Electric and Power Company, South Boston
Vulcan Materials Company, Halifax and South Boston

BIBLIOGRAPHY

Ad Hoc Committee. Cumulative Regulatory Effects on the Cost of Automotive Transportation (RECAT): Final Report of the Ad Hoc Committee. Prepared for The Office of Science and Technology. Washington, D.C.: U.S. Government Printing Office, 28 February 1972.

Anderson, Robert, and Crocker, Thomas. "Air Pollution and Residential Property Values." Urban Studies 8 (October 1971): 171.

Anmer, Christine and Anmer, Dean S. Dictionary of Business and Economics. (New York: The Free Press, 1977).

Auditor of Public Accounts. Comparative Report of Local Government Revenues and Expenditures Year Ended June 30, 1982. Richmond, VA: Auditor of Public Accounts, 1983.

Baumol, William J. Economic Theory and Operations Analysis, 4th ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1977.

_________., and Oates, Wallace E. The Theory of Environmental Policy: Externalities, Public Outlays, and the Quality of Life. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1975.

Bjornstad, David J., and Vogt, David P. "Some Comments Relating to Model Specification on 'Effects of Nuclear Power Plants on Residential Prperty Values.'"Journal of Regional Science 24 (February 1984): 135-138.

Blomquist, Glen. "The Effect of Electric Utility Power Plant Location on Area Property Value." Land Economics 50 (February 1974): 97-99.

___________. "Value of Life Saving: Implications of Consumption Activity." Journal of Political Economy 87 (June 1979): 540-558.

Borts, George H. "The Greenhouse Program: Is it Economically Feasible and Justifiable?: Comment." The Northeast Journal of Business and Economics 10 (Spring/Summer 1984): 29-34.

Broome, John. "Trying to Value a Life." Journal of Public Economics 9 (February 1978): 91-100.

_________. "Trying to Value a Life: A Reply." Journal of Public Economics 12 (October 1979): 259-262.

Buchanan, James, and Faith, Roger. "Trying Again to Value a Life." Journal of Public Economics 12 (October 1979): 245-248.

Burchell, Robert W., and Listokin, David. The Fiscal Impact Handbook: Estimating Local Costs and Revenues of Land Development. New Brunswick, NJ: The Center for Urban Policy Research, 1978.

Chatterjee, Samprit, and Price, Bertram. Regression Analysis by Example. New York: John Wiley & Sons, 1977.

Chiang, Alpha C. Fundamental Methods of Mathematical Economics. 2nd ed. New York: McGraw-Hill Book Co., 1974.

Christ, Carl. "A Review of Input-Output Analysis." Input-Output Analysis: An Appraisal. Princeton: Princeton University Press, 1955.

"Citing Costs, TVA cancels Four Reactors." Washington Post, 30 August 1984, sec. A, p. 1.

"Closings of Nuclear Plants." U.S. News and World Report 97 (30 July 1984): 58.

Coale, Charles W., Jr. A Report of the Fresh Vegetable Marketing Study Conducted for Southside and Southwestern Virginia Vegetable Growers by the USDA. Department of Agricultural Economics. Blacksburg, VA: Virginia Polytechnic Institute and State University, March 1983.

Cobb, James C. The Selling of the South: The Southern Crusade for Industrial Development 1936-1980. Baton Rouge, LA: Louisiana State University Press, 1982.

29 Code of Federal Regulations. 1910.1000. Subpart Z (revised as of 1 July 1983): Tables 21-23, pp. 667-672.

40 Code of Federal Regulations. app. A. sec. 50.7 (revised as of 1 July 1983): 542.

Committee on the Biological Effects of Ionizing Radiation. Effects on Populations of Exposure to Low Levels of Ionizing Radiation (Washington, D.C.: National Academy Press, 1980): 185.

"Cost May Halt New TVA Reactor." Washington Post, 17 July 1984, sec. A, p. 2.

Cummins, K. W., and Spengler, G. L. "Ecosystems." Water Spectrum (Fall 1978): 1-9.

Davies, J. Clarence; Gusman, Sam; and Irwin, Frances. Determining Unreasonable Risk Under the Toxic Substances Control Act. Washington, D.C.: The Conservation Foundation, 1979.

Dickson, David. "Uranium Shortage Turns Glut." Science 22 (3 August 1984): 484.

Dunning, Donald E.; Leggett, Richard W.; and Sullivan, Robert E. "An Assessment of Health Risk from Radiation Exposure." Health Physics 46 (May 1984): 1050.

Elliot, David, and Yarrow, George. "Cost-Benefit Analysis and Environmental Policy: A Comment." Kyklos 30, 2 (1977): 300-309.

Elliot-Jones, M. F. Input-Output Analysis: A Nontechnical Description. New York: The Conference Board, 1971.

"Factors Influencing Long-Term Interest Rates." FRB SF Weekly Letter, Federal Reserve Bank of San Francisco (1 June 1984): 1.

Farrar, D., and Glauber, R. "Multicollinearity in Regression Analysis: The Problem Revisited." Review of Economics and Statistics. vol. 49 (February 1967): 92-107.

Federal Register. vol. 48. no. 196 (7 October 1983): 45927 , 45930-31.

Finsterbusch, Kurt. Understanding Social Impacts: Assessing the Effect of Public Projects. Beverly Hills, CA: Sage Publications, 1980.

Fisher, Anthony C., and Krutilla, John V. "Valuing Long-Run Ecological Consequences and Irreversibilities." Journal of Environmental Economics 1 (August 1984): 96-109.

Forester, Thomas H.; McNorn, Robert F.; and Singell, Larry D. "A Cost-Benefit Analysis of the 55 MPH Speed Limit." Southern Economic Journal 50, 3: 631-641.

Freeman, A. Myrick, III; Haveman, Robert H.; and Kneese, Allen V. The Economics of Environmental Policy. New York: John Wiley & Sons, Inc., 1973.

Freund, John E. Mathematical Statistics. 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1971.

Gamble, Hays, and Downing, Roger. "Effects of Nuclear Power Plants on Residential Property Values." Journal of Regional Science 22 (November 1982): 457.

________. "Some Comments Relating to Model Specification on 'Effects of Nuclear Power Plants on Residential Property Values.': A Reply." Journal of Regional Science 24 (February 1984): 135-136.

General Accounting Office. Cost-Benefit Analysis Can Be Useful in Assessing Environmental Regulations, Despite Limitations. The Comptroller General Report to The Congress of The United States. GAO/RCED-84-62. General Accounting Office, 6 April 1984.

Gillis, Malcolm, and Peprah, Ignatius. Severance Taxes on Coal and Uranium in the Sunbelt. Austin, TX: Bureau of Business Research, University of Texas at Austin, 1981.

Glickman, Norman J. Econometric Analysis of Regional Systems: Explorations in Model Building and Policy Analysis. New York: Academic Press, 1977.

Grossman, Philip J. Economic Base Analysis: Theory and Application. Charlottesville, VA: Tayloe Murphy Institute, June 1984.

Harmston, Floyd K., and Lund, Richard E. Application of an Input-Output Framework to a Community Economic System. Columbia, MO: University of Missouri Press, 1967.

Haveman, Robert H., and Margolis, Julius, eds. Public Expenditure and Policy Analysis. 2nd ed. Chicago: Rand McNally College Publishing Co., 1977.

Hawkins, D., and Simons, H. A. "Some Conditions on Macroeconomic Stability." Econometrica 17 (July-October, 1949).

Heilman, James M.; Dubler, Mary Lynn; Knapp, John L.; and Martin, Julia H. Virginia Occupational Demand, Supply and Wage Information. Charlottesville, VA: Tayloe Murphy Institute, 1983.

Herfindahl, Orris C., and Kneese, Allen V. Economic Theory of Natural Resources. Columbus, OH: Charles E. Merrill Publishing Co., 1974.

Hill, T. P. Profits and Rates of Return. Paris: Organization for Economic Co-operation and Development, 1979.

Hinrichs, Harley H., and Taylor, Graeme M., eds. Program Budgeting and Benefit-Cost Analysis: Cases, Text, and Readings. Pacific Palisades, CA: Goodyear Publishing Co., 1969.

Hjalte, Krister; Lidgren, Karl; and Stahl, Ingemar. Environmental Policy and Welfare Economics. Cambridge: Cambridge University Press, 1977.

Howe, Charles W. Natural Resource Economics: Issues, Analysis, and Policy. New York: John Wiley & Sons, Inc., 1979.

Isard, Walter. Methods of Regional Analysis: An Introduction to Regional Science. Cambridge, MA: The M.I.T. Press, 1960.

_________, and Kuenne, Robert E. "The Impact of Steel Upon the Greater New York-Philadelphia Industrial Region." Review of Economics and Statistics 35 (November 1953): 289-301.

Jaksch, John A. "Air Pollution: Its Effects on Residential Property Values in Toledo, Oregon." Annals of Regional Science 4 (December 1970): 43.

Johnston, J. Econometric Methods. 2nd ed. New York: McGraw-Hill Book Co., 1972.

Jones-Lee, M. W. "Trying to Value a Life: Why Broome Does Not Sweep Clean." Journal of Public Economics 12 (October 1979): 249-256.

_________. The Value of Life: An Economic Analysis. Chicago: The University of Chicago Press, 1976.

Knapp, John L. Economic Trends in Substate Regions of Virginia, 1973-78. An Analysis of the State's Planning Districts. Charlottesville, VA: Tayloe Murphy Institute, May 1981.

Kneese, Allen V., and Schultze, Charles L. Pollution, Prices, and Public Policy. Washington, D.C.: The Brookings Institution, 1975.

Krutilla, John V., and Fisher, Anthony C. The Economics of Natural Environments. Baltimore: Johns Hopkins University Press, 1975.

Leontief, Wassily W. Studies in the Structure of the American Economy. New York: Oxford University Press, 1953.

_________. Input-Output Economics. New York: Oxford University Press, 1966.

Mark, Jonathan. "A Preference Approach to Measuring the Impact of Environmental Externalities." Land Economics 56 (February 1980): 103-116.

Marline Uranium Corporation and Union Carbide Corporation. An Evaluation of Uranium Development in Pittsylvania County, Virginia. 8 vols., 15 October 1983.

_________. Technical Memoranda-1984, Final Draft. 2 vols., August 1984.

_________. Technical Summary and 1984 Supplement with Supporting Technical Memorandan. 2 vols., August 1984.

Marshall, John M. "Gambles and the Shadow Price of Death." The American Economic Review 74 (March 1984): 73-86.

May, Eleanor G. Retail Sales in Virginia, 1983. Charlottesville, VA: Tayloe Murphy Institute, May 1984.

McKean, Roland N. Efficiency in Government Through Systems Analysis: With Emphasis on Water Resources Development. New York: John Wiley & Sons, Inc., 1958.

"Meltdown." Economist 291 (19-25 May 1984): 87-88.

Miernyk, William H. The Elements of Input-Output Analysis. New York: Random House, 1965.

Mieszkowski, Peter, and Saper, Arthur. "An Estimate of the Effects of Airport Noise on Property Values." Journal of Urban Economics 5 (October 1978): 425-440.

Mishan, E. J. Cost-Benefit Analysis. New and expanded ed. New York: Praeger, 1976.

Moore, Frederick T., and Peterson, James W. "Regional Analysis: An Inter-industry Model of Utah." Review of Economics and Statistics. 37 (November 1955): 368-383.

Moss, Norman. The Politics of Uranium. New York: Universe Books, 1982.

National Bureau of Economic Research. Studies in Income and Wealth. vol. 18. Input-Output Analysis: An Appraisal. Princeton, NJ: Princeton University Press, 1955).

________. Household Production and Consumption. New York: Columbia University Press, 1975.

National Research Council. Uranium Resource Group Supply and Delivery Panel of the Committee on Nuclear and Alternative Energy Systems. Study of Nuclear and Alternative Energy Systems, Supporting Paper 1: Problems of U.S. Uranium Resources and Supply to the Year 2010. Washington, D.C.: National Academy of Sciences, 1978.

Nelson, Jon P. "Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications." Land Economics 57 (August 1981): 363-372.

Office of the Assistant Secretary of Defense. President's Economic Adjustment Committee . Modeling the Regional Economic Impact of Major New Military Bases. Washington, D.C.: The Pentagon, April 1983.

Organization for Economic Co-operation and Development. Uranium: Production and Short Term Demand. A Joint Report by the European Nuclear Energy Agency and the International Atomic Energy Agency, January 1969.

Organization for Economic Co-operation and Development. Uranium: Resources, Production and Demand. A Joint Report by the OECD Nuclear Energy Agency and the International Energy Agency, December 1975.

________. Uranium: Resources, Production and Demand, including other Nuclear Fuel Cycle Data. A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, 1976.

________. Resources, Production and Demand. A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, 1977.

_________. Uranium: Resources, Production and Demand. A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, 1979.

_________. World Uranium Potential. A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, December 1978.

_________. World Uranium Potential: An International Evaluation. A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, December 1978.

Pearce, David W. "The Limits of Cost-Benefit Analysis as a Guide to Environmental Policy." Kyklos 29, 1 (1976): 97-112.

_________. "Cost-Benefit Analysis and Environmental Policy: A Reply to Elliot and Yarrow and to Smith." Kyklos 30, 2 (1977): 314-318.

Pines, David, and Weiss, Yoram. "Land Improvement Projects and Land Value." Journal of Urban Economics 3 (January 1976): 1-13.

Radetzki, Marian. Uranium: A Strategic Source of Energy. New York: St. Martin's Press, 1981.

Samuelson, Paul. "Abstract of a Theorem Concerning Substitutability in an Open Leontief Model." In Collected Scientific Papers of Paul A. Samuelson. vol. 1. Edited by J. Stiglitz. Cambridge, MA: The M.I.T. Press, 1966.

Seneca, Joseph J., and Taussig, Michael K. Environmental Economics. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1984.

Smith, Kerry V. "Cost-Benefit Analysis and Environmental Policy: A Comment." Kyklos 30, 2 (1977): 310-313.

Spengler, Albert W. Tax Rates in Virginia's Cities, Counties and Selected Towns: 1982. Charlottesville, VA: Institute of Government, University of Virginia, 1982.

_________. Tax Rates in Virginia's Cities, Counties and Selected Towns: 1983. Charlottesville, VA: Institute of Goverment, University of Virginia, 1983.

State Air Pollution Control Board. Regulations for the Control and Abatement of Air Pollution. (Richmond, VA: State Air Pollution Control Board, 31 July 1981): 47-49.

Taylor, June H., and Yokell, Michael D. Yellowcake, the International Uranium Cartel. New York: Pergamon Press, 1979.

Thaler, Richard, and Rosen, Sherwin. "The Value of Saving a Life." Household Production and Consumption. Nestor E. Terleckyj, ed. New York: National Bureau of Econòmic Research, 1976.

Tresch, Richard W. Public Finance: A Normative Theory. Plano, TX: Business Publications, Inc., 1981.

Uranium Mining and Radiation Safety. Proceedings of a Conference at Michigan Technological University, Houghton, Michigan. Houghton, MI: Sponsored by Operation ACTION U.P., 19 September 1980.

U.S. Advisory Commission on Intergovernmental Relations. Local Nonproperty Taxes and the Coordinating Role of the State. A-9. Washington, D.C.: U.S. Government Printing Office, September 1981.

________. Tax Capacity of the Fifty States: Methodology and Estimates. M-134. Washington, D. C.: U.S. Government Printing Office, March 1982.

U.S. Atomic Energy Commission. Environmental Survey of the Uranium Fuel Cycle. Washington, D.C.: U.S. Government Printing Office, April 1974.

U.S. Congress. House. Committee on Interstate and Foreign Commerce. International Uranium Cartel. Hearings before the subcommittee on Oversight and Investigations. Serial No. 95-39, vol. 1, 95th Cong., 1st sess., 1977.

________. ________. Committee on Interstate and Foreign Commerce. International Uranium Supply and Demand. Hearing before the subcommittee on Oversight and Investigations. Serial No. 94-150, 94th Cong., 2nd sess., 1976.

________. ________. Committee on Judiciary. The Insurance Industry. Hearing before the subcommittee on Antitrust and Monopoly. Pursuant to S. Res. 40. pts. 18, 18A & B, 91st Cong., 1st sess., 1969.

________. ________. Joint Economic Committee. Economic Indicators, May 1984. Washington, D.C.: U.S. Government Printing Office, 1984.

________. Senate. Committee on the Judiciary. Auto Insurance Liability. Hearings before the subcommittee on Antitrust and Monopoly on S. Res. 40. 91st Cong., 1st sess., 1969.

U.S. Department of Agriculture. Crop Reporting Board. Agricultural Prices, Annual Summary 1982. Washington, D.C.: Crop Reporting Board Publications, June 1983.

________. Economic Research Service. Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1981. ECIFS1-2. Washington, D.C.: U.S. Government Printing Office, October 1982.

U.S. Department of Commerce. Bureau of the Census. 1978 Census of Agriculture, Virginia. AC76-A-46. vol. 1 pt. 46. Washington, D.C.: U.S. Government Printing Office, 1981.

________. ________. 1982 Census of Agriculture, Virginia. AC82-A-46. vol. 1. pt. 46. Washington, D.C.: U.S. Government Printing Office, 1984.

________. ________. 1972 Census of Mineral Industries. MIC72(1)-1. Washington, D.C.: U.S. Government Printing Office, December 1975.

________. ________. State Government Finances in 1982. GF83. No. 3. Washington, D.C.: U.S. Government Printing Office, October 1983.

________. Bureau of Economic Analysis. "County and Metropolitan Personal Income, 1980-82." Survey of Current Business 64 (April 1984): 30-52.

________. ________. 1980 OBERS BEA Regional Projections: Economic Activity in the United States. vol. 1: Methodology, Concepts, and State Data. Washington, D.C.: U.S. Government Printing Office, July 1981.

________. ________. 1980 OBERS BEA Regional Projections: Economic Activity in the United States. vol. 2.: Economic Areas. Washington, D.C.: U.S. Government Printing Office, July 1981.

________. ________. 1980 OBERS BEA Regional Projections: Economic Activity in the United States. vol. 8: Region 5, Southeast. Washington, D.C.: U.S. Government Printing Office, July 1981.

________. ________. RIMS II Regional Input-Output Modeling System. Washington, D.C.: U.S. Government Printing Office, April 1981.

U.S. Department of Energy. Energy Information Administration. Commercial Nuclear Power: Prospects for the United States and the World. Washington, D.C.: U.S. Government Printing Office, November 1983.

________. ________. Nuclear and Alternate Fuels Division. United States Uranium Mining and Milling Industry: A Comprehensive Review. A report to the Congress by The President of the United States. Washington, D.C.: U.S. Government Printing Office, May 1984.

________. ________. Office of Coal, Nuclear, Electric and Alternate Fuels. World Uranium Supply and Demand: Impact of Federal Policies. DOE/EIA-0387. Washington, D.C.: U.S. Government Printing Office, March 1983.

U.S. Department of Energy. Energy Information Administration. Office of Energy Markets and End Use. Monthly Energy Review. DOE/EIA-0035(83/12[4]). Washington, D.C.: U.S. Government Printing Office, March 1984.

________. ________. State Energy Price and Expenditure Report 1970-1981. DOE/EIA-0376(81). Washington, D.C.: U.S. Government Printing Office, June 1984.

________. ________. 1982 Survey of U.S. Uranium Exploration Activity. Washington, D.C.: U.S. Government Printing Office, August 1983.

________. ________. 1982 Survey of U.S. Uranium Exploration Activity. Washington, D.C.: U.S. Government Printing Office, September 1983.

________. Grand Junction Area Office, Colorado. Statistical Data of the Uranium Industry. GJO-100(83). Grand Junction, CO: Bendix Field Engineering Co., 1 January 1983.

U.S. Department of Labor. Bureau of Labor Statistics. Consumer Price Index. Washington, D.C.: Bureau of Labor Statistics, 1981-84.

U.S. Environmental Protection Agency. Final Environmental Impact Statement for Standards for the Control of Byproduct Materials from Uranium Ore Processing (40 CFR 192). vols. 1 and 2. EPA-520/1-83-008-1 and -2. Washington, D.C.: Office of Radiation Programs, September 1983.

________. Office of Radiation Programs. Regulatory Impact Analysis of Final Environmental Standards for Uranium Mill Tailings at Active Sites. EPA 520/1-83-010. Washington, D.C.: Office of Radiation Programs, September 1983.

U.S. Nuclear Regulatory Commission. Environmental Assessment related to the Operation of Hansen Uranium Mill Project. WM-24. NUREG-0749. Cyprus Mines Corporation, January 1981.

________. Office of Nuclear Material Safety and Safeguards. Final Environmental Statement Related to Operation of Moab Uranium Mill. NUREG-0453. Springfield, VA: National Technical Information Service, January 1979.

________. ________. Final Generic Environmental Impact Statement on Uranium Milling. Project M-25. NUREG-0706. app. A-F. vol. 2. Washington, D.C.: U.S. Government Printing Office, September 1980.

U.S. Nuclear Regulatory Commission. Office of Nuclear Material Safety and Safeguards. Final Generic Environmental Impact Statement on Uranium Milling. Project M-25. NUREG-0706. app. G-V. vol. 3. Washington, D.C.: U.S. Government Printing Office, September 1980.

_________. Office of Nuclear Regulatory Research. Division of Safeguards, Fuel Cycle and Environmental Research. The Social and Economic Effects of the Accident at Three Mile Island: Findings to Date. By C. B. Flynn and J. A. Chalmers. NUREG/CR-1215. Washington, D.C.: U.S. Government Printing Office, January 1980.

_________. Reactor Safety Study. An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants. app. VI. October 1975.

_________. Three Mile Island: A Report to the Commissioners and to the Public. vol. 2. pt. 2. Washington, D.C.: U.S. Government Printing Office, 1979.

U.S. Office of Personnel Management. Federal Civilian Workforce Statistics: Annual Report of Employment by Geographic Area. 31 December 1979.

_________. Federal Civilian Workforce Statistics: Annual Report of Employment by Geographic Area. 31 December 1980.

Vannate, Robin L.; Marshall, G.W.; Cummins, K.W.; Sedell, J.R.; and Cushing, C.E. "The River Continuum Concept." Canadian Journal of Fisheries and Aquatic Sciences 37, 1 (1980): 130-137.

Varian, Hal. Microeconomic Analysis. New York: W.W. Norton & Co., 1978.

Virginia Coal and Energy Commission. Agreement or Non-Agreement Status: Options for Virginia. Presented to Uranium Administrative Group by The Agreement/Non-Agreement Subcommittee, 18 November 1983.

Virginia Department of Education. Facing Up-17, Statistical Data on Virginia's Public Schools, 1981-82 School Year. Richmond, VA: Division of Management Information Services, March 1983.

Virginia Department of Planning and Budget. Economic Research Section. Projections and Economic Base Analysis: Halifax-South Boston Area. Richmond, VA: Virginia Department of Planning and Budget, December 1976.

Virginia Department of Taxation. Local Tax Rates, Tax Year-1983. Richmond, VA: Virginia Department of Taxation, 1983.

_________. Virginia Retail Sales and Use Tax Regulation 1-63. Richmond, VA: Virginia Department of Taxation, January 1979.

________. Virginia Retail Sales and Use Tax Regulation 1.65.2: Mining and Milling Processing. Richmond, VA: Virginia Department of Taxation, 15 March 1983.

________. 1982 Virginia Assessment/Sales Ratio Study. (Richmond, VA: Department of Taxation, March 1984).

Virginia Division of State Planning and Community Affairs. Projections and Economic Base Analysis: Danville-Pittsylvania Area. Richmond, VA: Virginia Divisioin of State Planning and Community Affairs, March 1973.

Virginia Employment Commission. 1982 Wage Survey of Selected Manufacturing Occupations. Richmond, VA: Virginia Employment Commission, February, 1983.

________. 1981 Wage Rates and Fringe Benefits. Richmond, VA: Virginia Employment Commission, October 1981.

________. Manpower Research Division. Covered Employment and Wages, 1982. Richmond, VA: Virginia Employment Commission, 1982.

________. Manpower Research Division. Covered Employment and Wages, 1983. Richmond, VA: Virginia Employment Commission, 1983.

________. Confidential E.S. 202, First quarter of 1983.

Ware, Peggy M. Virginia: An Outline of State and Local Taxes. Richmond, VA: Division of Industrial Development, June 1984.

Wieand, Kenneth. "Air Pollution and Property Values: A Study of the St. Louis Area." Journal of Regional Science 13 (April 1973): 91-96.

Williams, Alan. "A Note on 'Trying to Value a Life.'" Journal of Public Economics 12 (October, 1979): 257-258.

Yokell, Michael D. Environmental Benefits and Costs of Solar Energy. Lexington, MA: D. C. Heath & Company, 1980.