draft

NUREG-0504

environmental statement

related to operation of

PLATEAU RESOURCES LIMITED

SHOOTERING CANYON URANIUM PROJECT

FEBRUARY 1979

Docket No. 40-8698

7903020161

U. S. Nuclear Regulatory Commission • Office of Nuclear Material Safety and Safeguards

NUREG-0504

DRAFT ENVIRONMENTAL STATEMENT

related to the

Plateau Resources Limited
SHOOTERING CANYON URANIUM PROJECT
(Garfield County, Utah)

Docket No. 40-8698

February 1979

Prepared by the
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUMMARY AND CONCLUSIONS

This Draft Environmental Statement was prepared by the staff of the U.S. Nuclear Regulatory Commission and issued by the Commission's Office of Nuclear Material Safety and Safeguards.

1. This action is administrative.

2. The proposed action is the issuance of a Source Material License to Plateau Resources, Ltd., for the construction and operation of the proposed Shootering Canyon Uranium Project with a product (U_3O_8) production limited to 2.2×10^5 kg (4.9×10^5 lb) per year.

3. The following is a summary of environmental impacts and adverse effects.

   a. Impacts to the area from the operation of the Shootering Canyon Uranium Project will include the following:

      - Alterations of up to 140 ha (350 acres) that will be occupied by the mill, mill facilities, borrow areas, tailings areas, and roads.

      - An increase in the existing background radiation levels of the mill area as a result of continuous but small releases of uranium, radium, radon, and other radioactive materials during construction and operation.

      - Socioeconomic effects on the local area, particularly the proposed community of Ticaboo, where the majority of workers will be housed during project construction and operation.

      - Production of solid waste material (tailings) from the mill at a rate of about 680 MT (750 tons) per day and deposition as a slurry in an onsite impoundment area.

   b. Surface water will not be affected by normal milling operations. Mill process water will be taken from the Navajo aquifer, and process water will be discharged to the tailings impoundment at about 0.68 m^3 (150 gal) per minute. Some 6.9×10^5 m^3 (560 acre-ft) of water per year will be utilized by the mill.

   c. There will be no planned discharge of liquid or solid effluents from the mill and tailings site. The discharge of pollutants to the air will be small and the effects negligible. The estimated total annual whole-body and organ dose commitments to the population near the mill site are presented below. Natural background doses are also presented for comparison. The dose commitments from normal operations of the proposed Shootering Canyon mill will represent only very small increases in doses from current background radiation sources.

   d. Construction and operation of the Shootering Canyon mill will require the commitment of small amounts of chemicals and fossil fuels, relative to their abundance.

   e. Construction and operation of the Shootering Canyon mill will provide employment and induced economic benefits for the region but may also result in some socioeconomic stress.

   f. The tailings disposal impoundment, occupying up to 28 ha (70 acres) when filled with tailings solids, may be unavailable for further productive use. However, when reclamation is completed and testing shows that radiation levels have been reduced to acceptable levels, it may be possible to return the tailings area to its former use as potential grazing land. After reclamation, the area topography will be similar to its present state.

Annual population dose commitments[a] within an 80-km (50-mile) radius of the mill site

Receptor organ	Dose (man-rems/per year)	
	Plant effluents	Natural background[b]
Total body	1.50	329
Lung	10.5	329
Bone	6.13	329
Bronchial epithelium	66.0	1631

[a] Based on a projected year 2000 population of 3264.

[b] The estimated natural background dose rate to the whole body is 101 millirems/year. The bronchial epithelium dose from naturally occurring radon-222 is assumed to be 500 millirems/year (Sect. 2.10).

4. Principal alternatives considered are as follows:

   a. alternative sites for the mill,

   b. alternative mill processes,

   c. alternative of using an existing mill,

   d. alternative methods of tailings management,

   e. alternative energy sources, and

   f. alternative of no licensing action on the mill.

5. The following Federal, State, and local agencies have been asked to comment on this Draft Environmental Statement:

   Department of Commerce
   Department of the Interior
   Department of Health, Education, and Welfare
   Federal Energy Regulatory Commission
   Department of Energy
   Department of Transportation
   Environmental Protection Agency
   Department of Agriculture
   Advisory Council on Historic Preservation
   Department of Housing and Urban Development
   Utah State Planning Coordinator

6. This Draft Environmental Statement was made available to the public, to the Environmental Protection Agency, and to other specified agencies in February 1979.

7. On the basis of the analysis and evaluation set forth in this Environmental Statement, it is proposed that any license issued for the Shootering Canyon mill should be subject to the following conditions for the protection of the environment:

   a. The applicant shall construct a tailings disposal facility that will incorporate the features described in Alternative 1 of Sect. 10.3 and in Sect. 3.2.4.7 and that will meet the safety criteria specified in NRC Regulatory Guide 3.11.

b. The applicant shall control release of airborne particulates from tailings by use of a water sprinkler system, chemical stabilization, covering with soil, or other equivalent means until reclamation of the tailings is completed.

c. The applicant shall implement the environmental monitoring program described in Table 6.2 of this document. The applicant shall establish a control program that shall include written procedures and instructions to control all environmental monitoring prescribed herein and shall provide for periodic management audits to determine the adequacy of implementation of these environmental controls. The applicant shall maintain sufficient records to furnish evidence of compliance with these environmental controls. In addition, the applicant shall conduct and document an annual survey of land use in the area surrounding the proposed project.

d. Before engaging in any activity not assessed by the NRC, the applicant shall prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not assessed or that is greater than that assessed in this Environmental Statement, the applicant shall provide a written evaluation of such activities and obtain prior approval of the NRC for the activity.

e. The applicant shall immediately notify the Office of the State Archaeologist if artifacts are discovered during construction of the mill or tailings disposal areas and shall have an archaeological survey performed prior to disturbing any previously unsurveyed areas.

f. If unexpected harmful effects or evidence of irreversible damage not otherwise identified in this Environmental Statement are detected during construction and operation, the applicant shall provide to the NRC an acceptable analysis of the problem and a plan of action to eliminate or reduce the harmful effects or damage.

g. The applicant shall provide for stabilization and reclamation of the mill site and tailings disposal areas and mill decommissioning as described in Sects. 3.3 and 10.3 of this document.

h. The applicant shall provide surety arrangements to ensure completion of the mill site and tailings area stabilization, reclamation, and decommissioning plans.

8. The proposed position of the NRC is that, after weighing the environmental, economic, technical, and other benefits of the operation of Shootering Canyon Uranium Project against environmental and other costs and after considering available alternatives, the action called for under the National Environmental Policy Act of 1969 and 10 CFR Part 51 is the issuance of a Source Material License subject to conditions 7a through 7h, above.

As announced in a *Federal Register* notice dated 3 June 1976 (41 FR 22430), the NRC is preparing a generic environmental statement on uranium milling. Although it is the NRC's position that the tailings impoundment method discussed in this Statement represents the most environmentally sound and reasonable alternative now available at this site, any NRC licensing action may be subject to revision in accordance with the conclusions of the final generic environmental impact statement and any related rule making.

CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

FOREWORD

This Draft Environmental Impact Statement is issued by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Material Safety and Safeguards, in response to the request by Plateau Resources, Ltd., for the issuance of an NRC Source Material License, authorizing operation of the mill proposed for the Shootering Canyon Uranium Project. This document has been prepared in accordance with Commission regulation 10 CFR Part 51, which implements requirements of the National Environmental Policy Act of 1969 (NEPA; P.L. 91-190). The mill will be owned and operated by Plateau Resources, Ltd. (the applicant).

The NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the nation may

- fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
- assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;
- attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
- preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice;
- achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities; and
- enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of the NEPA calls for preparation of a detailed statement on

(i) the environmental impact of the proposed action,
(ii) any adverse environmental effects that cannot be avoided should the proposal be implemented,
(iii) alternatives to the proposed action,
(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
(v) any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

Pursuant to 10 CFR Part 51, the NRC Division of Fuel Cycle and Material Safety prepares a detailed statement on the foregoing considerations with respect to each application for a Source Material License for a uranium mill.

In accordance with 10 CFR Part 40, Section 31, the applicant has submitted an Environmental Report to the NRC as part of its license application. In conducting the required NEPA review, Commission representatives (the staff) met with the applicant to discuss items of information in the Environmental Report, to seek additional information that might be needed for an adequate assessment, and generally to ensure that the Commission has a thorough understanding of the project. In addition, the staff sought information from other sources to assist in the evaluation, conducted field inspections of the project site and surrounding area, and met with State and local officials charged with protecting State and local interests. On the basis of the foregoing activities and other such activities or inquiries as were deemed useful and appropriate, the staff has made an independent assessment of the considerations specified in Section 102(2)(C) of the NEPA.

That evaluation has led to the issuance of this Draft Environmental Statement (DES) by the Office of Nuclear Material Safety and Safeguards. The DES has been distributed to Federal, State, and local governmental agencies and to other interested parties for comment. A summary notice has been published in the *Federal Register* regarding the availability of the applicant's Environmental Report and this DES. Comments should be addressed to

Director, Division of Fuel Cycle and Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

After comments on the DES have been received and considered, the staff will prepare a final Environmental Statement that includes discussion of questions and comments submitted by reviewing agencies or individuals. Further environmental considerations are made on the basis of these comments and combined with the previous evaluation; the total environmental costs are then evaluated and weighed against the environmental, economic, technical, and other benefits to be derived from the proposed project. The consideration of available alternatives and environmental costs and benefits provides a basis for denial or approval of the various Federal actions, with appropriate conditions to protect environmental values.

Single copies of this DES, NUREG-0504, may be obtained by writing

Division of Technical Information and Document Control
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

1. INTRODUCTION

1.1 THE APPLICANT'S PROPOSAL

Pursuant to Title 10, *Code of Federal Regulations* (CFR), Part 40.31 and to 10 CFR Part 51, Plateau Resources Limited (the applicant), on May 5, 1978, applied to the Nuclear Regulatory Commission (NRC) for an NRC Source Material License to construct and operate a uranium processing mill. This mill, hereafter referred to as the Shootering Canyon Uranium Project, will process ores from independent and company-owned mines.

This project will consist of construction and operation of a mill with a nominal processing capacity of 680 metric tons (MT) (750 tons) of dry ore per day. The design capacity of 717 MT (790 tons) per day allows for plant shutdowns while still maintaining the nominal production schedule.

The applicant presently controls by ownership, lease, or contract, ore reserves containing approximately 2500 MT (2800 tons) of uranium oxide (U_3O_8) with an average ore grade of 0.10%. For purposes of calculation, an operating schedule of 24 hr/day, 365 days per year was assumed. The mill is designed for 90% U_3O_8 recovery. At this schedule, there are over ten years of proven ore supply. The applicant has designed for a 15-year project lifetime with the expectation that other ore sources will be discovered or purchased later. Based on these figures, the mill will produce about 224 MT (247 tons) of U_3O_8 per year. Details are given in Sect. 3.2.

Waste materials (tailings) from the mill will be produced at a rate of about 680 MT (750 tons) of solids per day and stored in a tailings impoundment. The storage capacity has been designed for 20 years in case additional ore is located during the 15 years of planned project operation. Details of the design and operation of the tailings disposal system are given in Sect. 3.2.5.

In accordance with NRC Guides 3.5 and 3.8, the applicant has submitted a Source Material License Application (Form NRC-2),[1] an Environmental Report (ER),[2] supplements to the ER in response to questions by the NRC staff, and a tailings management plan including geotechnical engineering studies.[3] In this Environmental Statement, the ER is cited extensively; however, its full title and documentation are given only in the list of references for Sect. 1. Hereinafter the applicant's Environmental Report will be cited parenthetically as ER, with section, page, figure, table, appendix, and/or supplement number.

1.2 BACKGROUND INFORMATION

The proposed Plateau Resources, Ltd., mill will be located in Garfield County, Utah, about 21 km (13 miles) north of Bullfrog Basin Marina and about 77 km (48 miles) south of Hanksville, Utah (Fig. 1.1). Ore for the mill will be provided through an existing ore buying station near Blanding in San Juan County, Utah (Fig. 2.1), and applicant-owned mines located about 5.6 km (3.5 miles) north of the planned mill (Fig. 1.1). The buying station, owned by the applicant, purchases ore from independent mines.

The surface area of the project site is controlled by mill site claims. The mill and tailings impoundment will occupy about 46 ha (114 acres) of the site. At the end of the proposed 15-year project lifetime, the reclaimed tailings impoundment will occupy approximately 28 ha (70 acres).

A proposed new town, Ticaboo, to be located about 4.2 km (2.6 miles) south of the plant site, will occupy an additional 260 ha (640 acres). Although not the subject of licensing action, the socioeconomic impacts of Ticaboo will be discussed in detail.

ES-4666

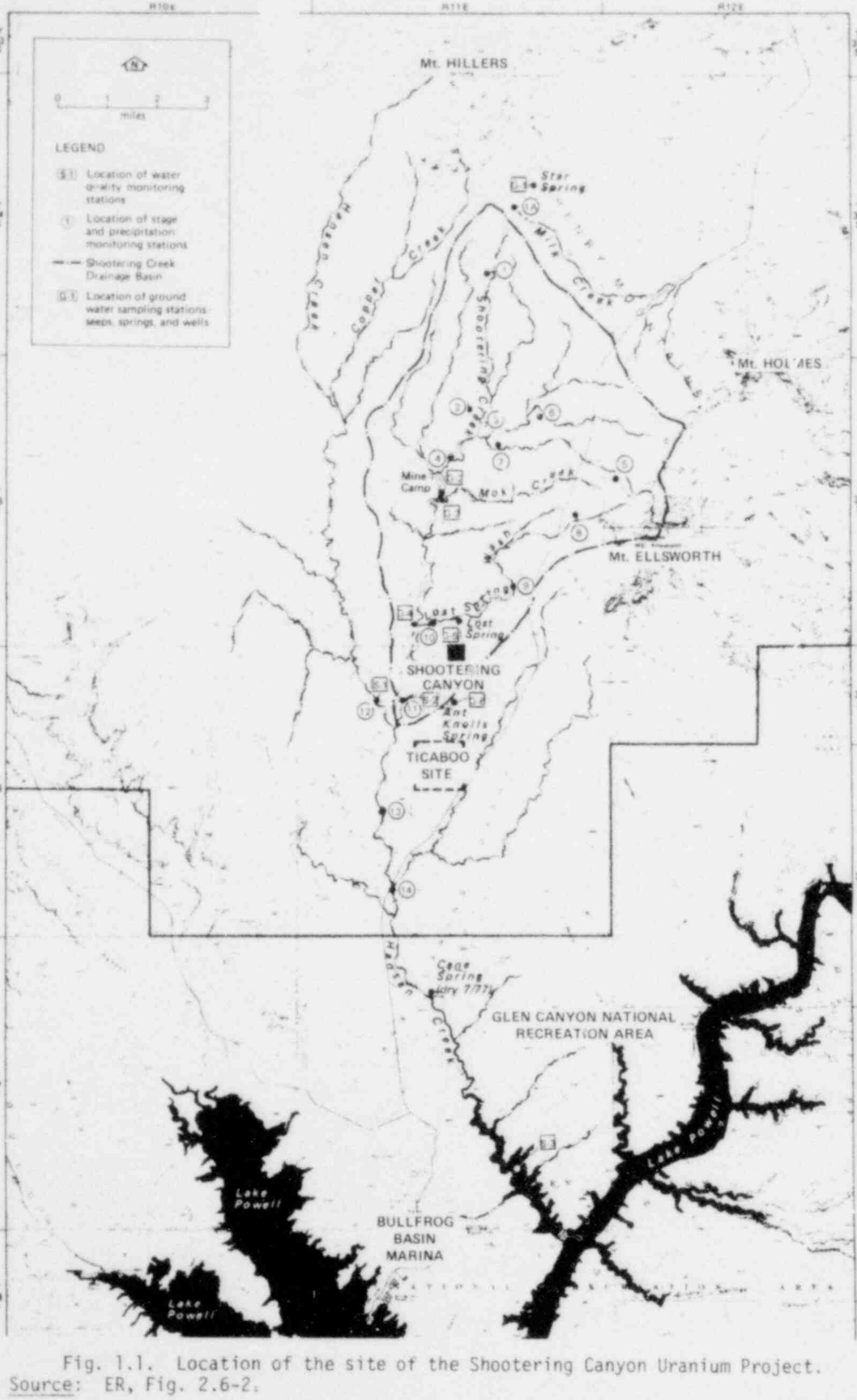


Fig. 1.1. Location of the site of the Shootering Canyon Uranium Project. Source: ER, Fig. 2.6-2.

The purpose of this Environmental Statement is to discuss in detail the environmental effects of project construction and operation as well as monitoring and mitigating measures proposed to minimize the effects of the overall project on the immediate area and surrounding environs.

1.3 FEDERAL AND STATE AUTHORITIES AND RESPONSIBILITIES

Under 10 CFR Part 40, an NRC license is required in order to "receive title to, receive, possess, use, transfer, deliver ... import ... or export ... source material ..." (i.e., uranium and/or thorium in any form containing 0.05% or more of uranium, thorium, or combinations thereof). Part 51 of 10 CFR provides for the preparation of a detailed Environmental Statement pursuant to the National Environmental Policy Act of 1969 (NEPA) prior to the issuance of an NRC license to authorize uranium milling.

The NEPA became effective on January 1, 1970. Pursuant to Section 102(2)(C), in every major Federal action significantly affecting the quality of the human environment, Federal agencies must include a detailed statement by the responsible official on

1. the environmental impact of the proposed action,
2. any adverse environmental effects that cannot be avoided should the proposal be implemented,
3. alternatives to the proposed action,
4. the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
5. any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

This detailed Environmental Statement has been prepared in response to the above requirements.

The State of Utah implements other rules and regulations affecting the project through necessary permits and approvals provided by State agencies. The Utah Division of Oil, Gas, and Mining is the responsible agency for all mine and mill sites within the State under the "Utah Mined Land Reclamation Act of 1975." Title II of the "Uranium Mill Tailings Radiation Control Act of 1978" gives the NRC direct licensing authority over uranium mill tailings. Bonding arrangements will be required to assure funding for reclamation of the tailings impoundment and mill site grounds and for decommissioning of the facility.

1.4 STATUS OF REVIEWS AND ACTIONS BY FEDERAL AND STATE AGENCIES

Required Federal regulatory actions include the issuance of a Source Material License by the NRC. In addition, before construction and operation of the Shootering Canyon Uranium Project can be completely implemented, the State of Utah requires that permits or licenses be obtained prior to the initiation of various stages of construction and operation of the mill. The current status of these regulatory approvals and permits is given in Table 1.1. The applicant will acquire these approvals and permits as needed.

1.5 NRC MILL LICENSING ACTIONS

In June 1976 [*Fed. Regist.* 41(108): 22430-22431 (June 3, 1976)], the NRC specified that applicants requesting a Source Material License prior to the NRC's issuance of its generic environmental impact statement on uranium milling (scheduled for release in 1979) should address five criteria that will be weighed by the Commission in licensing and relicensing actions. These criteria are considered below as they apply to the Shootering Canyon Uranium Project.

Table 1.1. Status of regulatory approvals and permits required prior to operation of the Shootering Canyon Uranium Project

Permit or license[a]	Granting authority[a]	Status
Right-of-Way Approval	BLM	Applied May 1978
Recording of Mine and Mill Site Claims	BLM	Continuing
Quantity Grant Selection		
Approval to USLB	BLM	Applied April 1978
Approval to Purchase from UU	USLB	Approved March 1978
Construction Approval	USDH-ACC	Approved February 1978
Notice of Construction Commencement	UOSHA	
Appropriation of Water Certificate	USE	Change requested April 1978
Filing of Mine Reclamation Plan	UDNR-DOGM	Filed 1977
Solid Waste Disposal Permit	UBH	
Encroachment Permit	UDT	
Discharge Permit (if required)	UCWP	
Source Material License	NRC	Applied May 1978

[a]Explanation of acronyms and initialisms: BLM, U.S. Bureau of Land Management; USLB, Utah State Land Board; UU, University of Utah, Institutional Council; USDH-ACC, Utah State Division of Health, Air Conservation Committee; UOSHA, Utah Occupational Safety and Health Administration; USE, Utah State Engineers Office; UDNR-DOGM, Utah Department of Natural Resources, Division of Oil, Gas, and Mining; UBH, Utah Board of Health; UDT, Utah Department of Transportation; UCWP, Utah Committee on Water Pollution; and NRC, U.S. Nuclear Regulatory Commission.

1. *It is likely that each individual licensing action of this type would have a utility that is independent of the utility of other licensing actions of this type.*
This statement is manifestly true for uranium mills in general and for the Shootering Canyon mill in particular. This mill is located near mining operations producing low-grade ore (≈0.10%). The costs of hauling this ore over longer distances make this project virtually independent of other milling operations. This milling project can be considered on its own merits, licensing actions with respect to other mills are independent of this mill, and a separate cost-benefit analysis can be performed.

2. *It is not likely that the taking of any particular licensing action of this type during the time frame under consideration would constitute a commitment of resources that would tend to significantly foreclose the alternatives available with respect to any other individual licensing action of this type.*
The proposed action involves the construction and operation of a mill to produce yellow cake (U_3O_8) from local uranium ore bodies. As pointed out in the response to the first criterion, uranium mills are normally located close to economically exploitable ore bodies. The ore would not likely be exploited to provide feed for a more distant mill. As to the commitment of resources, none of the materials involved in the construction and operation of the mill are unique or in short supply; hence, licensing this mill would not affect any licensing action with respect to other mills. Air, land, and water resources would be used locally but not to an extent to preclude the erection and operation of another mill.

3. *It is likely that any environmental impacts associated with any individual licensing action of this type would be such that they could adequately be addressed within the context of the individual license application without overlooking any cumulative environmental impact.*
This Environmental Statement contains an assessment of the environmental impacts associated with the proposed licensing action and their severity, and includes proposed monitoring programs and actions to mitigate the impacts. Cumulative impacts have been addressed within the context of the individual license. The relative isolation of the proposed site virtually ensures that all appropriate environmental impacts can be adequately addressed in this site-specific Environmental Statement. Adverse effects characteristic of all uranium mills will be evaluated in a forthcoming generic environmental statement. The major objective of the generic statement is the generation of proposals to mitigate such effects.

4 *It is likely that any technical issues that may arise in the course of a review of an individual license application can be resolved within that context.*
The applicant has considered alternative mill processes, alternative tailings disposal methods, and other technical issues in its license application and Environmental Report. The staff has reviewed the applicant's evaluations and, in addition, has evaluated other technical issues. All of these evaluations and, presumably, any further technical issues that may arise during review are resolvable within the content of the individual licensing action, inasmuch as this mill is independent of other mills. In addition, the license will be conditioned as required by the *Federal Register* notice of June 3, 1976, to permit revision of waste management and other practices.

5. *A deferral on licensing actions of this type would result in substantial harm to the public interest as indicated above because of uranium fuel requirements of operating reactors and reactors now under construction.*
As previously stated by the NRC,[4] "the full capacity of existing mills will be required to support presently operating nuclear power reactors and those expected to begin operation in 1977." The Shootering Canyon mill is one of a small number of new mills that have been proposed in the last several years, and a deferral of its operation could extend the time required for the delivery of fuel to reactors now operating or under construction. This delay could adversely affect the ability of these reactors to deliver needed electrical power. Such a shortfall of electrical energy is generally construed to be harmful to the public interest (see also Appendix B).

REFERENCES FOR SECTION 1

1. Plateau Resources Limited, *Application for Source Material License, Shootering Canyon Processing Facility, Garfield County, Utah,* May 5, 1978.

2. Plateau Resources Limited, *Environmental Report, Shootering Canyon Uranium Project,* Garfield County, Utah, Docket No. 40-8698, May 1978.

3. Plateau Resources Limited, *Tailings Management Plan and Geotechnical Engineering Studies, Shootering Canyon Uranium Project, Garfield County, Utah,* September 1978.

4. "Uranium Milling, Intent to Prepare a Generic Environmental Impact Statement," *Fed. Regist.* 41: 22430 (1976).

2. THE EXISTING ENVIRONMENT

2.1 CLIMATE

2.1.1 General influences

Although the climate in the vicinity of the Shootering Canyon Uranium Project varies somewhat with elevation and terrain features, it can generally be described as semiarid (steppe). Days are usually clear with abundant sunshine, low annual precipitation, low humidity, and high potential evaporation. Daily ranges in temperature are relatively large, and winds are normally light to moderate. Because synoptic-scale meteorological influences in the region are relatively weak, topography and local micrometeorological effects play an important role in determining the climate.

2.1.2 Temperatures

Although no long-term climatic records are available for the immediate vicinity of the site, records are available for several locations in the general vicinity. Seasons in the region are well defined. Winters are cold though usually not severe, and summers are hot. Interpolation of data from several locations in the region (Table 2.1), which show a reasonably good correlation between temperature and elevation, indicate that the normal mean annual temperature at the site is about 12°C (54°F). January is usually the coldest month, and a normal mean monthly temperature of about -0.6°C (31°F) is estimated for the site. July, generally the warmest month at the site, has an estimated normal mean monthly temperature of about 26°C (78°F). Temperatures above 32°C (90°F) are not uncommon in the summer, but temperatures above 38°C (100°F) are infrequent. Data collected at the site for one year (August 1977-July 1978) show an annual mean temperature of 15.9°C (60.6°F) (Table 2.1). January had a mean temperature of 2.4°C (36.3°F), and the July mean was 30.4°C (86.7°F).

Table 2.1. Normal mean temperatures at selected regional weather stations in the general vicinity of the Shootering Canyon Uranium Project

Station	Elevation, msl		Normal mean temperatures					
			Annual		January		July	
	m	ft	°C	°F	°C	°F	°C	°F
Bullfrog Basin Marina	1165	3822	14.9	58.9	0.6	33.1	29.2	84.5
Bluff	1315	4315	12.6	54.6	−0.5	31.1	25.9	78.7
Estimated for site	1372	4500	12	54	−0.6	31	25.5	78
Capitol Reef National Park	1676	5500	11.8	53.2	−1.3	29.7	24.9	76.9
Escalante	1771	5810	9.2	48.6	−2.8	26.9	21.6	70.8

2.1.3 Precipitation

On the basis of regional records and one year of onsite data (Table 2.2), annual precipitation is estimated to be about 18 cm (7 in.) at the site; however, precipitation is expected to increase with increasing elevation to about 51 cm (20 in.) or more on the upper slopes of Mount Hillers north of the site. During the summer and early fall moist air moves in from the Gulf of Mexico, usually producing precipitation; however, heavy local storms can produce more than 2.5 cm (1 in.) of rain in a single day.

Table 2.2. Normal annual precipitation at selected regional weather stations in the general vicinity of the Shootering Canyon Uranium Project

Station	Elevation, msl		Precipitation	
	m	ft	cm	in.
Bullfrog Basin	1165	3822	13.6	5.35
Bluff	1315	4315	19.2	7.55
Site data	1372	4500	18.0[a]	7.30[a]
Capitol Reef National Park	1676	5500	18.4	7.24
Escalante	1771	5810	28.5	11.22

[a]Based on one year of data – August 1977 through July 1978.

Source: ER, Table 2.7-2 and ER Supplement, Appendix S-2.

2.1.4 Winds

Winds in the region are moderate, with occasional strong winds during late winter and spring frontal activities and during thunderstorm activity in the summer. Spring is generally the region's windy season. Although local winds vary with the seasons and the time of day, the prevailing winds are southwesterly. Summaries of wind direction and wind speed distributions are given in Table D.2 of Appendix D for the first year of actual site data.

2.1.5 Storms

Hailstorms are unusual in this area. Strong winds and thunderstorms can occur in the vicinity of the site in the spring and summer. The maximum precipitation reported to have fallen within 24 hr over a 30-year period at Blanding, Utah, was 5.03 cm (1.98 in.).

The site is susceptible to occasional duststorms, which vary greatly in intensity, duration, and time of occurrence. The basic conditions for blowing dust are found in the general vicinity: wide areas of exposed, dry topsoil and occasional strong, turbulent winds. Duststorms usually occur during the warmer months following frontal passages and occasionally precede thunderstorm activity. Tornadoes have been observed in the general region, but they occur infrequently. (See Sect. 5.1.3.1 for an estimate of the probability.)

2.2 AIR QUALITY

The proposed mill site lies within the jurisdiction of the Four Corners Interstate Air Quality Control Region (AQCR) which encompasses parts of Colorado, Arizona, New Mexico, and Utah. This region has recently been designated as an attainment area for suspended particulate matter, sulfur dioxide, photochemical oxidants, carbon monoxide, and nitrogen dioxide,[1] which indicates that levels of these pollutants in the region are within Federal air quality standards.

The character of the immediate area of the proposed mill site is rural. There are no major urban or industrial air pollutant sources presently operating in the vicinity of the proposed mill. Total suspended particulate matter and sulfur dioxide have been monitored at Bullfrog Basin Marina, approximately 21 km (13 miles) south of the proposed site. Except for the short-term (24-hr) particulate standard, all reported values (ER, Table 2.7-9) were well below the Federal and State of Utah air quality standards. The 24-hr particulate violations are probably related to natural fugitive dust associated with high winds. Sulfur dioxide concentrations at Bullfrog Marina have been below the limit of detection (0.005 ppm) most of the time although infrequent concentrations as high as 0.01 to 0.02 ppm (ER, Sect. 2.7) have been noted.

Total suspended particulate matter was monitored for one year at the applicant's mine camp located approximately 5.6 km (3.5 miles) north of the proposed plant site (ER, Sect. 6.1). The annual geometric mean, 55 $\mu g/m^3$, approached the 60-$\mu g/m^3$ Federal and State of Utah secondary standard for this pollutant. Six of the 48 samples exceeded the 150-$\mu g/m^3$ 24-hr secondary standard, and two (267 $\mu g/m^3$ and 262 $\mu g/m^3$) exceeded the 260-$\mu g/m^3$ 24-hr primary standard. The higher annual geometric mean at the mine camp is likely related to fugitive dust emission from equipment and vehicle activity on dirt roads in the mine camp area. The mine camp is located in a 0.08-km-wide (0.5-mile-wide) canyon with walls 91 to 122 m (300 to 400 ft) above the camp. This topography would tend to decrease the local atmospheric dispersion potential, thereby intensifying the atmospheric pollutants. The proposed plant site is located on a low mesa that rises about 60 m (200 ft) above the valley floor of Shootering Canyon (ER, Sect. 2.4). Therefore, data collected at the mine camp could be higher than what may actually exist at the proposed plant site.

No other air quality data is available for the immediate vicinity of the site. Nitrogen dioxide is monitored at Page, Arizona, the closest reporting station. Results indicate that annual mean concentrations of this pollutant in the region are well below the 100 $\mu g/m^3$ Federal and State standard. Between 1973 and 1976, annual average concentrations ranged between 10 to 24 $\mu g/m^3$ (ER, Table 2.7-11). As a result of possible influences of emissions from the Navajo power generating plant near Page, these data may indicate higher concentrations than occur at the proposed plant site. Ozone, also monitored at Page, has not exceeded the Federal and State standard.

2.3 TOPOGRAPHY

The proposed facility site is located in rugged terrain about 8 km (5 miles) southwest of Mount Ellsworth. The bluffs and mesas in the vicinity are typical of the landscape that characterizes much of southeastern Utah. The proposed tailings impoundment site is in a small, isolated catchment that presently drains into Shootering Creek. The site is bordered on the west by a butte that rises approximately 150 m (500 ft) above the valley floor. Shootering Creek lies just to the west of this butte. The proposed plant site is located on a low mesa that forms the east side of the tailings impoundment. This mesa is approximately 760 m (2500 ft) long, 120 to 240 m (400 to 800 ft) wide, and rises about 60 m (200 ft) above the valley floor of Shootering Canyon.

2.4 DEMOGRAPHY AND SOCIOECONOMIC PROFILE

The proposed mill and mine facilities will be located in the Shootering Creek drainage basin, Garfield County, southeastern Utah, within Townships 35 and 36 South, Range 11 East (Fig. 1.1). Utah Highway 276 will serve as the major access route. An unimproved road in Shootering Canyon now connects the project site to Highway 276 about 6 km (4 miles) south of the proposed ore processing facility (ER, p. 2-1).

The social and economic impacts of the proposed mill and mine operation will be defined primarily by the geographical area of Garfield County, Utah. Regional impacts will primarily affect Garfield, Wayne, and San Juan counties, Salt Lake City, and parts of western Colorado. The major political jurisdictions impacted will be Garfield County, Garfield School District, Kane County, and the State of Utah. If any local special services or taxing jurisdictions are formed, they will receive related impacts.

2.4.1 Demography of the area

2.4.1.1 Current population and distribution

Compared to most eastern states, Utah is rather sparsely populated with a 1977 population of 1,271,300 — a 20% increase since 1970. This population represents an overall density of 39.9 persons per square kilometer (15.4 persons per square mile), but nearly 70% of Utah's population lives in the counties of Salt Lake, Utah, and Weber where Salt Lake City, Provo, and Ogden, respectively, are located.

Although Garfield, Wayne, San Juan, and Kane counties are sparsely populated, they have been experiencing considerable population growth. This growth has been a function of several factors, for example, increased economic opportunities resulting from mining, milling, and increased tourism.

Garfield County, which covers 13,500 km^2 (5217 sq miles), had a 1977 population of 3600, a 14% increase in population since 1970; however, population density remains low with 0.3 persons per square kilometer (0.7 per square mile) (Table 2.3). Approximately 90% of the residents live in the western portion of the county near the major transportation corridor. In 1973 about 40% of the Garfield County population resided in Panguitch; Escalante and Tropic were the next largest towns (ER, p. 2-16). See Fig. 2.1.

Table 2.3. Area population for Wayne, Garfield, San Juan, and Kane counties compared with the State of Utah, 1970 and 1977

County	Land area		Population			Population per given area			
						1970		1977[a]	
	km^2	sq miles	1970	1977[a]	Percentage change	km^2	sq mile	km^2	sq mile
Wayne	6,446	2,489	1,483	1,800	21.4	0.2	0.6	0.3	0.7
Garfield	13,512	5,217	3,157	3,600	14.0	0.2	0.6	0.3	0.7
San Juan	20,419	7,884	9,606	13,000	35.3	0.5	1.2	0.6	1.6
Kane	10,632	4,105	2,421	3,800	57.0	0.2	0.6	0.3	0.9
State total	213,260	82,340	1,059,273	1,271,300	20.0	5.0	12.9	5.9	15.4

[a]Preliminary results.

Source: U.S. Bureau of Census, 1970; Utah Population Work Committee, 1977.

Wayne County, which covers an area of 6450 km^2 (2490 sq miles), had a population of 1800 in 1977. This 21.4% increase since 1970 yields a population density of 0.3 persons per square kilometer (0.7 per square mile) (Table 2.3). Approximately 70% of the population lives in the western part of the county. In 1973, the population centers were Bicknell with 283, Loa with 344, and Torrey with 90 residents (ER, p. 2-16). About 45% of the Wayne County population is composed of Navajo Indians, who live on or near the Navajo Reservation.[2]

San Juan County had a 1977 population of 13,000 residing in an area of 20,400 km^2 (7880 sq miles). The population has increased 35.3% since 1970, giving a population density of 0.6 persons per square kilometer (1.6 per square mile) (Table 2.3). Two communities account for nearly 40% of San Juan County's population — Blanding, with a 1977 population of 3075, and Monticello, the county seat, with 2208 residents.

Kane County, which has an area of 10,620 km^2 (4100 sq miles), had a 1977 population of 3800. This population represents a 57% increase in population since 1970, although density is only 0.3 persons per square kilometer (0.9 per square mile) (Table 2.3).

ES-4587

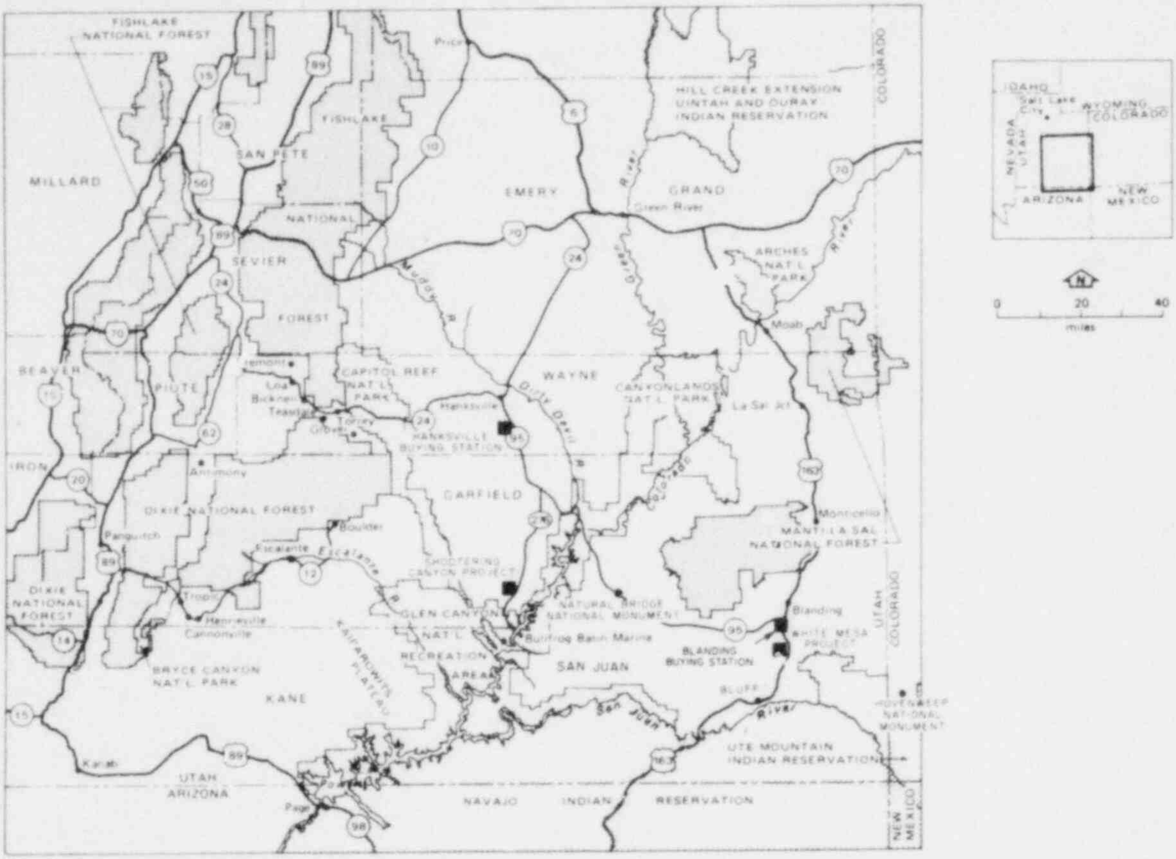


Fig. 2.1. Location of the proposed Shootering Canyon Uranium Project. Source: Modified from the ER, Fig. 2.1-1.

2.4.1.2 Projected population

According to projections prepared by the Utah Agricultural Experimental Station, Utah's population in the year 2000 is expected to be between 1,655,500 and 2,163,900 (Table 2.4). Both extremes of this population range assume a gradual decline in mortality and a constant fertility; however, the high figure also assumes a positive net migration while the low figure is based a net migration of zero.

Garfield County population projections for the year 2000 show a percentage population increase from a low of 37% to a high of 78%. Any major population increase that does occur will most likely be a consequence of the proposed uranium mill project.

2.4.1.3 Transient population

The proposed facility is located near Bullfrog Basin Marina in the Glen Canyon National Recreation Area. Visitation to the recreation area and the marina results in a substantial transient population within the impact area. Total visitation has been increasing over the last ten years for both the recreation area and for Bullfrog Basin Marina. In 1977, visitation for the recreation area was 281,805, a 9% increase over the 1976 visitation figure; in 1977, visitation to the marina was 156,330, a 29% increase. Available data indicate that the 1978 visitation for the whole park and for the marina will be substantially higher than for the previous year. Park officials predict that the current trend will continue unless there is a full-scale energy shortage which could result in drastic use cuts (Bullfrog Unit Manager, National Park Service, personal communication, July 20, 1978). Although the area is used throughout the entire year, visitation is heaviest during March, April, May, and June with the most intense use occurring over the Memorial Day weekend (16,000 people per day at Bullfrog Marina in 1978).

Table 2.4. Population projections,[a] Garfield, Wayne, Kane, and San Juan counties compared with the State of Utah

	1975[b]	1980	1990	2000	Percentage increase, 1975–2000
Garfield County					
High	3,480	3,940	4,670	5,960	71.3
Low	3,470	3,760	4,460	5,120	47.6
San Juan County					
High	12,816	17,373	26,002	33,300	160
Low	12,716	13,954	16,917	19,753	55
Wayne County					
High	1,960	2,660	3,770	4,530	131.1
Low	1,950	2,060	2,310	2,510	28.7
Kane County					
High	3,485	5,096	7,907	10,099	189.8
Low	3,471	3,719	4,335	5,004	44.2
Utah					
High	1,216,843	1,420,553	1,803,985	2,163,927	78
Low	1,206,584	1,302,815	1,484,231	1,655,528	37

[a] High projections assume a gradual decline in mortality, a constant fertility, and a positive net migration. Low projections assume a gradual decline in mortality, a constant fertility, and no net migration.

[b] U.S. Census estimations for 1975 indicate that actual population for the State and the four counties was below the "low" projection presented in this table.

Source: Energy Fuels Nuclear, Inc., *Environmental Report, White Mesa Uranium Project, San Juan County, Utah*, Denver, Jan. 30, 1978.

2.4.2 Socioeconomic profile

2.4.2.1 Social profile

The population characteristics of Garfield County can be summarized as follows: predominately white and of the Mormon faith; a male/female distribution that roughly approximates that of the nation; and an age distribution that shows concentrations in the 35-54 age group and the 6-13 age group. Kane and Wayne counties have similar population characteristics. San Juan County differs in the larger proportion (46%) of its Indian population and the cultural influence of this population.

The Shootering Canyon site is located in the Garfield County School District. The county is run by a three-man Board of Commissioners. Additional county officers include a clerk, assessor, attorney, recorder, treasurer, sheriff, and justice of the peace. The county seat is Panguitch.[3]

2.4.2.2 Economic profile

Garfield County

Garfield County had a labor force of almost 1800 persons during the first quarter of 1978. The county's unemployment rate was 10.5%, about double the State average (Table 2.5). In 1978, 26.9% of the population was employed in government jobs. In the private sector, service activities provided 23.6% of the employment with close to 50 establishments. Manufacturing accounts for 19.4% of Garfield County's nonagricultural jobs. Kaib[illegible] Industries, a sawmill, employed 115 persons. Another sawmill, Stud Enterprises, and a clothing manufacturer, Southern Utah Industries, each employed 45 persons.[4] Other significant employment sectors were trade activities and agriculture.

Table 2.5. Labor force in Wayne, Garfield, Kane, and San Juan counties and the State of Utah in 1978

	Wayne		Garfield		Kane		San Juan		Utah[a]	
	Number	Percentage of nonagricultural	Number	Percentage of nonagricultural	Number	Percentage of nonagricultural	Number	Percentage of nonagricultural	Number	Percentage of nonagricultural
Civilian labor force	982		1766		1217		4489		527,800	
Employed persons	915		1581		1071		4142		497,300	
Unemployed persons	67		185		146		347		30,500	
Unemployment rate, %	6.8		10.5		12.0		7.7		5.8	
Nonagricultural payroll jobs	447	100	1299	100	815	100	2952	100	484,200	100
Manufacturing	29	6.5	252	19.4	103	12.6	197	6.7	74,400	15.4
Mining	50	11.2	48	3.7	4	0.5	935	31.7	14,700	3.0
Construction	69	15.4	62	4.8	5	1.1	155	5.3	30,600	6.3
Transportation, communications, utilities	2	0.4	71	5.5	55	6.7	168	5.7	29,300	6.0
Trade	52	11.6	195	15.0	282	34.6	424	14.4	118,100	24.4
Finance, insurance, real estate	7	1.6	15	1.2	25	3.1	27	0.4	22,100	4.6
Services	24	5.4	306	23.6	88	10.7	322	10.9	80,900	16.7
Government	214	47.9	350	26.9	249	30.5	724	24.5	114,100	23.6

[a]1977 figures.
Source: Utah Department of Employment Security, *Employment Newsletter*, March 1978.

Assessed valuation of Garfield County for 1977 was $14,468,983. The total school levy for that year was 39.00 mills and for the county 12.50 mills. For the proposed new town, Ticaboo (Sect. 2.4.3.4), a mill levy of 51.50 mills on each dollar would be assessed.[3]

Wayne, San Juan, and Kane counties

Wayne, San Juan, and Kane counties had 1978 unemployment rates of 6.8, 7.7, and 12%, respectively, all exceeding the State average of 5.8% (Table 2.5).

Income

In 1977, personal income totaled $7505 million for Utah. Wayne County had $10.9 million, the third lowest in the State. Personal income for Garfield County totaled $17.9 million, while total personal income for Kane and San Juan counties was $14.3 million and $43.8 million respectiv ly.[5]

Per capital income for Utah averaged $5900 in 1977. Garfield, Kane, and San Juan counties were lower than the State average with per capita incomes of $5000, $3700, and $3400 respectively. Wayne County had a per capita income of $6100.[6]

Monthly wages of nonagricultural employees averaged $859 on the State level in 1977. Average monthly wages in Kane, Garfield, Wayne, and San Juan counties were $555, $627, $720, and $842 respectively.[5]

2.4.2.3 Transportation

State highways 95 and 276 are major ground transportation routes from the site to the more populated areas outside of Garfield County. Both roads are recently paved and in good condition. Traffic on the roads is light even under conditions of heavy visitation at Bullfrog Marina. Access to the Garfield County seat of Panguitch is restricted because of the absence of any direct east/west roads. Distances to larger population and service centers outside the county are substantial; Moab, Green River, and Blanding are each over 160 km (100 miles) away. Commercial air service is not available to the area, nor is bus or rail service (Utah Multicounty Planning Commission, personal communication, August 9, 1978). Hanksville does have airport facilities that are run by the State of Utah, and Bullfrog Basin Marina has an airstrip. Use of the Hanksville airport has increased over the last seven years due to increased tourism and mining.[7] Because of the absence of direct roads to the county seat, provisions of services to the eastern part of the county is difficult. In the past, there has been little demand for services because the area was sparsely populated.

2.4.3 Residential options and service availability within commuting range to proposed facility

At present, three population centers provide housing and some services for individuals living and working in the area: Bullfrog Basin Marina, a National Park Service facility; Hanksville, an unincorporated community of 410 people; and the Shootering Canyon mining camp, run by Plateau Resources Limited. These three towns have neither available housing nor services to support the operating force for the Shootering Canyon mill. In addition, a private developer proposes to construct a new town, Ticaboo, near the mill site. After construction of Ticaboo, the mining camp will be shut down.

2.4.3.1 Bullfrog Basin Marina

Bullfrog Basin Marina is located 21 km (13 miles) south of the proposed mill site in the Glen Canyon National Recreation Area in Kane County. The marina consists of several office buildings, a service station and concession, docking facilities, camping sites, a limited number of mobile home units, and several duplexes.

Bullfrog has a permanent resident population of approximately 115, which is composed of 40 park service employees and families, 60 concession employees and families, and 15 State employees and families. In addition, for about eight months of the year, the park service employs 15 additional employees. Seasonal concession employees can number 70. At the peak of the tourist season approximately 200 people may reside at the park facilities (Bullfrog Unit Manager, National Park Service, personal communication, July 20, 1978).

Housing at Bullfrog consists mainly of mobile homes. The National Park Service has two duplexes and is building two more, and the State of Utah has one duplex. Most employees, however, live in trailers. Visitors and contractors working within the recreation area may rent the motel units in the form of single, double, or triplex trailer units. The number of units available varies according to the size of the marina's work force. Expansion of accommodations at the Bullfrog Marina is restricted by the National Park Service. Its own concept plan, however, calls for the construction of a 100-unit motel and a 100-space recreational vehicle park, both to be completed in two years (Utah Multicounty Planning Commission, personal communication, August 9, 1978). These facilities will only be available to park users.

Services at Bullfrog are limited. Until recently a single trailer school and one teacher provided shelter and instruction for school-age children of families working at the park facility and at the Shootering Canyon mine. In anticipation of the construction of Ticaboo and the mill, an additional trailer unit and teacher have been assigned to the park facility. Limited medical services include trained and equipped emergency medical technicians plus occasional visits of a nurse. Commercial services include a convenience store-restaurant and a gas station. There is no commercial power at the park facility. Police protection is provided by the National Park Service.

2.4.3.2 Hanksville

Located 77 km (48 miles) north of the proposed mill in Wayne County on Utah Route 24 at the junction of Utah Route 95 is the unincorporated town of Hanksville, population 410. The population of Hanksville has increased substantially in the last eight years due to increased mining activities, tourism at Lake Powell, and the establishment of a branch office of the Bureau of Land Management (50 employees) near the town (Utah Multicounty Planning Commission, personal communication, August 9, 1978).

Although there is plenty of land available for development, people in the community have been reluctant to sell. Some land speculation has occurred, however, as a consequence of the population growth, and land values have increased. The average price presently for a building lot within the community is $2000 per acre. Farming land is selling for approximately $1000 per acre without water.[7]

Hanksville presently has approximately 150 households, 75 single-family units and 75 mobile homes. The average cost of a new home is approximately $40,000. There are three motels within the city with a total of approximately 30 units.[7]

Although there has been recent development, Hanksville is still limited in the quantity and quality of services that the town can provide without substantial increases in expenditures and considerable activity in the private sector. Although an adequate water supply is available in underlying aquifers, housing availability has been severely restricted by the lack of available public water. The town has recently received a loan from the Utah State Water Resources Board to replace existing water lines and provide 380 m^3 (100,000 gal) of water storage. This loan represents 75% of the estimated cost of $150,000 to $175,000 to build the system. The system should be adequate to serve 650 persons or an increase of approximately 250 persons over the existing population.[8] No central sanitary sewer facilities exist, and there are no plans to construct any. Hanksville does have electric power and telephone services although the former is not adequate to support a large population increase.

Law enforcement is provided by Wayne County and consists of one part-time deputy assigned to the region. The State Highway Patrol also gives some police protection. There are no jail facilities in Hanksville, and violators of the law are transferred to Loa. Hanksville is served by a rural fire protection district. A new building has recently been constructed at a cost of $54,000. A fire truck and ambulance stationed in Hanksville will be stored in the building. The fire truck is a 1956 pumper. There are three volunteers to handle the fire equipment; they receive no remuneration. The Bureau of Land Management also has a pumper truck stationed in Hanksville that can be used for fighting residential fires.[3,7]

Other services include the elementary school, which handles grades K-8. Enrollment is now at capacity with 60 students. High school students are bused to Bicknell, 100 km (60 miles) away. There are three teachers on the Hanksville school staff.[7] The town has one small library located in the church, and it is also serviced once a week by the Utah State Bookmobile. There are no community-owned parks or playgrounds, although there is a small playground adjacent to the school and a cement slab with basketball standards adjacent to the old church.[7] There is no hospital or clinic in Hanksville; only emergency services are available.[3,7]

2.4.3.3 Shootering Canyon mining camp

Located 5.6 km (3.5 miles) north of the proposed site is the Shootering Canyon mining camp. The campsite is in a potential flash flood area. Access to the site is over a graded dirt road. The camp, in existence for two years, provides housing and food for approximately 60 mine employees and their families.[3] The current population is 154. Approximately half of the residents live permanently at the camp, and half commute on a four-days-on, three-days-off schedule.

Housing at the camp consists of trailers. There are minimal services: electricity (provided by a small portable generator), a company mess, and a telephone. The applicant proposes to shut down and dismantle the camp when adequate housing facilities are provided at Ticaboo.

2.4.3.4 Ticaboo

A private developer plans to construct a new town, Ticaboo, approximately 4.2 km (2.6 miles) south of the mill site. The proposed site is in Section 16, Township 36 South, Range 11 East (Fig. 1.1). Adjacent to and west of State Highway 276, both the mill site and the Ticaboo site are geographically isolated from the western portion of Garfield County and from the county seat of Panguitch because there are no direct east/west connecting roads. Table 2.6 lists highway distances to the site and the population of the nearest towns. The Ticaboo site is a school section owned by the State of Utah and leased to the Ticaboo Development Corporation under the provisions of Special Lease Agreement No. 399.

Table 2.6. Highway distances to the Shootering Canyon site

Town	Distance		Population
	km	miles	
Bullfrog Basin	23	14	100–200[a]
Hanksville	77	48	410[b]
Green River	192	119	1302[b]
Bicknell	203	126	382[b]
Loa	214	133	450[b]
Blanding	237	147	3075[c]
Monticello	278	173	2208[c]

[a]Bullfrog Unit Manager, National Park Service, personal communication, July 20, 1978.

[b]Director, Community and Natural Resources Planning, Six County Commissioners Organization, personal communication, Aug. 23, 1978.

[c]Energy Fuels Nuclear, Inc., *Environmental Report, White Mesa Uranium Project, San Juan County, Utah*, Denver, Jan. 30, 1978, p. 2-15.

Surrounded by Federal land under the management and supervision of the Bureau of Land Management, all development for the subdivision with the exception of the sewer lagoon system and the solid waste disposal area will be within the square mile of the school section.

2.5 LAND USE

2.5.1 Land resources

Garfield County [13,430 km^2 (5185 sq miles)] is the fifth largest county in Utah. Approximately 89% of the land (including national parks, forests, recreation areas, and resource lands) is in the public domain. The U.S. Bureau of Land Management (BLM) manages surface and mineral rights on approximately 6.9×10^5 ha (1.71×10^6 acres), % of the total area of Garfield County (ER, Table 2.2-4). These lands are used for recre...on, mineral development, livestock grazing, and resource protection as part of BLM's multiple-use responsibilities (ER, p. 2-22, and ref. 3).

The remainder of the land in Garfield County is owned by the State (7%), by county and local governments (0.01%), and by private individuals (4%). Utah holdings consist of park and recreation lands and school sections. Private ownership, primarily in agricultural land, generally is concentrated in the vicinity of Loa, Bicknell, and Torrey about 113 km (70 miles) northwest of the site, although some ranches and farms are scattered across the county (ER, p. 2-23).

2.5.1.1 Mill ownership

The facility site is located on mill site claims. The major land uses within a 16-km (10-mile) radius of the site are livestock grazing and recreation, including the Glen Canyon National Recreation Area and Lake Powell.

2.5.1.2 Farmlands

Vegetation in the area of the Shootering Canyon Uranium Project is exclusively native, uncultivated, and generally sparse. Studies conducted by the BLM indicate that the grazing potential of the project area ranges from about 0.014 to 0.03 animal unit months per acre;[3] therefore, if a 7.5-month grazing season per year is assumed, 101 to 217 ha (250 to 536 acres) of land are required to support one cow with calf for one year.

2.5.1.3 Urban areas

There are no urban areas within 100 km (60 miles) of the proposed site.

2.5.2 Historical, scenic, and archaeological resources

2.5.2.1 Historical sites

There are no historical sites on or adjacent to the project site. As of November 1978, the closest historic site listed in the "National Register of Historic Places" is the Starr Ranch, located about 13 km (8 miles) north of the site at the base of Mount Hillers. Landmarks of southeastern Utah included in the "National Register" are summarized in Table 2.7.

2.5.2.2 Scenic areas

Southeastern Utah is known for its unusual scenic qualities, in particular the abundance of massive stone arches and other outstanding rock formations. The general area features a uniquely rugged terrain with wide vistas, badlands, and steep canyons.

Canyonlands National Park is an area of unusual and interesting geologic formations, and the Glen Canyon National Recreation Area offers opportunities for water sports on Lake Powell, a man-made lake on the Colorado River. Capitol Reef National Park contains numerous colorful stone formations. At National Bridges National Monument, rock arches span deep canyons, forming the largest natural bridges in the world. These and other natural and scenic landmarks draw visitors to southeastern Utah every year (Fig. 2.1). In addition, the area contains an abundance of Indian ruins and petroglyphs.

2.5.2.3 Archaeological sites

The applicant contracted Archaeological-Environmental Research Corporation of Salt Lake City, Utah, to conduct an archaeological reconnaissance of the site and vicinity. Only one archaeological site, a lithic scatter about 400 m by 100 m, was found. The proposed access road through this site was rerouted to avoid most of the lithic remnants. Artifacts in the small area to be disturbed have been salvaged by the State of Utah.

2.6 WATER

2.6.1 Surface water

The proposed Shootering Canyon Uranium Project will be located in the 84-km^2 (32-sq mile) Shootering Creek drainage basin, in an area that has no nearby permanent bodies of water. This basin is bounded by the Henry Mountains on the north and east and the Hansen Creek drainage basin on the west and south (Fig. 1.1). All streams within the drainage basin containing the facility site, including Lost Spring Wash, Moki Creek, and Shootering Creek, are intermittent, and the nearest large permanent water body is Lake Powell, approximately 16 km (10 miles) south-southwest (ER, Sect. 2.6).

Table 2.7. Historic sites in southeastern Utah included in the "National Register of Historic Places"

Location	Site
San Juan County	
Blanding	Edge of Cedars Indian Ruin
35 miles southeast of Blanding	Hovenweep National Monument
Southeast of Mexican Hat	Poncho House
25 miles southeast of Monticello	Alkali Ridge
30 miles west of Monticello	Salt Creek Archaeological District
Glen Canyon National Recreation Area	Defiance House[a]
14 miles north of Monticello	Indian Creek State Park[a]
Wayne County	
Capital Reef National Park on Utah Route 24	Fruita School House
3 miles southeast of Bicknell	Hans Peter Nielson Gristmill
60 miles south of Green River, in Canyonlands National Park	Harvest Scene Pictograph
Green River vicinity	Horseshoe (Barrier) Canyon Pictograph Panel
Capital Reef National Park	Gifford Barn[a]
Capital Reef National Park	Lime Kiln[a]
Capital Reef National Park	Oyler Tunnel[a]
Garfield County	
40 miles south of Hanksville	Starr Ranch
South of Hanksville	Susan's Shelter
Near Panquitch	Bryce Canyon Airport Hangar

[a]Pending nominations to the "National Register of Historic Places."

Sources: U.S. Department of the Interior, "National Register of Historic Places," *Fed. Regist.* 41(28), Feb. 10, 1976, and subsequent issues through 43(225), Nov. 21, 1978.

Although there are no USGS flow records for the ephemeral streams within the basin, high runoff in these streambeds has been observed following thunderstorms (ER, Sect. 2.6). For example, an estimated 0.3-0.6 cm (0.13-0.25 in.) rainfall on the upper Hansen Creek drainage basin resulted in a flash flood during which water levels in Hansen Creek rose to 0.6 m (2 ft) and the measured flow velocity was 1.8 m/sec (6 fps). Within 45 min, the stage had dropped considerably, and flow velocity was reduced to 0.3 to 0.6 m/sec (1 to 2 fps). Flow from this thunderstorm also occurred in the upper portion of Shootering Creek, but, because of a porous stream channel, the flow had infiltrated into the groundwater before reaching its confluence with Hansen Creek. Thus, substantial surface flows can occur in these stream beds in response to the short, intense thunderstorms that are observed most frequently in this region during summer and early fall. These flows, however, are quickly dissipated, chiefly through percolation into the underlying stream channel.

2.6.1.1 Water use

Potable water is presently drawn from two sources near the proposed facility (ER, Sect. 2.6). Untreated water from well G-3 (Fig. 1.1) is used as drinking water for the mining camp. This well is pumped 9 hr/day at a rate of 0.1 m^3/min (30 gpm). Star Spring, located approximately 15 km (9.4 miles) north of the site, is also used as a potable water supply when treated with iodine. In addition, livestock and wildlife can utilize water from springs, seeps, and intermittent surface flows in the vicinity of the site.

Lake Powell, to the south of the proposed facility, is a multipurpose reservoir. Its uses include the generation of hydroelectric power, swimming, boating, fishing, and public water supply.

2.6.1.2 Water quality

Water quality parameters in Hansen and Shootering creeks were measured for surface flows that followed summer rainstorms. (See Fig. 1.1 for locations of sampling sites.) These flows were quite turbid (greater than 150 Jtu) and contained large concentrations of both suspended and dissolved solids (Table 2.8). Concentrations of total dissolved solids in these samples ranged from 900 to 5391 mg/liter, while total suspended solids concentrations of 48,000 to 590,000 mg/liter give evidence of the highly erosive nature of these flash floods. The chemical composition of the three samples was variable, depending on the products of erosion in that portion of the watershed which had received the rainfall (ER, Sect. 2.6). In all cases, however, sodium and sulfate were the dominant ions (Table 2.8). These "mudflow" conditions shown in Table 2.8 are not presumed to represent baseline water quality; further monitoring requirements are discussed in Sect. 6.3.1.

Streams in the vicinity of the project site have been categorized as Class C waters by the Utah Water Pollution Committee and the Utah Water Pollution Control Board. Waters in this category are to be protected against controllable pollution so as to be suitable, after treatment, for domestic water supplies. In addition, Class C waters should be suitable without treatment for irrigation, stock watering, recreation (except swimming), and the propagation and perpetuation of fish, other aquatic life, and wildlife.[8] Maximum permissible concentrations of various chemical constituents such as sulfates, iron, manganese, and total dissolved solids, however, were exceeded in these samples (ER, Table 2.6-5).

Surface and bottom water samples from the Hansen Creek arm of Lake Powell were also analyzed on a single date in 1977 (Table 2.8 and Fig. 1.1). The dominant ions in this case were sodium, calcium, and sulfate. Lake Powell waters are designated as Class CWR by the aforementioned Utah State agencies (ER, Sect. 2.6). With the exception of more stringent bacterial and recreation criteria, standards for Class CWR waters are equivalent to those for Class C waters.[8] Based on the two samples taken, Lake Powell water generally falls within the criteria established for this category (ER, Table 2.6-5).

2.6.2 Groundwater

Groundwater is an important potential source of water supply in the vicinity of the site because there are few surface water sources. The primary aquifers in the area are the Entrada and Navajo sandstones (see Sect. 2.7.1.2). These aquifers receive most of their recharge from areas of high elevation, and some natural discharge occurs as springs. Groundwater supplies in the area, however, have not been significantly developed because of a lack of users. Groundwater from springs in the area is used by livestock and wildlife while several wells provide potable and industrial water for existing mining activities.

Hydrogeologic characteristics of the underlying formations were determined from pumping tests conducted near the plant site. Groundwater in the Entrada Sandstone was found to occur under confined conditions primarily because of the presence of thin impermeable units (e.g., siltstone or claystone) within the sandstone. The depth to water averaged about 64 m (210 ft) in the test wells, and the hydraulic gradient was to the south at approximately 7.2 m/km (130 ft per mile). As determined from the pump test, permeability averaged 2.64×10^{-5} cm/sec; however, considerable variation (1×10^{-4} to 6.5×10^{-7} cm/sec) was observed during detailed evaluation by packer tests (ER, p. 2-103). Transmissivity was calculated to be 425 m^3/day per meter (130 gpd per foot). Both the low permeability and transmissivity values indicate that the Entrada would be expected to be a low-yielding aquifer in this area.

Table 2.8. Surface water quality at selected locations in the vicinity of the proposed Shootering Canyon Uranium Project

Parameter[a]	Hansen Creek S-1 7/19/77	Shootering Creek S-2 7/19/77	Shootering Creek S-3 8/20/77	Lake Powell surface S-4 8/19/77	Lake Powell subsurface S-4 8/19/77
General characteristics and constituents					
pH, units	6.8	6.9	6.9	8.4	7.9
Oxidation reduction potential,[b] mv	+100	+120		130	+160
Specific conductance, μmhos/cm	5500	3500	1220	870	830
Total dissolved solids	5391	3180	900	589	573
Total suspended solids	592,800	561,800	48,490	15	7
Turbidity, JTU	>150	>150	>150	0.8	1.3
Calculated alkalinity (as $CaCO_3$)	808	627	146	119	136
Calculated hardness (as $CaCO_3$)	2068	1657	619	288	295
Oil and grease	188	131			
COD	304	104	403	7.8	3.8
Major ions					
Calcium	149	309	100	65	69
Magnesium	402	202	6.2	29	27
Sodium	1150	325	139	82	74
Potassium	45	39	30	3.4	3.1
Iron	1.97	0.67	22.0	0.02	0.05
Manganese	3.5	4.6	7.65	<0.001	0.002
Bicarbonate	985	765	178	143	166
Carbonate	0	0	0	1.4	0
Sulfate	3494	2041	457	315	237
Chloride	48	19	6.1	62	51
Fluoride	0.3	0.15	1.02	0.53	0.48
Boron	0.2	0.2	0.2	0.3	0.3
Nutrients					
Total phosphate (as P)	0.3	3.6	0.8	0.5	0.5
Orthophosphate (as P)	0.2	<0.1	0.1	0.1	0.1
Nitrate (as N)	11.7	0.6	4.5	0.6	0.9
Nitrite (as N)	0.1	0.1	0.2	0.1	<0.01
Kjeldahl nitrogen	1.0	33	9.4	0.10	0.10
Ammonia (as N)	0.82	0.25	1.10	0.10	0.10
Trace metals and toxic materials					
Aluminum	2.4	3.0	50	1	2
Antimony	<0.01	0.01	<0.01	<0.01	<0.01
Arsenic	<0.01	0.01	0.07	<0.01	<0.01
Barium	0.06	1.4	6.6	0.5	0.5
Beryllium	0.001	0.001	0.04	<0.001	<0.001
Bromide	0.8	0.6	0.43	0.22	0.38
Cadmium	<0.001	0.001	<0.001	<0.001	<0.001
Cobalt	0.01	0.01	0.10	<0.01	0.01
Chromium	0.005	0.001	0.066	0.003	0.003
Copper	0.019	0.017	0.18	0.002	0.005

Table 2.8 (continued)

Parameter[a]	Hansen Creek S-1 7/19/77	Shootering Creek S-2 7/19/77	Shootering Creek S-3 8/20/77	Lake Powell surface S-4 8/19/77	Lake Powell subsurface S-4 8/19/77
Cyanide	<0.1	<0.1			
Iodide	0.75	1.00	0.07	0.46	0.53
Lead	<0.001	0.001	0.020	<0.001	<0.001
Mercury	0.0007	0.0008	0.0007	0.0005	0.0006
Molybdenum	0.002	0.002	0.002	0.002	0.002
Nickel	0.03	0.02	0.12	<0.01	<0.01
Selenium	0.03	0.03	<0.01	<0.01	<0.01
Silver	<0.01	0.01	<0.01	<0.01	<0.01
Strontium	15.6	24.1	10.3	0.6	0.6
Tin	5	5	5	2	3
Titanium	0.08	0.03	<0.01	0.01	0.01
Vanadium	0.03	0.02	0.45	0.01	0.02
Zinc	0.04	0.05	0.35	<0.01	0.01
Radiological trace elements					
Total uranium (μg/liter)[c]	71	63	46	6	6
Total uranium (μg/liter ± σ)[d]	22 ± 5	13 ± 5	12 ± 6	<5	<5
Total uranium (μg/liter ± σ)[e]	29.3 ± 1.4	12.1 ± 0.6	7.4 ± 0.4	5.43 ± 0.27	4.69 ± 0.23
U-234 (μg/liter ± σ)[e]	0.00351 ± 0.00018	0.00126 ± 0.00007	0.00060 ± 0.00003	0.00046 ± 0.00003	0.00039 ± 0.00002
U-235 (μg/liter ± σ)[e]	0.209 ± 0.011	0.085 ± 0.004	0.0521 ± 0.0026	0.0395 ± 0.0020	0.0335 ± 0.0016
U-238 (μg/liter ± σ)[e]	29.1 ± 1.4	12.0 ± 0.6	7.3 ± 0.4	5.39 ± 0.27	4.66 ± 0.23
Ra-226 (pCi/liter ± σ)[f]	0.4 ±0.1	0.5 ± 0.1	0 ± 0.05	0.08 ± 0.04	0 ± 0.04
Ra-228 (pCi/liter ± σ)[f]	0 ± 4	0 ± 2	0 ± 1	0 ± 1	0 ± 1
R-222 (pCi/liter ± σ)[f]	145 ± 7	108 ± 5	42 ± 4	0 ± 2	0 ± 2
Th-230 (pCi/liter ± σ)[f]	0 ± 0.1	0.2 ± 0.1	0.3 ± 0.1	0 ± 0.06	0 ± 0.07
Th-232 (pCi/liter ± σ)[f]	0 ± 0.1	0 ± 0.1	0 ± 0.1	0 ± 0.05	0 ± 0.07
Gross α (pCi/liter ± σ)[f]	0 ± 13	0 ± 11	4 ± 2	0 ± 3	7 ± 2
Gross β (pCi/liter ± σ)[f]	82 ± 10	84 ± 8	27 ± 3	13 ± 2	19 ± 3
Bacteria (colonies per 100 ml)					
Total coliforms			4100	<1	<1
Fecal coliforms	530	1070	3700	<1	<1
Fecal streptococci			6700	<1	<1

[a] Values expressed as milligrams per liter unless otherwise stated. Analyses conducted by Controls for Environmental Pollut[illegible], Inc. (CEP), Santa Fe, New Mexico.

[b] Field measurement by Woodward-Clyde Consultants.

[c] As determined by CEP using atomic absorption spectroscopy.

[d] As determined by LFE Corporation, Richmond, California, using fluorometric techniques.

[e] As determined by LFE using mass spectrometry.

[f] Analysis conducted by LFE.

The pump tests indicated that the Carmel Formation serves as an aquaclude between the Entrada and Navajo sandstones. No drawdown was observed in wells completed in the Entrada and the Carmel formations during pumping of the Navajo sandstone aquifer (ER, p. C2-61). Depth to water in the Navajo averaged approximately 140 m (450 ft) and is confined under artesian conditions. The hydraulic gradient is to the south at approximately 12 m/km (65 ft/mile), and discharge from this aquifer is into Lake Powell. As determined from the pump test, permeability averaged 1.12 x 10^{-3} cm/sec, and transmissivity was calculated to be 62,130 m^3/day per meter (19,000 gpd per foot). These values indicate that the Navajo Sandstone is a much higher-yielding aquifer than the Entrada Sandstone.

Groundwater quality in the area was determined by sampling and analyses from springs and wells in the area. Locations of these sources are shown in Fig. 1.1, and the results of the analyses are presented in Table 2.9. Although water from the springs is generally suitable for both livestock and drinking water purposes, selenium concentrations exceeded the recommended limits for both of these uses at Star Spring (G-1) and Lost Spring (G-5). At Ant Knolls Spring (G-6), the concentrations of iron and manganese were present in amounts greater than those recommended for public water supply, and the mercury concentration was greater than that recommended for livestock waters. Well G-2 is completed in the Entrada Sandstone, and water from this well exceeds the drinking water standards for total dissolved solids, iron, and sulfate. The Navajo Sandstone is the source of water for Well G-3 and water from this well meets both livestock and drinking water standards.

2.7 GEOLOGY, MINERAL RESOURCES, AND SEISMICITY

2.7.1 Geology

2.7.1.1 Regional geology

The proposed project site is located within the Canyonlands section of the Colorado Plateau physiographic province in southeastern Utah.[5] In this area, thousands of feet of pre-Tertiary sedimentary rocks have been uplifted and moderately deformed resulting in numerous local structures such as upwarps, monoclines, and basins. Additionally, igneous intrusions have produced several domal uplifts in the region. Subsequent erosion has removed most of the post-Jurassic rocks leaving a landscape characterized by deep canyons, mesas, and buttes.

As shown in Fig. 2.2, the site is located within the Henry Mountains Basin, which is bounded on the west by the Waterpocket Fold (monocline) and on the east by the Monument Upwarp. Elevations within the basin range from 1200 to 2100 m (4000 to 7000 ft). The Henry Mountains, which include Mt. Ellsworth (Fig. 2.2), are located within the basin. Major peaks rise 1200 to 1500 m (4000 to 5000 ft) above the surrounding basin.

2.7.1.2 Site geology

The site for the proposed project is located in an area characterized by buttes, mesas, and canyons, approximately 8 km (5 miles) southwest of Mt. Ellsworth (Fig. 1.1). The project area includes a low mesa on which the proposed mill will be located and a small drainage basin, which will contain the proposed tailings impoundment. To the west, a tall butte separates the site from Shootering Canyon. Drainage from the site is to the southwest into Shootering Creek. Local relief in the area ranges from 60 to 150 m (200 to 500 ft).

In this area, the geologic structure is relatively simple with the various sedimentary formations dipping gently (approximately 2°) to the west. Sedimentary rocks exposed at the surface are predominantly sandstones of Upper Jurrasic age. The high buttes and mesas west and north of the site are capped by the Salt Wash Member of the Morrison Formation (ER, p. 2-50). This sandstone unit contains the uranium deposits that are mined in the area. Exposed cliffs surrounding the buttes and mesas are generally comprised of the Summerville and Entrada sandstone formations.

The bedrock underlying the site is the Entrada Sandstone, a generally massive, fine-grained sandstone cemented with calcite. In the vicinity of the site, the Entrada Sandstone is approximately 140 m (450 ft) thick (ER, p. 2-62). Beneath the Entrada lies the Carmel Formation, a heterogeneous unit approximately 66 m (215 ft) thick composed of sandstone, siltstone,

Table 2.9. Groundwater quality at selected locations in the vicinity of the proposed Shootering Canyon Uranium Project

Parameter[a]	Star Spring G-1 7/20/77	Camp Well G-2 8/19/77	Camp Well G-3 8/19/77	Seep Along Shootering Creek G-4 7/19/77	Lost Spring G-5 7/20/77	Ant Knolls Spring G-6 8/19/77
General constituents						
pH, units	7.8	8.2	8.1	7.5	8.0	7.9
Oxidation reduction potential,[b] mV		+170	+175			+95
Specific conductance, μmhos/cm	300	900	530	4000	250	365[b]
Total dissolved solids	194	648	333	3486	142	
Total suspended solids	<1	10	8	3054	7	
Turbidity, JTU	3.8	3.0	0.65	>150	8.0	
Calculated alkalinity (as $CaCO_3$)	111	156	153	118	99	195
Calculated hardness (as $CaCO_3$)	144	156	78	1243	109	317
Oil and grease	29			10	45	
COD	48	27	12	128	64	4.0
Major ions						
Calcium	44	26	19	320	23	69
Magnesium	6.5	20	18	77	12	21
Sodium	6.9	150	59	708	7	19
Potassium	0.4	5.5	5.2	22	2.1	4.8
Iron	0.13	0.85	0.15	[illegible]	0.03	0.82
Manganese	0.009	0.004	0.002	0.82	0.010	0.136
Bicarbonate	136	190	187	144	121	238
Carbonate	0	0	0	0	0	0
Sulfate	33	310	99	2377	11	24
Chloride	2.2	11	7.1	26	3.6	12
Fluoride	0.18	0.53	0.45	0.44	0.09	1.31
Boron	0.2	0.5	0.2	0.2	0.3	0.3
Nutrients						
Total phosphate (as P)	0.4	0.4	0.5	0.8	0.6	0.7
Orthophosphate (as P)	<0.1	0.1	<0.1	<0.1	<0.1	0.2
Nitrate (as N)	0.2	1.8	1.5	1.8	0.6	2.7
Nitrite (as N)	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
Kjeldahl nitrogen	1.1	0.38	1.08	3.4	6.0	2.8
Ammonia (as N)	0.07	0.11	0.10	<0.01	0.22	0.25
Trace metals and toxic materials						
Aluminum	<0.1	1	0.8	14.7	0.2	10
Antimony	<0.01	<0.01	<0.01	<0.01	<0.01	<0.0
Arsenic	<0.01	<0.01	<0.01	<0.01	0.01	0.04
Barium	<0.1	0.5	0.5	0.2	0.3	0.7
Beryllium	0.001	<0.001	<0.001	0.003	0.001	<0.001
Bromide	0.1	0.32	0.25	0.9	0.3	0.88
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.00
Cobalt	<0.01	<0.01	<0.01	0.01	<0.01	<0.01

Table 2.9 (continued)

Parameter[a]	Star Spring G-1 7/20/77	Camp Well G-2 8/19/77	Camp Well G-3 8/19/77	Seep Along Shootering Creek G-4 7/19/77	Lost Spring G-5 7/20/77	Ant Knolls Spring G-6 8/19/77
Chromium	<0.001	0.003	0.003	0.004	0.001	0.003
Copper	0.003	0.003	0.036	0.027	<0.001	0.006
Cyanide	<0.1			<0.1	<0.1	
Iodide	0.67	0.43	0.51	0.17	0.24	0.36
Lead	0.003	<0.001	<0.001	0.003	<0.001	0.002
Mercury	<0.0004	0.0012	0.0005	<0.000	<0.0004	0.0017
Molybdenum	0.001	0.002	0.002	0.001	0.001	0.003
Nickel	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Selenium	0.06	<0.01	<0.01	<0.01	0.13	<0.01
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	0.34	1.3	0.9	6.6	0.76	0.9
Tin	1	1	2	<1	<1	1
Titanium	0.03	0.01	0.02	0.09	0.04	0.04
Vanadium	0.01	0.01	0.02	0.01	0.02	0.08
Zinc	4.4	0.07	0.21	0.07	<0.01	0.02
Radiological trace elements						
Total uranium (μg/liter)[c]	6	13	6	9	11	2
Total uranium (μg/liter ± σ)[d]	<6	14 ± 5	8 ± 5	10 ± 5	<6	<5
Total uranium (μg/liter ± σ)[e]	0.27 ± 0.013	17.9 ± 0.9	7.8 ± 0.4	8.5 ± 0.4	1.70 ± 0.08	3.01 ± 0.15
Uranium-234 (μg/liter ± σ)[e]	0.00002 ± 0.00001	0.00147 ± 0.00008	0.00100 ± 0.00006	0.00062 ± 0.00005	0.00014 ± 0.00002	0.00025 ± 0.00001
Uranium-235 (μg/liter ± σ)[e]	0.00192 ± 0.0001	0.126 ± 0.006	0.0546 ± 0.0027	0.061 ± 0.003	0.0120 ± 0.0006	0.0216 ± 0.0011
U-238 (μg/liter ± σ)[e]	0.268 ± 0.013	17.8 ± 0.9	7.7 ± 0.4	8.4 ± 0.4	1.69 ± 0.08	2.99 ± 0.15
Ra-226 (pCi/liter ± σ)[f]	0 ± 0.03	0.16 ± 0.04	0.08 ± 0.04	0.08 ± 0.03	0.17 ± 0.03	0.13 ± 0.04
Ra-228 (pCi/liter ± σ)[f]	0 ± 1	0 ± 2	0 ± 1	0 ± 1	0 ± 1	0 ± 1
R-222 (pCi/liter ± σ)[f]	68 ± 3	102 ± 5	106 ± 5	350 ± 20	36 ± 2	40 ± 2
Th-230 (pCi/liter ± σ)[f]	0 ± 0.1	0.14 ± 0.06	0.11 ± 0.06	0 ± 0.1	0.2 ± 0.1	0 ± 0.06
Th-232 (pCi/liter ± σ)[f]	0 ± 0.1	0.15 ± 0.06	0.21 ± 0.07	0 ± 0.1	0 ± 0.1	0 ± 0.05
Gross α (pCi/liter ± σ)[f]	0 ± 3	8 ± 4	5 ± 2	0 ± 7	0 ± 3	0 ± 3
Gross β (pCi/liter ± σ)[f]	0 ± 4	16 ± 3	16 ± 3	62 ± 7	0 ± 4	16 ± 2
Bacteria (colonies per 100 ml)						
Total coliforms		<1	<1			<1
Fecal coliforms	<1	<1	<1	<1	<1	<1
Fecal streptococci		<1	<1			<1

[a] Values expressed as milligrams per liter unless otherwise stated. Analyses conducted by Controls for Environmental Pollution, Inc. (CEP), Santa Fe, New Mexico.
[b] Field measurement by Woodward-Clyde Consultants.
[c] As determined by CEP using atomic absorption spectroscopy.
[d] As determined by LFE Corporation, Richmond, California, using fluorometric techniques.
[e] As determined by LFE using mass spectrometry.
[f] Analyses conducted by LFE.

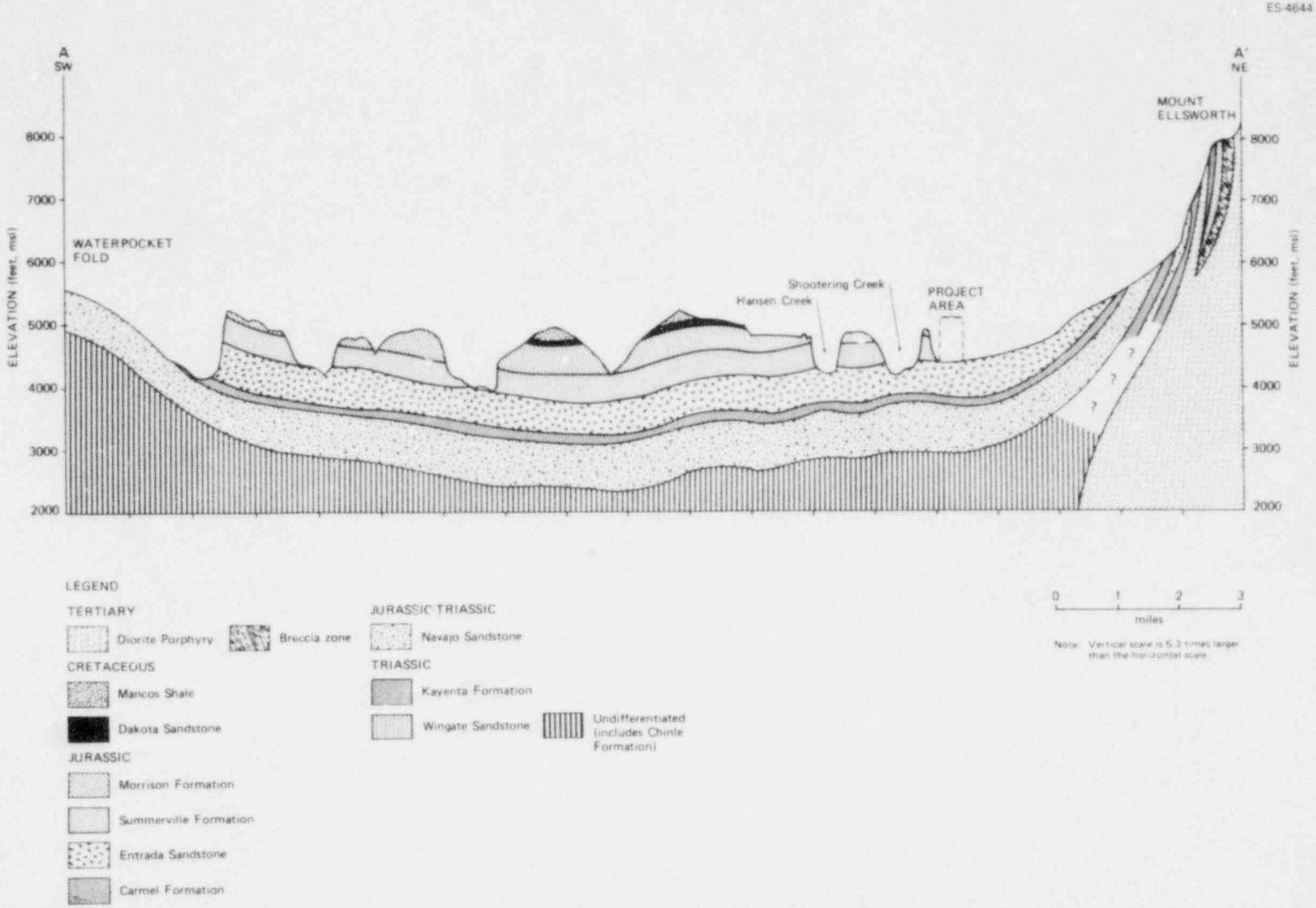


Fig. 2.2. Generalized geological cross section across the western part of the Henry Mountains basin. Source: ER, Fig. 2.4-4.

mudstone, limestone, and gypsum. The Carmel is underlain by the Navajo Formation, a massive sandstone unit, which is about 240 m (800 ft) thick in the vicinity of the site. The base of the Navajo is approximately 430 m (1400 ft) beneath the surface at the site (ER, p. C2-23).

2.7.2 Mineral resources

The development of mineral resources has been limited in the vicinity of the proposed project site. Uranium and associated vanadium are the only minerals currently being extracted in commercial quantities. The South Henry Mountains uranium area includes the Woodruff Springs, Delmonte, and Shootering Canyon deposits.[10] Known uranium mineralization occurs in channel sandstones within the Salt Wash Member of the Morrison Formation.[9]

Coal is present in the Cretaceous formations in the area. The Henry Mountains coal field has known commercial deposits in the Dakota Sandstone, the Ferron Sandstone, and the Emery Sandstone.[10] Because of erosion, these formations are not present in the immediate vicinity of the proposed site. Other known minerals in the vicinity include copper, gold, and silver. These minerals have been generally found in the Henry Mountains, but the quantities produced have been insignificant. No petroleum is produced in the vicinity of the proposed project.

2.7.3 Seismicity

Within a 320-km (200-mile) radius of the proposed site, 112 earthquakes with an intensity greater than V (Modified Mercalli) or a magnitude estimated or measured at greater than 3.5 (Richter) have occurred since 1853. The largest event had an epicenter about 177 km (110 miles) northwest of the site and had a maximum intensity of VIII to IX and an estimated magnitude of 6.7.[11] The event nearest the site had an epicenter in the Circle Cliffs uplift about 61 km (38 miles) north of the proposed site. This earthquake, which occurred on September 30, 1963, had a magnitude of 4.5.

Based on the region's seismic history, the probability of a major damaging earthquake occurring at or near the site is remote. Algermissen and Perkins[12] indicate that there is a 90% probability that a horizontal acceleration of 4% of gravity would not be exceeded in 50 years. However, should such an acceleration level occur, only minor damage would be expected.

2.8 SOILS

Soils on the proposed site of the Shootering Canyon project are classified as either Entisols or Aridisols. The former order consists of soils having no pedogenic horizons; the latter includes soils with pedogenic horizons that are low in organic matter and are never moist for more than three consecutive months (ER, Sect. 2.4).

Little variation was observed in soil texture, color, and consistency throughout the site. The soils were generally sandy in texture, modified in some places by gravel or cobbles at the surface. Both soil and sandstone rock outcrops were red in color. Soil consistency was loose (noncoherent) in surface samples and loose or soft in deeper samples (ER, Sect. 2.4).

The content of organic matter in all of the soil profiles on the site was extemely low, and except for a greater bulk density with depth, horizon development was not generally apparent. Because the soils are derived almost entirely from a single source (windblown dust and fine sands), the soil grain size is quite uniform, about 117 μm (ER, Appendix B). All of the surface soils in the vicinity of the facility site are highly susceptible to wind erosion. Mounds of deposited sand were observed around the sparse clumps of vegetation. Although sandy soils are usually well drained, the lack of organic matter, sparse vegetation cover, and relatively steep slopes over much of the area contribute greatly to the potential for water erosion. Annual precipitation in the vicinity is normally low [18 cm (7 in.)], but maximum point precipitation could be as high as 8 cm (3.2 in.) in a 24-hr period occurring every 100 years.

Five major soil mapping units were delineated on the proposed tailings impoundment and plant site (Fig. 2.3). Deep sands on gentle slopes (4 to 10%) cover the majority (40%) of the tailings impoundment site. Soil sampled in this mapping unit was more than 76 cm (30 in.) deep and ranged in texture from sand to loamy-fine sand. According to the applicant, except for the very fine, sandy surface material, these soils constitute the best "topsoil" available on the proposed site for use in reclamation (ER, Sect. 2.4). Shallow to deep sand on

Fig. 2.3. Soils map of those areas that would be affected by the proposed tailings impoundment and plant site. Source: ER, Fig. 2.4-5.

gentle to moderate slopes (10 to 30%) comprise about 30% of the tailings impoundment site. These soils were typically 15 to 30 cm (6 to 12 in.) deep, generally devoid of organic matter, and consisted of very fine sand. Recent shifting of surface material was evident in several areas. Sandstone rock outcrop occurs on about 15% of the tailings impoundment site, with slopes ranging from 10 to 30%. Because of the exposed rock, precipitation runoff leads to erosion in areas downgrade and adjacent to the main drainage of this mapping unit. The remainder of the tailings impoundment site is covered by moderately steep to very steep (30 to 80%) talus slopes. These areas are present on the periphery of the impoundment as well as the plant site. Soils on these slopes are typically immature and very shallow. Soil over most of the plant site consists of shallow to deep sand. The nearly flat terrain of this area has resulted in some of the soils extending below 150 cm (60 in.) near the center of the site and to about 50 cm (20 in.) near the outer edges of the site. Cobbly or gravelly material occurred on the surface of all of the sample sites in this mapping unit. The soils were essentially devoid of organic content and showed little evidence of horizon development.

Soils in the vicinity of the site have not been surveyed by the Soil Conservation Service, but in the opinion of the staff, it is unlikely that any of the soils would be classified as prime or unique farmland.[13]

2.9 BIOTA

2.9.1 Terrestrial

2.9.1.1 Flora

Vegetation in the vicinity of the facility site is very similar to that of the potential,[14] characterized as desert shrub and dominated by a blackbrush/Mormon tea association. Plant cover is sparse in the area, ranging from about 15 to 25% (ER, Table 2.8-1). Blackbrush (*Coleogyne ramosissima*), the dominant species, accounts for about 25 to 65% of the total plant cover. Mormon tea (*Ephedra torreyana*), the other major shrub species, comprised approximately 15 to 25% of the total cover. Other common associates at the proposed site include smallhead snakeweed (*Gutierrezia microcephala*), the indigobrush (*Dalea polyadenia*), and desert sage (*Salvia carnosa*). Herbaceous vegetation at the site is especially sparse (<1% of ground cover). Herbaceous species often form only a relatively small portion of ground cover in southeastern Utah, but the drought conditions in the region prior to sampling may have further reduced the abundance of this component of the plant community. Of the herbaceous species present in the project area (ER, Table E-1), galleta grass (*Hilaria jamesii*) is the most common. This species is typically associated with sandy soils and arid lands throughout the Four Corners region.

Productivity in this ecosystem varies greatly from year to year, depending on the moisture supply. Productivity studies were not conducted at the site, but the Utah Division of Wildlife Resources has estimated that on a regional level the total vegetative cover for desert shrub vegetation consists of less than 10% browse species and less than 1% grasses and forbs (ER, Sect. 2.8). Forage production of these plants is estimated to be 340 kg/ha (300 lb/acre) for browse species, 60 kg/ha (55 lb/acre) for grass species, and 6 kg/ha (5 lb/acre) for forbs.

Of the 65 proposed endangered plant species in Utah,[15] only one is thought to be associated with habitat and soil types in the vicinity of the facility site. *Phacelia mammalariensis* has a documented distribution in Garfield County, restricted to Tropic Shale, Dakota Sandstone, and Kaiparowatts formations.[16] This endangered species was not observed during the field surveys (ER, Sect. 2.8), and Fig. 2.4-2 of the ER, which depicts the geologic formations near the proposed facility, indicates that it is unlikely that this species occurs on the site.

2.9.1.2 Fauna

The limited vegetation in the area may account for the relatively low diversity of wildlife species observed by the applicant. Wildlife representative of the facility area are listed in Table 2.10. Lack of any aquatic habitat in the immediate vicinity of the site precludes the establishment of any significant amphibian populations.

Table 2.10. Wildlife species observed or expected to occur in the vicinity of the site[a]

Scientific name	Common name	Observed[b]	Expected
Big game or large mammals			
Odocoileus hemionus	Mule deer		U[c]
Medium-sized mammals			
Canis latrans	Coyote	C	
Lepus californicus	Black-tailed jackrabbit	C	
Sylvilagus auduboni	Desert cottontail	C	
Taxidea taxus	Badger		U
Small mammals			
Chiroptera	Bats		C
Dipodomys ordi	Ord's kangaroo rat	C	
Neotoma lepida	Desert woodrat	C	
Onychomys leucogaster	Northern grasshopper mouse	C	
Peromyscus crinitus	Canyon mouse	C	
Peromyscus maniculatus	Deer mouse		C
Perognathus parvus	Great Basin pocket mouse	U	
Raptors			
Aquila chrysaetos	Golden eagle		R
Buteo jamaicensis	Red-tailed hawk	U	
Cathartes aura	Turkey vulture	C	
Falco mexicanus	Prairie falcon	R	
Falco sparverius	American kestrel	U	
Upland game birds			
Zenaidura macroura	Mourning dove	C	
Columba fasciata	Band-tailed pigeon		U
Perching birds			
Eremophila alpestric	Horned lark	C	
Lanius ludovicianus	Loggerhead shrike		U
Petrochelidon pyrrhonota	Cliff swallow		U
Spizella breweri	Brewer's sparrow		C
Tyrannus verticalus	Western kingbird	C	
Crovus corax	Common raven	C	
Reptiles			
Cnemidophorus tigris	Western whiptail	C	
Phrynosoma douglassi	Short-horned lizard	U	
Uta stansburiana	Side-blotched lizard	C	

[a] This list represents species that are most likely to occur in the facility area.

[b] Observed during July and October 1977 field surveys.

[c] Symbols representing anticipated relative abundance: common (C)—usually observed daily, dominant species in the area; uncommon (U)—regularly seen but not on a daily basis, not a dominant species; rare (R)—only occasionally observed or captured.

Source: Modified from the ER, Table E-2.

Rodents, lagomorphs, and carnivores were the dominant mammalian species present at the site. The most abundant rodent was Ord's kangaroo rat (ER, Table 2.8-2). The sandy soil on the site is the preferred habitat of this burrowing species. The area is not considered to be prime habitat for big game species, and no major populations of these animals are present in the immediate vicinity of the site. Mule deer (*Odocoileus hemionus*), elk (*Cervis canadensis*), and bison (*Bison bison*) occur in the region, but they are generally associated with the pinyon-juniper woodlands and coniferous forests at higher elevations in the mountains north of the site (ER, Fig. 2.8-2). Some mule deer may occasionally enter the area during severe winters or during the hunting season, but their normal winter and summer ranges are in the Henry Mountains north of the site and at higher elevations to the west (ER, Fig. 2.8-2). The closest critical winter range for mule deer in the region is approximately 48 km (30 miles) to the northwest (ER, Sect. 2.8). Desert bighorn sheep (*Ovis canadensis*) also occur in the region, being generally confined to rugged terrain south of the Colorado River (ER, Fig. 2.8-2). A small population is located north of the river about 24 km (15 miles) southwest of the site.

Only eight species of birds were observed at the site, four of which were raptors. Only one nest was observed; it was an active American Kestral nest, located on the south end of the butte on the west side of the tailings impoundment site. A prairie falcon was observed about 3.2 km (2 miles) north of the site during a reconnaissance survey in May 1977.

The western kingbird and horned lark were the only two songbirds observed during field studies. The mourning dove was observed on the site during July 1977 and is the only species of upland game bird that regularly inhabits the area. The Hungarian partridge (*Perdix perdix*) and blue grouse (*Dendragapus obscurus*), other upland game birds, can be found at some of the higher elevations in southeastern Utah where forest and mountain brush vegetation provide adequate food and cover. These areas are located more than 8 km (5 miles) from the proposed plant site, in the Henry Mountains or near the Colorado River. The project site is not located in any of the major waterfowl flyways. During the staff site visit in June 1978, two mallards (*Anas platyrhynchos*) were observed in a stock pond located about 8 km (5 miles) south-southeast of the project site. In addition, with Lake Powell located approximately 16 km (10 miles) to the south, it is conceivable that some waterfowl may be seen in the vicinity during spring and fall migrations.

No endangered species of wildlife were observed on the site.[17] The project site is within the range of the bald eagle (*Haliaeetus leucocephalus*) and the American peregrine falcon (*Falco peregrinus anatum*), but the lack of aquatic habitat indicates a low probability of these species occurring on the site. However, with the Colorado River and Lake Powell being located about 16 km (10 miles) from the site, these species may be observed in the region during migration periods.

2.9.2 Aquatic

As discussed in Sect. 2.6.1, there are no permanent streams or pools in the permit area that could harbor aquatic organisms throughout the year. There are approximately 24 km (15 miles) of stream drainage courses separating the proposed mill site from Lake Powell (ER, Sect. 6.1) which, because of a porous substrate and infrequent rainfall, only sporadically contain water. When water is present in these stream channels, it is in the form of highly turbid flash floods following rainstorms. Thus, the migration of fishes and other aquatic organisms from the lake to the vicinity of the site is prevented. Because of a lack of aquatic habitat in the project area, the applicant conducted no sampling program for aquatic biota.

There are three endangered aquatic species found in Utah.[17] The humpback chub (*Gila cypha*) is found in widely separated areas of the Green and Colorado rivers, from the Grand Canyon area northward to the vicinity of the Flaming Gorge Dam on the Utah-Wyoming border. Specimens have not been collected from Lake Powell, and the closest collection is from Lee's Ferry, downstream from the Glen Canyon Dam.[3] The Colorado River squawfish (*Ptychocheilus lucius*) is found in the middle and lower Green River, the main Colorado River above Lake Powell, and the Salt River. This species is adapted to life in turbid, swift, warm rivers and will not reproduce in cold tailwaters below high dams or in the reservoirs, such as Lake Powell, behind these dams.[18] Finally, the woundfin (*Plagopterus argentissimus*) is an endangered minnow that is now believed restricted to the Virgin River below Hurricane, Utah,[18] and, therefore, is not found in Lake Powell or the Colorado River.[3]

There are no threatened aquatic species listed for the State of Utah.[17]

2.10 NATURAL RADIATION ENVIRONMENT

Radiation exposure in the natural environment is due to cosmic and terrestrial radiation and to the inhalation of radon and its daughters. Measurements of the background environmental radioactivity at the proposed site have been initiated using thermoluminescent dosimeters (TLDs) (ER, p. 2-167). Preliminary results indicate an average total-body dose of 82 millirems per year. The elevation of Shootering Canyon (≈1.4 km) allowed us to approximate the cosmic radiation contribution to be about 50 millirems per year with terrestrial radiation adding 32 millirems. The cosmogenic radiation dose was estimated to be about 1 millirem per year. Terrestrial radiation originates from the radionuclides potassium-40, rubidium-87, and daughters from the decay of uranium-238, thorium-232, and, to a lesser extent, uranium-235. The dose from ingested radionuclides was estimated to result in a dose of 18 millirems per year to the total body.[19] The dose to the total body from all sources of environmental radioactivity is estimated to be about 101 millirems per year based on the preliminary site measurements.

The concentration of radon in the area is estimated to be in the range of 500-1000 pCi/m^3, based on the concentration of radium-226 in the local soil.[19,20] Exposure to this concentration on a continuous basis would result in a dose of up to 625 millirems per year to the bronchial epithelium.[21] In unventilated enclosures, the comparable dose could reach 1200 millirems per year.

The medical total-body dose for Utah is about 75 millirems per year per person.[22] The total dose in the area of the proposed mill from natural background and medical exposure is estimated to be 176 millirems per year.

REFERENCES FOR SECTION 2

1. U.S. Environmental Protection Agency, *Fed. Regist.* 43(43): 8962-9059 (Mar. 3, 1978).

2. Energy Fuels Nuclear, Inc., *Environmental Report, White Mesa Uranium Project, San Juan County, Utah*, Denver, Jan. 30, 1978, p. 2-15.

3. Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif. Aug. 29, 1978.

4. Utah Bureau of Economic and Business Research, 1976.

5. Utah Department of Employment Security, *Employment Newsletter*, March 1978.

6. Utah State Foundation, *Ticaboo Environmental Assessment*, November 1977.

7. Utah Multicounty Planning Commission, "Community Infrastructure Analysis," *Regional Coal Environmental Impact Statement: Central District*, March 1978.

8. Utah State Division of Health, *Code of Waste Disposal, Part II, Standards of Quality for Waters of the State*, Report SDH-San-99-I-6/65, Rev. 6/69, 1968.

9. William D. Thornbury, *Regional Geomorphology of the United States*, Wiley, New York, 1965.

10. H. H. Doelling, *Geology and Mineral Resources of Garfield County, Utah*, Utah Geological and Mineral Survey Bulletin 107, 1975.

11. K. Cook and R. Smith, "Seismicity in Utah, 1850 through June 1965," *Seismol. Soc. Am. Bull.* 57(4): 689-718 (1976).

12. S. T. Algermissen and D. M. Perkins, *A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States*, U.S. Geological Survey Open File Report 76-416, 1976.

13. R. W. Peterson, *Memorandum for Heads of Agencies; Analysis of Impacts on Prime and Unique Farmland in Environmental Impact Statements*, Council on Environmental Quality, Washington, D.C., Aug. 30, 1976.

14. A. W. Kuchler, *Potential Natural Vegetation of the Conterminous United States*, Special Publication 36, American Geographical Society, N.Y., 1964.

15. "Endangered and Threatened Species, Plants," *Fed. Regist.* 41(117): 24524-24572 (1976).

16. S. L. Welsh, N. D. Atwood, and J. L. Reveal, "Endangered, Threatened, Extinct, Endemic, and Rare or Restricted Utah Vascular Plants," *The Great Basin Naturalist*, 34(4): 327-376, 1975.

17. "Endangered and Threatened Wildlife and Plants: Republication of List of Species," *Fed. Regist.* 42(135): 36419-36431 (1977).

18. U.S. Department of the Interior, *Threatened Wildlife in the United States*, Resource Publ. 114, Office of Endangered Species and International Activities, Bureau of Sport Fisheries and Wildlife, 1973.

19. National Council on Radiation Protection and Measurements, *Natural Background Radiation in the United States*, Report No. 45, 1975.

20. K. J. Schaiger, "Analysis of Radiation Exposure On or Near Uranium Mill Tailings Piles," *Radiat. Data Rep.* 14: 41 (1974).

21. National Academy of Sciences — National Research Council, *The Effects on Population of Exposure to Low Levels of Ionizing Radiation, Report of the Advisory Committee on the Biological Effects of Ionizing Radiation* (BEIR Report), NAS-NRC, Washington, D.C., 1972.

22. U.S. Department of Health, Education, and Welfare, *Population Exposure to X-rays, U.S. 1970*, Report DHEW-73-8047, November 1973.

3. OPERATIONS

3.1 MINING OPERATIONS

The applicant has conducted an extensive ore development program in the Shootering Canyon area. Three ore bodies — the Lucky Strike 10 (an existing mine), the Tony M (a mine under development), and an unnamed ore body to the northeast of the Tony M — have been identified as commercial deposits (Fig. 3.1). As of January 1, 1978, the indicated and inferred reserves in these bodies exceeded 2500 MT (2800 tons) of U_3O_8, sufficient for at least ten years of production by the proposed mill. The applicant expects that further exploration in and around the ore bodies will reveal additional reserves (ER, p. 3-40).

The economically recoverable ore will vary in grade from 0.04% to 0.5% U_3O_8 with an estimated average grade of 0.10% U_3O_8. Under present plans, ore of less than 0.04% U_3O_8 would not be processed (ER, p. 3-43).

3.1.1 Mining techniques

In the Shootering Canyon vicinity, uranium ore is found in the Salt Wash member of the Morrison Formation. Typically, the Salt Wash sandstone in the area is overlain by approximately 30 to 244 m (100 to 800 ft) of non-ore-bearing sandstones. The type and the amount of this overburden preclude economic extraction of the uranium ore except by underground mining techniques. At many locations in the project vicinity, the Salt Wash sandstone is exposed on the walls of the deep canyons dissecting the surface of the region. Over the past 30 years at many exposed locations, horizontal drifts, or adits, have been driven directly into the ore bodies from the canyon walls. This procedure will be continued for the Shootering Canyon project. Borings to locate ore concentrations are drilled vertically from the surface through the overburden and ore horizon. The deep canyons in the area provide drainage to adjacent higher strata, and mines throughout much of the Salt Wash member will encounter little or no groundwater (ER, p. 3-43). Should small amounts of mine water be encountered, this seepage would be used to wet mine haulageways or ore piles to limit dusting. If substantial quantities are encountered, the water would be used in the milling process.[1]

Uranium ore mining for the Shootering Canyon project will be by conventional underground mining techniques (face drilling and blasting, loading, and haulage). Existing or new adits from the canyon walls will be used for access to the ore bodies, and drifts will be extended in the direction of known ore bodies. Scanning of the rock at the face of the drifts will indicate when ore-grade rock is encountered. Drift advancement will follow a regular sequence of drilling, blasting, and mucking. Drifts will be about 3.4 m (11 ft) wide and 2.7 m (9 ft) high. Tunnel structural stability in the drifts will be maintained by strategic placement of rock bolts, steel sets, and wood supports.

Waste rock will be segregated from ore-grade rock at the mine exit. Mining machines will load, haul, and dump fractured rock from the advancing drifts. These machines will deliver the rock to nearby loading stations, where it will be transferred to ore "buggies," which transport the rock to the surface. Ore-grade rock will be delivered directly to ore storage bins located near the mine entrances. Waste rock will be delivered to established disposal areas near the mine entrances, or possibly to the plant area, for use in the construction of the tailings impoundment dam (ER, p. 3-47).

Mining will be performed on a schedule of two 10-hr shifts per day, four days per week. Ore production is expected to average about 600 MT (660 tons) per shift, or about 2.4 MT (2.7 x 10^5 gross tons) per year. The ore will be transported to the mill in dump trucks of 30-ton capacity.

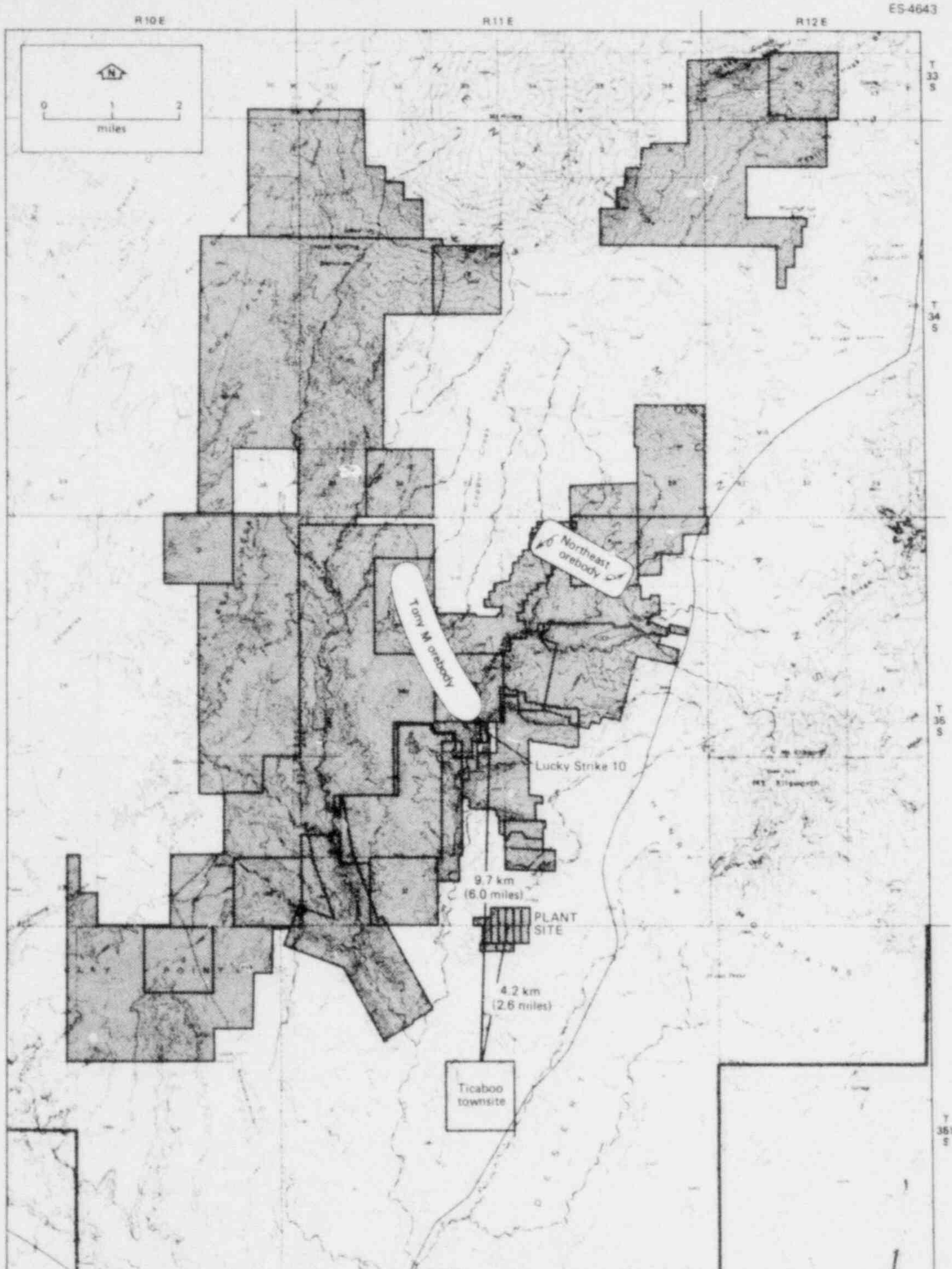


Fig. 3.1. Property holdings of Plateau Resources Ltd. in the Utah Shootering Canyon area. Source: ER, Fig. 3.6-1

Some ore for processing will be supplied from the Plateau Resources, Ltd., ore buying station near Blanding, Utah, which buys and stores uranium ore produced by independent mines (Fig. 2.1). By April 1978 the applicant had established purchase agreements with 12 mine operators. The purchased ore is primarily quartzose sandstone containing between 0.05% and 1.0% uranium [0.45 to 9.1 kg (1.0 to 20.0 lb) uranium as U_3O_8 per ton of ore].

Construction of the ore buying station began in March 1977, and operations began in August 1977. Ore purchases have averaged approximately 1800 MT (2000 tons) per month with an average uranium content of 0.11%. The applicant expects to stockpile ore until about October 1979 when transfer of ore to the proposed Shootering Canyon uranium processing facility will commence. At that time about 52,000 MT (57,000 tons) of ore will be stored at the ore buying station.

It is expected that a maximum of 4380 MT (4830 tons) of ore per month would be transferred to the proposed uranium processing facility, and the staff assumes that 1800 MT (2000 tons) per month would continue to be purchased. In that case the stockpile at the ore buying station would be depleted by late 1981; the ore buying station itself would either become a purchase and transfer facility [1800 MT (2000 tons) per month] with a minimum ore stockpile or be closed and the site reclaimed.

3.1.2 Mine waste disposal

Waste rock from the mines will be added to the existing talus slopes and waste rock now piled against the bottom of the Canyon walls. Ore buggies hauling waste rock from the mines will dump the rock from the mine access roads and from the level areas constructed at the mine entrances. The waste rock will assume its natural angle of repose as it is dumped. Appearance of the waste rock piles will be similar to the appearance of the numerous natural talus slopes now bordering the floor of Shootering Canyon and other canyons in the vicinity. The quantity of waste rock from the mining operations is estimated to be in the ratio of 1:1, waste rock to economically recoverable ore. On an annual basis, the waste rock quantity will be about 2.4×10^5 MT (2.7×10^5 tons), or 1.9×10^5 m^3 (2.5×10^5 yd^3). The area adjacent to the Tony M mine entry has an estimated capacity of approximately 2.3×10^6 to 2.7×10^6 MT (2.5×10^6 to 3×10^6 tons) of waste rock over the life of the project. Waste rock dumps will be located in areas that minimize their apparent size and their environmental and visual impacts. Dumping will be controlled to prevent obstruction to roads and drainage channels on the floor of the canyons (ER, p. 3-48). All mine waste dump and reclamation activities will be performed in accordance with the State of Utah Mined Land Reclamation Act of 1973 and the Utah Solid Waste Disposal Regulations.

3.2 THE MILL

The proposed Shootering Canyon Uranium Project is designed to process about 2.48×10^5 MT (2.74×10^5 tons) of ore per year. A process design rate of 717 MT (790 tons) per day has been used for the plant to allow for planned and nonscheduled shutdowns.

From previous exploration and mine development work, the overall average ore grade is estimated to be 0.10% U_3O_8. Because considerable grade variation may be encountered throughout the life of the project, the mill design will allow efficient recovery of uranium from ores of as little as 0.07% (average grade) U_3O_8. At this minimum average grade, the mill is estimated to have an overall recovery of 90%. The recovery is expected to increase slightly at higher feed grades. Based on 90% recovery, 0.10% U_3O_8 ore grade, and the average daily 680-MT (750-ton) processing rate, the proposed mill will produce about 614 kg (1350 lb) of U_3O_8 per day and a total of 224 MT (247 tons) per year.

The mill would utilize the conventional acid leach-solvent extraction process for uranium recovery. A general description of the mill process is given in Sect. 3.2.2.

3.2.1 External appearance of the mill

The plot plan of the proposed Shootering Canyon Uranium Project is shown in Fig. 3.2 and an artist's rendition of the mill in Fig. 3.3. The mill design features a compact layout that offers economic and efficient construction and operation. Auxiliary buildings and facilities are located around the perimeter of the mill site to yield a well-integrated complex. Within

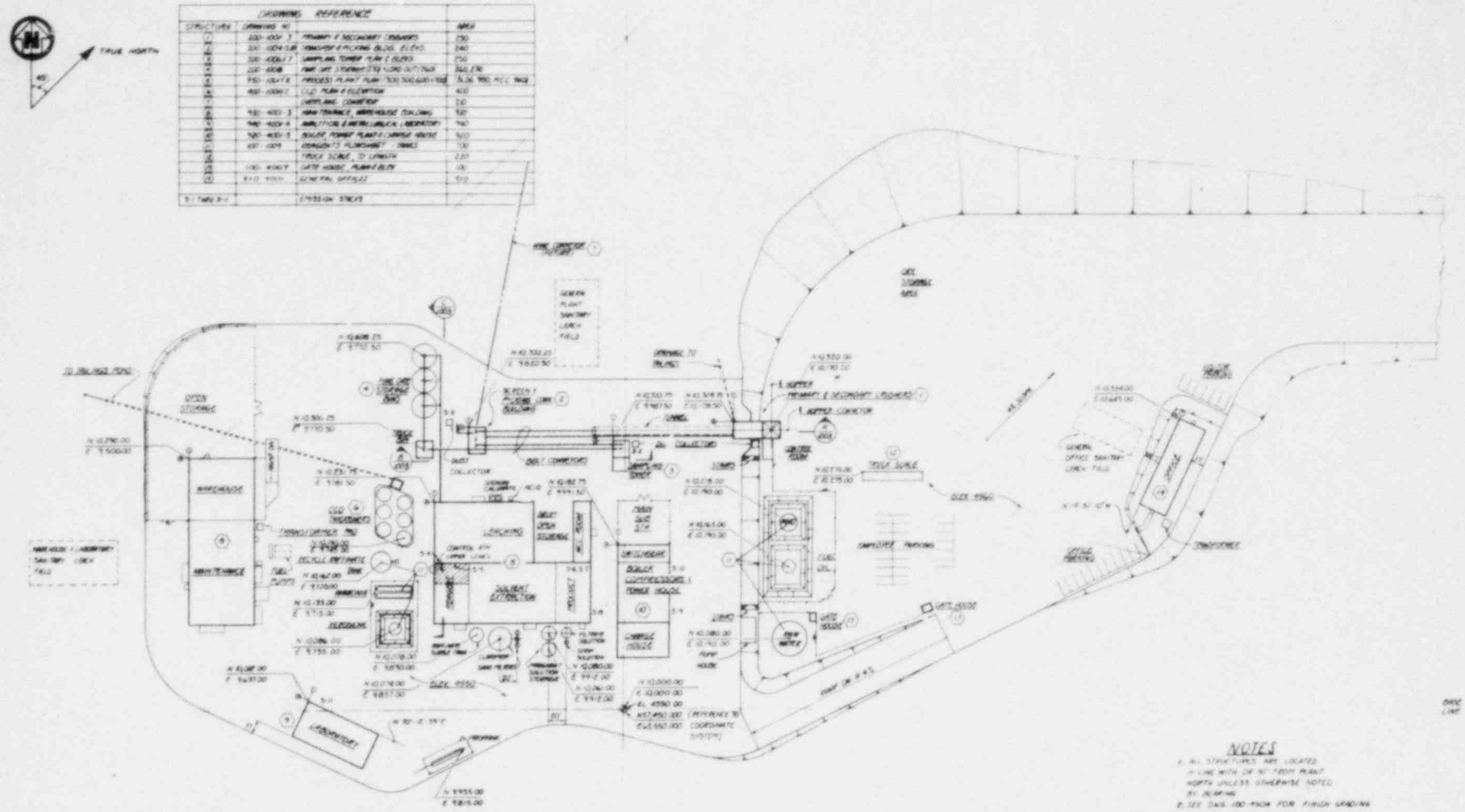


Fig. 3.2. Shootering Canyon Uranium Project plot plan. Source: ER, Fig. 3.1-1.

Fig. 3.3. An artist's rendition of the Shootering Canyon Uranium Project. Source: ER, Fig. 3.1-2.

the mill area, all process equipment will be housed or covered, except for the countercurrent decantation tanks, the clarifier, and the leach solution filters.

The earth-tone color of the building exteriors will blend with the high cliff to the west, which will form the background to the plant as seen from State Highway 276. A short stretch of that highway, about 3 km (2 miles) northeast of the site, provides the only available public view of the plant site (except from the air). From the highway, the only signs of activity at the plant will be vehicular movements.

No plumes of smoke or dust will mark the plant location. One stack rising about 30 m (100 ft) and several other stacks 24 to 27 m (80 to 90 ft) above plant grade will not appear in silhouette from the highway. The largest building in the complex will be about 43 by 55 m (140 by 180 ft) in plan dimensions and about 18 m (60 ft) high. Other smaller structures, associated with the ore crushing, storage, and conveying systems, will have maximum heights of 18 to 21 m (60 to 70 ft) above the general level of the plant site.

3.2.2 The mill circuit

The proposed Shootering Canyon mill will use a conventional acid leach-solvent extraction process to recover uranium. Figure 3.4 depicts the steps in the proposed process. Each of the major steps (ore storage, crushing and grinding, leaching, solvent extraction, countercurrent decantation, product precipitation, and product drying) is discussed in the remainder of this section.

ES-4659

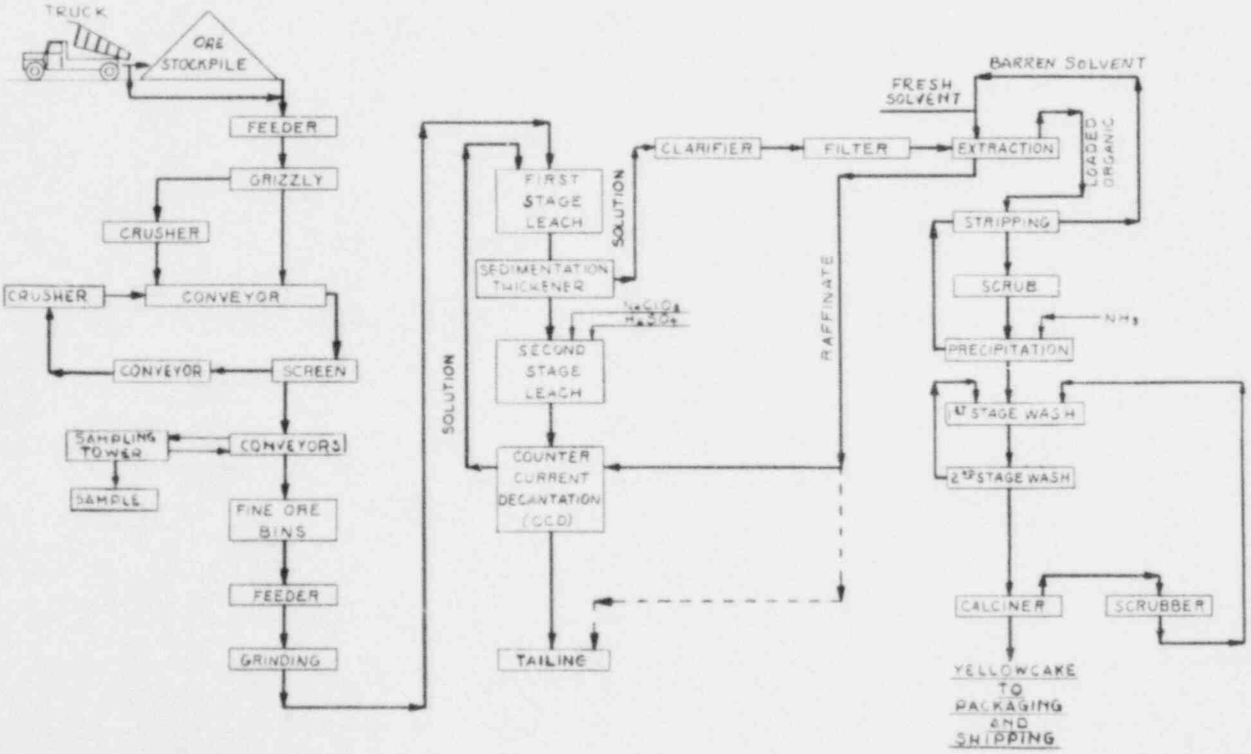


Fig. 3.4. Mill process at the Shootering Canyon Uranium Project. Source: ER, Fig. 3.2-1.

3.2.2.1 Ore stockpile

Ore from the mine will be hauled by truck to the plant, an approximate distance of 5.6 km (3.5 miles). The ore could be deposited on the crusher patio or dumped and fed directly to the ore crushing system. Ore may be stockpiled on the patio north of the primary crusher; the applicant estimates that the patio storage will average approximately 9×10^3 MT (1×10^4 tons), although capacity will exist for storing up to 9×10^4 MT (1×10^5 tons). During operations, the stockpile will be available on the patio as back-up plant feed in case the mine cannot deliver ore to the plant for any reason. Ore deposited on the patio will be picked up by a front-end loader and fed to the ore crushing system as required. Ore delivered from the Blanding ore buying station will be fed directly to the process (Fig. 3.4).

3.2.2.2 Ore crushing and grinding

The uranium in the project area is deposited as thin coatings and pore fillings between grains of sandstone. To ensure that uranium minerals are removed effectively from these grains, mined ore must first be reduced in size to fine particles by crushing and grinding so that a large surface area is exposed to the acid leach solution. Ore will be loaded into a receiving hopper consisting of an apron feeder and a stationary grizzly, which will split the feed into plus and minus 7.6-cm (3-in.) fractions. Oversized material +7.6 cm (+3 in.) will be fed to a jaw crusher. Material passing the stationary grizzly will be transported by conveyor belt to a vibrating screen with 1.9-cm (0.75-in.) openings. The elevating conveyor belt will be equipped with a metal detector and an electromagnet to remove any tramp iron from the ore so that equipment is protected from metallic mine trash. Material retained on the vibrating screen will be fed to a secondary crusher, where it will be further reduced in size and then returned to the screen by conveyor belt. Material passing through the screen will discharge onto a conveyor belt and be delivered to the fine-ore storage bins (Fig. 3.2).

The jaw crusher is designed to process 91 MT (100 tons) of ore per hour and the secondary crusher to process 32 MT (35 tons) of ore per hour. For normal operations, crushers will be operated for two 8-hr shifts per day, five days per week. The crushing schedule will be varied as required to accommodate changes in actual plant operations.

Ore will be fed from the fine-ore storage bins to a rod mill (Fig. 3.4) at a regulated average rate of about 28 MT (31 tons) per hour. The rod mill is expected to operate continuously. Water will be added to the ore to produce a slurry containing approximately 70% solids. As the mill rotates, steel rods will reduce the ore to sand-sized particles. The slurry will flow by gravity from the rod mill to a sump and from there be pumped to the leaching circuit.

3.2.2.3 Leaching

The leaching circuit will dissolve most of the uranium minerals from the sandstone grains. Leaching will be conducted in wood-stave tanks with a solution of sulfuric acid and controlled amounts of sodium chlorate. A two-stage leaching circuit, with a decant thickener between the leaching stages, is planned. The ore slurry from the grinding mill will be pumped to the first-stage leach (three tanks in series), where it will be contacted and agitated with a strong acid leach solution. Following the first-stage leach, the slurry will be transferred to the decant thickener, and the overflow liquor containing dissolved uranium will be advanced to the solvent extraction step discussed below. The thickened solids are advanced to the second-stage leaching circuit (four tanks) where further leaching is accomplished by the addition of sulfuric acid [82 kg (180 lb) per metric ton (ton) of ore] with a small amount of oxidant [(sodium chlorate, average rate 0.85 kg (1.7 lb) per metric ton (ton) of ore]. The second-stage leaching tanks will be operated in series, making the mean residence time of the slurry in the system about 16 hr. Discharge from the leach circuit will be a slurry consisting of the solids and a solution of uranium in dilute sulfuric acid.

3.2.2.4 Countercurrent decantation thickening

The slurry will be transferred to the first of a series of six countercurrent decantation tanks (known as "thickeners"), which make up the countercurrent decantation washing circuit. The solids that settle to the bottom of the first thickener will be transferred to the second thickener, and so on until they are discharged from the bottom of the sixth thickener to the tailings impoundment. Acidic wash water will be added to the sixth thickener, and the overflow "clear" liquid will be advanced to the fifth thickener, then successively to the first thickener. This countercurrent flow of liquid and solids washes the residual dissolved uranium compounds from the solids. The liquid overflow from the first thickener is collected and pumped to the first-stage leach. A long-chain polymer (flocculant) will be added to each thickener feed to increase the settling rate of the solids.

3.2.2.5 Solvent extraction feed preparation

The pregnant acid solution decanted from the thickener following the first-stage leach will be transferred to a clarifier. The applicant estimates that this liquid will contain approximately 200 ppm solids. The clarified liquid, containing about 50 ppm solids, will be pumped through sand filters to a storage tank from which the solvent extraction circuit is fed. The filtered liquid is expected to contain less than 10 ppm solids, which is low enough to prevent stable emulsion formation in the solvent extraction circuit. Settled solids from the clarifier will be added to the second-stage leach circuit. Solids collecting in the sand filters will be removed by backwashing and discharged to the first countercurrent decantation tank.

3.2.2.6 Solvent extraction

The primary purpose of the solvent extraction circuit is to concentrate and purify the uranium. In this process, the uranium is selectively extracted from the leach solution by an organic amine carried in a solvent, such as kerosene. Because the leach solution and the organic solvent are immiscible, the extraction is accomplished by vigorously mixing the two liquids and then allowing the resulting unstable emulsion to separate into organic and aqueous layers in a mixer-settler unit. To maximize the uranium concentration in the organic solvent and minimize uranium losses, the proposed mill will provide a four-stage countercurrent extraction section. The uranium-loaded solvent will pass to a four-stage stripper section. The barren leach solution (raffinate) leaving the extraction section will be used partly as wash water in the countercurrent decantation unit and the remainder sent as waste to the tailings impoundment area to limit the buildup of impurities in the plant circuit.

In the stripping section, the uranium-loaded organic solvent will be contacted with an aqueous ammonium sulfate solution to displace the uranium into the aqueous solution. The stripped organic solvent will be recycled to the extraction section while the uranium-rich ammonium sulfate solution is advanced to the precipitation circuit.

3.2.2.7 Precipitation

The pregnant ammonium sulfate solution will be passed through a heat exchanger to raise its temperature before being pumped into a series of precipitation tanks. Ammonia will be injected into the tanks to neutralize the solution and to effect the precipitation of ammonium diuranate (yellow cake). The barren ammonium sulfate solution will be filtered and recycled to the stripping stage of the solvent extraction circuit.

3.2.2.8 Drying and packaging

The precipitated yellow cake will be washed to remove soluble impurities, dewatered, and dried in an oil-fired multiple-hearth furnace. The dried product will then be passed through a crusher for reduction to minus 0.6 cm (0.25 in.). The finished product will be transported to a packaging station, where it will be discharged to steel drums at a design rate of about 150 kg/hr (350 lb/hr). Drying and packaging operations will be conducted for about 30 continuous hours per week. Product output from the plant will be about nine to ten barrels of U_3O_8 per week. Filled drums will be stored until a sufficient number have been assembled for shipment.

3.2.3 Nonradioactive wastes and effluents

3.2.3.1 Gaseous effluents

Milling operations will result in the release of nonradioactive gases and vapors to the atmosphere. The main sources of gaseous release will be the leach circuit, the solvent exchange circuit, the yellow cake precipitator and dryer, the analytical laboratory, and the mill power plant and heating systems.

Because of the small size, type of process, and heat input of the proposed mill, Federal and State atmospheric effluent emissions standards are not applicable. However, ambient air quality regulations are applicable to the mill operations. Air quality impacts from mill operations are discussed in Sect. 4.1.

Leaching

The leach tanks will be covered and equipped with a demister vent system. Therefore, aerosol and particulate releases will be minimal. Small amounts of sulfuric acid mist are expected to be present in the room containing the leach tanks. Building air will be combined with the exhaust from the demister and released to the atmosphere. Liquids collected by the demister will be returned to the leach circuit (ER, p. 3-25).

Carbon dioxide will be produced in the leach circuit as a result of interactions of carbonate materials in the ore with the acid in the leach solution. Trace quantities of sulfur dioxide and free chlorine may also be released. Gaseous releases from the leach circuit are not expected to affect air quality at the site.

Solvent extraction

Solvent extraction and stripping will be conducted in uncovered mixer-settler tanks housed within the mill building. Exposed organic solvents will be lost from the liquid surfaces by evaporation. It is estimated that these losses of hydrocarbons will be about 0.27 g/sec (2.1 lb/hr) (ER, p. 3-28). Because the solvent extraction room is designed to be ventilated at the rate of 5.7 m^3/sec (1.2×10^4 cfm), the hydrocarbon concentration in the building vent exhaust will be approximately 4.8×10^4 $\mu g/m^3$. Atmospheric dispersion is expected to quickly reduce this concentration below the ambient standard of 160 $\mu g/m^3$.

Yellow cake operations

Air from the yellow cake precipitators and thickeners area will be passed through a wet dust collector and vented to the atmosphere from a stack. The exhaust gases will contain ammonia at a concentration of about 100 ppm (ER, p. 3-29).

Combustion products such as carbon dioxide, sulfur dioxide, and nitrogen oxides will be released by the dryer. Because of the light-duty cycle and relatively small size of the dryer, these releases are not expected to be significant. The dryer exhaust will also contain ammonia at a concentration of 5 ppm (ER, p. 3-30).

Analytical laboratory

The plant will have an analytical and metallurgical laboratory in which the ore and process streams will be routinely analyzed and tested to provide a basis for optimizing processing conditions. The various process reagents and the finished product will also be analyzed as quality control measures. The fume hoods of the laboratory will collect air and an undefined mixture of chemical fumes and mists and discharge them through a stack to the atmosphere. This effluent is not expected to contain sufficient quantities of potential contaminants (radioactive or nonradioactive) to create a measurable impact (ER, p. 3-36).

Mill power plant

Electrical power and process heat for the Shootering Canyon Uranium Project will be supplied by diesel-generating units. Two 1200-kVA units would be provided, with one in operating mode and the other held in reserve. Number 2 diesel oil (maximum sulfur content 1%) will fuel the unit. Exhaust gases would be released from an 11-m (35-ft) stack. Table 3.1 lists the expected emission rates for this source as calculated by the applicant (ER, p. 3-37).

Table 3.1. Estimated pollutant emissions from diesel electric generating units

Pollutant	Short-term[a]		Annual average[b]	
	g/sec	lb/hr	g/sec	lb/hr
Carbon monoxide	2.0	16.0	1.9	14.9
Hydrocarbons	0.7	5.9	0.7	5.5
Nitrogen dioxide	9.3	74.0	8.7	69.0
Sulfur dioxide	0.62	4.9	0.58	4.6
Particulates	0.67	5.3	0.62	4.9

[a]Continuous operation is assumed.

[b]Operation for 340 days per year is assumed.

Source: ER, Table 3.5-2.

Building heat boiler

Diesel-driven generators will furnish waste heat for normal plant operations. An oil-fired boiler located in the power plant will be used as a supplementary heat source during cold weather. The boiler will burn an average of 6 gal and a maximum of about 20 gal of No. 2 burner oil per hour. Assuming a combustion heat of 1.5 x 10^8 J/hr (1.4 x 10^5 Btu/gal) for No. 2 burner oil,[2] the average heat input in the boiler would be about 1.5 x 10^7 J/min (1.4 x 10^4 Btu/min), with a maximum of about 4.9 x 10^7 J/min (4.6 x 10^4 Btu/min). The boiler would operate at the maximum fuel combustion rate only during cold weather. Maximum-rate operation is not expected to occur very often (ER, p. 3-37).

Emissions from the boiler will be vented to the atmosphere from an 11-m (35-ft) stack in the power plant (Table 3.2). These emissions will not exceed the applicable Utah standards.

Table 3.2. Estimated pollutant emissions from boiler

Pollutant	Estimated emissions[a]			
	Average		Maximum	
	g/sec	lb/hr	g/sec	lb/hr
Particulate matter	0.001	0.01	0.005	0.04
Sulfur dioxide	<0.107	<0.85	0.35	<2.8
Carbon monoxide	0.004	0.03	0.013	0.10
Hydrocarbons	0.001	0.01	0.003	0.02
Nitrogen oxides	0.016	0.13	0.055	0.44

[a]Estimates are based on emission factors for distillate fuel oil published in *Compilation of Air Pollutant Emissions Factors, AP-42*, EPA, 1975.

Source: ER, Table 3.5-1.

3.2.3.2 Liquid effluents

Sanitary liquid wastes will be treated and disposed of in accordance with the requirements of the Water Quality Division of the Utah State Division of Health. A system of concrete septic tanks will receive all the sanitary waste generated at the site. Effluents from these tanks will flow to the sanitary leach fields located to the south and west of the proposed mill. All other liquid wastes, spilled materials, and site drainage will be directed to the tailings impoundment for disposal by evaporation (Sect. 3.2.4.7).

3.2.3.3 Solid effluents

Nonradioactive solid wastes will be generated during normal maintenance and operation activities and in the ore crushing process. Trash, rags, wood scrap, and other nonradioactive debris will be generated within the mill. Because scrap iron, wood, and other mine trash separated from the ore will be contaminated only slightly, they may be disposed of as nonradioactive waste. These materials will be disposed of in landfill areas approved by the Utah State Division of Health and the appropriate Federal and/or local authorities.

3.2.4 Radioactive wastes and effluents

Mining and milling of natural uranium results in the release of some radioactivity to the environment. Uranium-238 and its daughter products in the ore are the most significant sources of radiation. The ore processed by the proposed Shootering Canyon mill will have an average grade of 0.10% uranium (U_3O_8). Ore of this grade has an activity of about 257 μCi of uranium-238 per ton of ore. The activity from uranium-235 and its daughters is only 1/20th that of the uranium-238 series and is radiologically insignificant.

Mining, ore transportation, milling operations, and tailings disposal present pathways for the release of radioactive effluents to the environment (Fig. 3.5). The amounts released through each of these pathways depend on system design, operating practice, ore type, and climate. The Shootering Canyon mill will utilize commonly practiced, state-of-the-art techniques to minimize radioactive effluents.

3.2.4.1 Mining

The underground mines serving the proposed mill will be sources of radon-222, ore dust, and mine drainage. The conditions in present mining operations indicate that mine drainage will be insignificant, thus eliminating radium release by this pathway. Dusting will be minimized by the moisture content of the ore and by keeping the floors of haulageways damp. Radon-222 releases will be a function of ore grade, rock characteristics, moisture, and area of ore exposed in the mine. Control of the mining release of radon is beyond the scope of this licensing action. Federal and State mine safety laws, however, provide for ventilation and other measures to protect mine employees and the public. All mining wastes will be disposed of in accordance with the Utah Mined Land Reclamation Act of 1975.

3.2.4.2 Transportation of ore to the mill

Transportation of ore to the mill is not expected to be a significant source of effluent. Run-of-mine ore will be relatively coarse material not prone to dusting. Minor spills of ore during the project life will cause some minor contamination of haul-road surfaces. Passage of vehicles over spilled ore materials and subsequent drying may promote dusting; however, the applicant plans to limit dust releases from haul roads by means of water sprays or chemical stabilizer treatment. Therefore, ore releases will be limited to the haul roads or their immediate vicinity. The potential effects of accidents involving ore transport from the Blanding ore buying station are discussed in Sect. 5.

3.2.4.3 Ore storage piles

During normal operation, ore trucks would deliver ore directly to the crushing unit. A 14-day supply of ore, approximately 9100 MT (10,000 tons), would be stockpiled near the mill

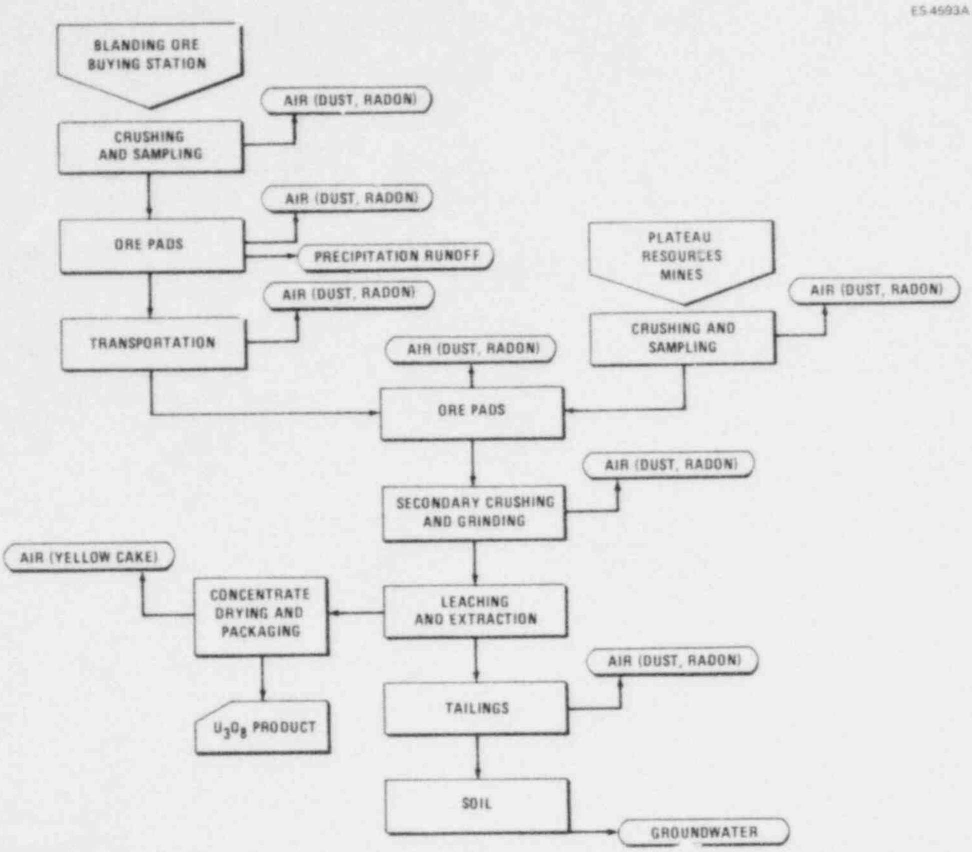


Fig. 3.5. Radionuclide dispersion pathways relevant to the Shootering Canyon Uranium Project.

to buffer mill operations against interruptions in the mining operations. A portion of the stockpile will consist of crushed and screened fine ore set aside to prevent interruption of mill operations by a crusher failure. Although present plans call for the storage of only 9100 MT (10,000 tons), the ore pad will be capable of storing as much as 91,000 MT (100,000 tons). The staff estimates the surface exposed during normal storage to be about 0.2 ha (0.5 acre); at maximum storage, up to 2.0 ha (5 acres) of surface will be present.

Although the ore storage area has a relatively large maximum capacity, its full use is not anticipated. The applicant has estimated that only 10-20% of the ore delivered to the mill will be deposited on and then removed from the ore storage pile. The remaining 80-90% will be fed directly from incoming vehicles to the ore crushers. This minimizes the handling of ore at the storage pile and will result in a relatively stable pile inventory. The applicant has estimated an average pile area of 0.25 ha (0.62 acres) to provide sufficient ore for approximately two weeks of mill operation. Because any large deviations from this estimate would be only of short-term duration and because the staff has estimated a lower average area, the applicant's estimate has been adopted for use in this analysis.

Ore stored on the pile would tend to dry out and become a source of dust emission. Also radon-222 gas would evolve in the pile and a portion would be released to the atmosphere. The applicant plans to spray the stored ore with water or apply chemical stabilizers to control dust emissions.[3] The staff estimates that the annual average dusting rate from the stored raw ore, which is composed mainly of rock-like fragments, will be approximately 10% of that estimated in Appendix D for dry tailings sands (192 $g/m^2 \cdot year$). The raw ore concentration of uranium-238 and each daughter in secular equilibrium, based on an average ore grade of 0.1%, would average about 283 pCi/g. Assuming that the emitted dust would have radioactivity concentrations 2.5 times those of the bulk ore, the annual release of uranium-238 and each particulate daughter is estimated to be 3.4×10^{-5} Ci. This estimate includes no reduction to account for dust control measures planned by the applicant and, therefore, implicitly allows for temporary and unusual upward variations of the storage pile area.

Radon-222 would be produced in the pile from decay of radium-226. Most of this radon decays in place. A small fraction escapes the pile by diffusion. If the same assumptions and considerations as detailed above and the calculational procedure described in Appendix F are used, release of radon-222 from the ore storage pile is estimated to be about 22 Ci per year. Variations in pile geometry that affect the surface area will affect the actual release rate encountered during operations. Maintaining the ore pile at minimum surface area and maximum height minimizes radon release. Water sprays applied to control dust release should also reduce radon releases.

Precipitation runoff from the ore storage area will be directed to the tailings impoundment. Therefore, no significant liquid effluent to the environment is expected from this source.

3.2.4.4 Crushing and grinding

The ore crushing unit is designed to minimize dust release. This control will be provided by the use of enclosed and/or hooded conveyors, feeders, bins, and hoppers. All the various discharge and transfer points in the system will be vented to wet dust collectors (high-energy venturi scrubbers or equivalent) with design removal efficiencies of at least 99.8% (ER, pp. 3-20, 3-21, and 3-27). The primary crushing unit, secondary crushing and sampling unit, and fine ore storage and feeding unit are served by separate dust collectors The applicant has estimated that the dust loading of the scrubbed exhaust air will be between 0.03 and 0.05 g/m^3. The staff has assumed a reduced average removal efficiency of 99% in order to account for the effects of aging, off-normal operation, and stray, unfiltered exhausts through doorways, etc. Based on this efficiency, the exhaust air dust loading would be 0.2 g/m^3. The radioactivity concentrations in the escaping dust are assumed to be 2.5 times those in the bulk ore.[4] Taking into account the proposed duty cycles and ventilation flow rates, the estimated annual releases of uranium-238 and each particulate daughter in secular equilibrium are 5.6×10^{-3} Ci for the primary or jaw crusher, 1.2×10^{-2} Ci for the secondary crusher, and 1.6×10^{-2} Ci for the fine-ore-blending operation.

The crushed ore is fed to the rod mill along with sufficient liquid to produce a slurry containing 70% solids. As a result, particulate releases from the grinding mill will be negligible.

Radon-222 gas is expected to be released during the crushing, blending, and grinding operations as a result of the extreme physical agitation involved in these processes. The staff has assumed that the entire radon-222 inventory of the processed ore would be released; 10% in each of the primary crushing, secondary crushing, and blending operations, and the remaining 70% in the rod mill. Radon-222 releases from these sources are estimated based on an average ore processing rate of 680 MT/day (750 tons/day) for 340 days per year and an average radon-222 concentration of 283 pCi/g. The resulting release estimates are 6.5 Ci/year for the primary crushing, secondary crushing, and blending operations (each), and 46 Ci/year for the rod mill. The only liquid waste produced in these operations would be dust slurries from the wet collector operation. These dust slurries would be combined with the rod mill ore slurry which is processed to recover uranium.

3.2.4.5 Leaching and extraction

Leaching and extraction are wet processes that would not make any significant contribution to the release of particulates. Because of the short residence time of ore in the mill circuit, radon-222 releases from these processes should not be significant and can be assumed to be included in the estimated releases from crushing and grinding.

3.2.4.6 Yellow cake drying and packaging

The uranium concentrate (precipitated ammonium diuranate) will be dried in a multiple-hearth furnace at 650-700°C.[5] The dried product will be 90% U_3O_8, with the remainder being nonvolatile salts and other impurities. Approximately 90% of the natural uranium, 5% of the thorium-230, and 0.2% of the radium-226 present in the ore are estimated to appear in the product.[6]

Product dust (yellow cake) will be present in the exhaust air streams of both the drying and packaging (product drumming) units. The applicant has estimated that, during operation, the exhaust streams from the drying and packaging units will contain about 0.007 to 0.01 kg/hr (0.016 and 0.021 lb/hr) of yellow cake, respectively, based on the design efficiency of 99.7% for the wet dust collectors (ER, Table 3.3-1). The staff has increased these mass release rates based on a reduced estimated average collection efficiency of 99%. Considering that the dryer and packaging unit will be operated for 30 hr/week and for 50 weeks per year, the estimated annual yellow cake release from both sources combined is 84 kg. The radioactivity content of this release is estimated to be 2.1×10^{-2} Ci/year of uranium-238 and uranium-234 (each), 1.2×10^{-3} Ci/year of thorium-230, and 4.7×10^{-5} Ci/year of radium-226 and lead-210 (each). No significant release of radon-222 from yellow cake operations is anticipated.

3.2.4.7 Tailings retention area

The tailings discharged from the countercurrent decantation unit of the mill is in the form of a slurry containing about 910 kg (2000 lb) of solids and 1.11 m^3 (293 gal) of liquids per ton of dry ore fed to the mill. The tailings liquid contains residual acid from the leaching step and dissolved solids placed in solution by leaching and rejected in the solvent extraction raffinate. The estimated composition of the waste solutions after neutralization to a pH of 4 is given in Table 3.3.

Table 3.3. Estimated composition of liquid fraction in plant tailings slurry

Parameter	Amount
Composition (mg/liter)	
Fe	130
V	2
U	0.34
Na	760[a]
NH_3	10[a]
Cl	140
SO_4	12,800
Cu	260[a]
Ca	500
Mg	2700
Al	3
Mn	730[a]
Zn	15[a]
Mo	5[a]
Organics	470
pH	4.0
Radiochemical assay (pCi/liter)	
Gross alpha	2.4×10^{5}[a]
Gross beta	5×10^{6}
Th-230	3700
Ra-226	50[a]
Pb-210	280[a]

[a]Staff estimates.

Other sources: ER, p. 3-26, and "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," Sept. 15, 1978.

Both the liquid and solid portions of the tailings will be a source of low-level radiation due to the uranium and daughter products left in the wastes. Less than 10% of the original uranium, 95% of the thorium, 99.8% of the radium, and essentially 100% of the other uranium-238 decay daughters remain with the tailings. With the exception of thorium-230, the radioactive components of the waste generally have a low solubility and remain mostly in the solids.

Because of the potential adverse radiological and chemical nature of uranium mill tailings, permanent environmental isolation is required. The tailings management plan should be designed to prevent excessive release of solids by wind erosion and of liquids by seepage, leakage, or overflow during operation of the mill. Following cessation of milling operations, the tailings management plan should also provide for adequate stabilization of the tailings against long-term erosion and minimize the leaching of radioactive solids, the diffusion of radon-222 gas, and the direct gamma radiation dose from the tailings. The tailings management plan proposed by the applicant is discussed in the remainder of this section. The merits of the proposed impoundment and alternative tailings management methods are discussed in Sect. 10.3.

The applicant proposes to construct an impoundment in a natural basin to the west of the mill (Fig. 3.6). The impoundment will be closed by an engineered embankment 36 m (118 ft) high (maximum) and about 460 m (1500 ft) long. The ultimate capacity of the impoundment will be 3.2×10^6 m^3 (2600 acre-ft), or 5×10^6 MT (5.5×10^6 tons), sufficient to hold the tailings solids from 20 years of mill operation at 680 MT (750 tons) per day.

ES-4650

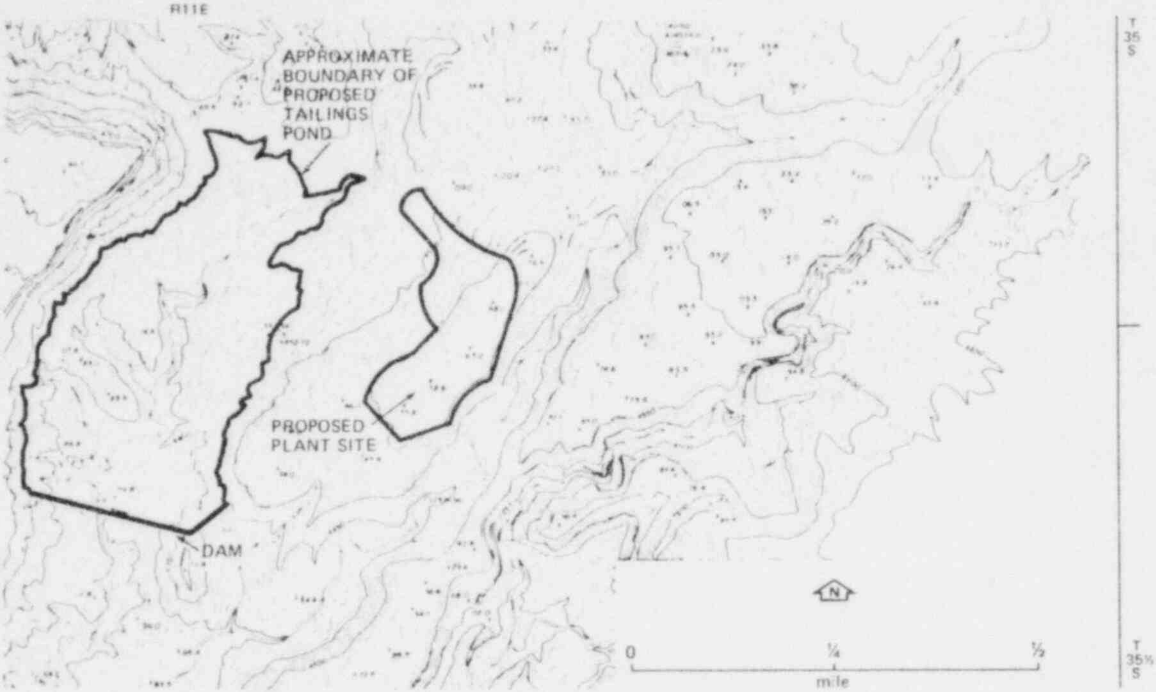
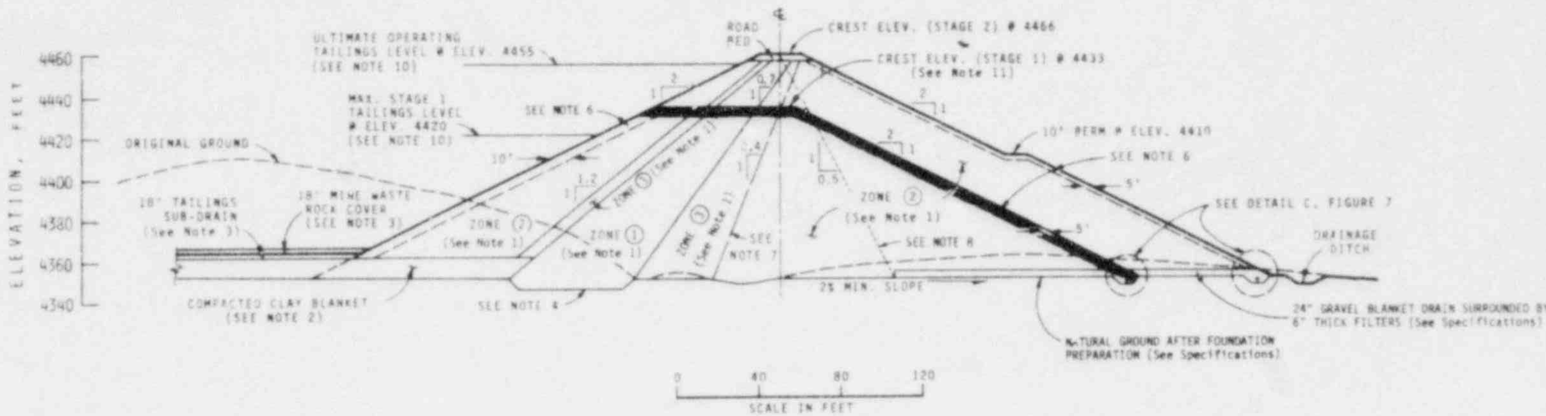


Fig. 3.6. Locations of the proposed tailings impoundment and plant site for the Shootering Canyon Uranium Project. Source: Plateau Resources, Ltd., Tailings Management Plan, Proposed Ore Processing Facility, Shootering Canyon Uranium Project, Utah, prepared by Woodward-Clyde Consultants, San Francisco, Calif., Rev. May 1978, Fig. 1.

The impoundment is planned to be constructed in two phases. The first phase will feature an embankment that is 26 m (85 ft) high [crest elevation 1351 m (4433 ft)], enclosing an area of 16 ha (39 acres). This phase will provide sufficient capacity for seven years of mill operation. For the second phase, the dam crest elevation will be raised from 1351 m to 1361 m (4466 ft), and the impoundment area would be expanded to 28 ha (68 acres). The dam will be constructed with a core of silty clay material keyed to the bedrock underlying the impoundment. The core will be blanketed with layers of sand, gravel, and coarse rock to stabilize the embankment and to prevent erosion (Fig. 3.7).

The floor and sides of the basin will be lined with a compacted clay-silt-sand material available from a borrow area approximately 3.2 km (2 miles) north of the impoundment site. The thickness of the liner will be a minimum of 0.6 m (2 ft) near the final waterline of the impoundment and will be 10% of the expected final hydraulic head in the deeper portions of the impoundment area. The applicant's consultant has measured the permeability of the proposed liner material to be approximately 5×10^{-7} cm/sec (0.52 ft/year). Because the impoundment would be built over sandstone bedrock, differential settlement should not be of sufficient severity to compromise liner integrity.

The seepage characteristics of the proposed impoundment are discussed in Sect. 4.3.2. To limit seepage to a reasonable value, the NRC will require use of a liner material having a permeability not greater than 1×10^{-7} cm/sec. The maximum potential seepage rate from the full impoundment with this less permeable liner is estimated by the staff to be less than 6.8×10^{4} m^3 (55 acre-ft) per year or about 185 m^3/day (34 gal/min).



NOTES:

1. ZONE ① - SILTY SANDY CLAYEY SOIL (SEE SPECIFICATIONS).
   ZONE ② - BOULDERS, COBBLES, GRAVELS, SAND. THE MATERIAL OF THIS ZONE TO BE PLACED SO THAT THE FINER PORTION WILL BE ADJACENT TO ZONE ③ AND THE COARSER PORTION WILL BE AT THE OUTSIDE SLOPE SURFACES. (SEE SPECIFICATIONS).
   ZONE ③ - SELECTED FINE SAND (SEE SPECIFICATIONS).
2. THICKNESS OF COMPACTED CLAYEY SOIL BLANKET TO BE 10% OF DISTANCE FROM FINAL GROUND SURFACE TO MAXIMUM DESIGN WATER SURFACE, BUT NOT LESS THAN 2 FEET. (SEE SPECIFICATIONS)
3. PROVIDE 18 INCHES EACH OF TRAFFIC COMPACTED MINE WASTE ROCK AND TAILINGS SUB-DRAIN MATERIAL (SEE SPECIFICATIONS).
4. EXTEND ZONE ① TO SOUND BEDROCK AS DIRECTED BY GEOTECHNICAL ENGINEER. PROVIDE SLUSH GROUT ON FOUNDATION CONTACT FOR ZONE ① AS DIRECTED BY GEOTECHNICAL ENGINEER. (SEE SPECIFICATIONS).
6. ZONE OF UPSTREAM AND DOWNSTREAM SLOPE PROTECTION TO CONSIST OF PEDIMENT MATERIAL OF WHICH 50% IS COARSER THAN 12 INCHES (SEE SPECIFICATIONS).
7. DOWNSTREAM BOUNDARY OF ZONE ③ SHOWN IS MINIMUM REQUIREMENT.
8. EXTEND BLANKET DRAIN AND FILTERS FROM TOE TO LINE SHOWN, BUT NOT ABOVE ELEVATION 4445.
10. A MAXIMUM OF 2 FEET OF LIQUID IS TO BE MAINTAINED ON TOP OF TAILINGS.
11. REMOVE PEDIMENT MATERIAL (ROAD BED) OVERLYING ZONES ① AND ③ PRIOR TO RAISING EMBANKMENT TO ULTIMATE LEVEL.

Fig. 3.7. Proposed design of the tailings dam for the Shootering Canyon Uranium Project. Source: Plateau Resources, Ltd., Tailings Management Plan and Geotechnical Engineering Studies, Shootering Canyon Uranium Project, prepared by Woodward-Clyde Consultants, San Francisco, Calif., September 1978, Fig. 6.

The applicant proposes to install a tailings drainage system in the lower portion of the initial tailings impoundment area for the primary purpose of dewatering the deposited tailings in place as rapidly and as thoroughly as possible. The expected benefits of this operating mode are the recovery and potential recycle of tailings liquid (thereby reducing project water requirements), the reduction of seepage losses by decreasing the hydraulic head above the pond liner, and more rapid settling and stabilization of the tailings. This settling will permit reclamation of the tailings area shortly after plant operations have ceased, which will minimize radon emissions and dispersal of airborne tailings during the drying out period. If the system operates as planned, the applicant will extend it to the remainder of the impoundment as part of the second phase of the impoundment expansion. Should the system prove ineffective (e.g., drainage pipes become blocked), modifications to impoundment operation procedures would be proposed by the applicant.

The drainage system will consist of a network of perforated plastic drainpipe covering the compacted clay liner of the impoundment. The main collector drain will run upstream from the dam along the bottom of the impoundment basin. Branching lateral drains will connect to the collector drain at about 150-m (500-ft) intervals. All drains will be extended up the sides of the basin to an elevation of 15 m (50 ft) above the base of the dam and will follow topographic depressions as much as possible. The main collector drain will discharge into a sump located at the low point of the impoundment. A vertical riser pipe installed in one corner of the sump will be progressively lengthened to extend above the tailings at all times, and drained tailings liquid will be removed by a well-type pump installed in the riser. To prevent plugging of the drain pipes by the tailings solids, each pipe will be encased in a jacket of pea gravel overlaid by a sand filter berm. The berms will divide the impoundment into several cells within which a layer of sand and mine waste rock will be placed. This material will serve as a drainage blanket and will also partially neutralize the acidic tailings liquid by reaction with the carbonate in the mine waste rock.

The system will be operated by discharging tailings slurry from a single spigot into a corner of one of the drainage cells. In this way, the deposited solids will form a nearly flat conical mound around the discharge point with the sands segregating near the discharge point and the slimes deposited at the bottom of the slope. After the mound builds up, the discharge point will be shifted to another corner of the cell or to a second cell and the deposited slimes will be allowed to stabilize enough to prevent displacement or disturbance by subsequent additions of tailings slurry. The operational cycle is expected to require from four to eight cells to ensure adequate stabilization of the slimes before the feed point is shifted. As the cells are filled, the drainage berms will be built up with tailings sands. To improve the neutralization capacity of the system, additional calcareous mine waste rock may be placed over the deposited sands prior to resuming the tailings feed. If percolation of the tailings liquid through the carbonate material fails to produce adequate neutralization, the applicant proposes to add calcareous material to the tailings slurry in a manner designed to obtain more intimate contact with the acidic tailings liquid.

The system is designed so that liquids discharged to the cells will seep through the deposited solids into the drainage blanket and along the top of the clay liner to the drainage pipes. The fine particulates in the slurry feed are expected to be removed by the sand filters as the liquid drainage flows from the blankets to the pipe collectors.

The carbonate content of the mine waste rock in the impoundment will provide some neutralization of the acid in the liquid wastes. Based on a tailings pH of 1.5 and a mine waste carbonate content of 10%, the applicant estimates that neutralization would require 18 kg (40 lb) of waste rock per ton of ore processed (addition of this rock material would increase the volume of the solids in the impoundment by approximately 2%). The staff believes that this value is unrealistic because it does not account for the buffering effects of the bisulfate ion (HSO_4^-) and other chemicals. At the expected solution pH of 1.5 and total sulfate concentration of 12,800 ppm (12.8 g/liter), the concentration of the bisulfate ion is roughly three times higher than that of the free hydrogen ion. As neutralization consumes the hydrogen ion, the bisulfate would dissociate into sulfate and more hydrogen ion. Therefore, neutralization would not be complete until both the hydrogen and bisulfate ions are consumed. In this case, complete neutralization would require 72.7 kg (160 lb) of waste rock per ton of ore processed, and the quantity of waste rock required for total neutralization over the life of the project would be roughly 8% of the ore mass processed.

The main benefit to be derived from neutralization is a substantial reduction of the dissolved solids content of the liquid wastes. About 90% of the radium, most of the thorium, and much of the copper, cobalt, aluminum, iron, molybdenum, and vanadium would be precipitated from solution as would sulfate in the form of gypsum. The neutralized solution may be suitable for recycle to the mill process resulting in a net reduction in water consumption. However, should residual contaminants preclude recycle to the process, the reduction in tailings acidity will at least render toxic materials in the wastes less susceptible to leaching and transport. In either case, the collected liquids will be available for wetting the tailings beaches as part of the dust control program, for dilution of the tailings slurry to aid in transport to the impoundment, and should be more readily evaporated than the untreated solution.

The proposed tailings management system will prevent excessive segregation of sands and slimes. The interbedding of sands and slimes resulting from the filling procedure utilized will facilitate the drainage and stabilization of the slimes. The long-term stability of the impoundment should be improved over that of conventional impoundments, which have a large slimes area subject to seismic liquifaction and differential settlement.

The particulate, seepage, and radon releases would be at their maximum values toward the end of the mill operating life. At that time the surface area of the tailings impoundment will exceed the required evaporation area, exposing the tailings beach to potential wind erosion and increased radon diffusion. If the tailings drainage system successfully reduces the hydrostatic head and hence the seepage through the liner, the evaporation area will increase by 0.12 ha (0.3 acre) for every acre-foot reduction in seepage. During the early stages of operation, smaller seepage losses and impoundment areas would result in the evaporation area covering the entire active tailings area, thus reducing the area of tailings exposed to the atmosphere.

The tailings beach and the drained cells will be subject to drying and subsequent dust emissions through wind erosion. To minimize dusting the applicant plans to apply the tailings liquids to all exposed dry areas. Assuming this control to be 80% effective, approximately 5.5 ha (14 acres) of the exposed area will be a source of wind-blown particulates. The annual average dry tailings pile dusting rate, on the basis of data presented in Appendix D, would be approximately 192 g/m^2·year (4.74 MT/acre-year). This rate corresponds to annual radioactive releases of 7.52 x 10^{-4} Ci of uranium-238 and uranium-234, 7.15 x 10^{-3} Ci of thorium-230, and 7.52 x 10^{-3} Ci of radium-226 and lead-210.

In addition to particulate releases, the exposed tailings beach will also be a significant source of radon-222. The annual release, estimated using the models and data described in Appendix F, is calculated to be 2470 Ci. This estimate is based on the assumption that the entire tailings area will emit radon at the rate of about 283 pCi/m^2·sec.

As noted above and in Sect. 4.3.2, the maximum seepage from the impoundment without operation of the drainage system will be about 6.8 x 10^4 m^3 (55 acre-ft) per year. The applicant estimates that, if the drainage system is successful, the hydrostatic head across the pond liner may be reduced to as little as about 0.9 m (3 ft) and could reduce the seepage from the impoundment to less than 5.5 m^3/day (1 gal/min). Because the seepage will be neutralized in either the impoundment areas or in the bedrock under the impoundment, almost all of the dissolved radionuclides and many of the heavy metals are expected to be immobilized within the immediate area of the impoundment.

3.2.4.8 Source terms

Sections 3.2.4.1 through 3.2.4.7 describe the nature and quantity of radioactive effluents conservatively estimated to be generated by milling operations at the Shootering Canyon Uranium Project. Estimates employed in the above discussions were derived from project design parameters and data from similar mills.[7-37] The estimates reflect operation of the fully developed mill and tailings area. Initial releases from the tailings area will be lower than the estimated values for several years after start-up. Therefore, the use of full-scale operation as the basis for estimates adds some additional conservatism to the analysis. Table 3.4 gives the design parameters used in estimates of radioactive release rates. The source terms for the milling operations and areas are presented in Table 3.5.

Table 3.4. Principal parameter values used in the radiological assessment of the Shootering Canyon Uranium Project

Parameter	Value[a]
General data	
Average ore grade, % U_3O_8	0.10
Ore concentration, pCi of U-238 and daughters per gram	283
Ore processing rate, MT/day	680
Days of operation per year	340
Ore storage piles[b]	
Actual area, ha (acres)	0.25 (0.62)
Effective dusting area, ha (acres)	0.25 (0.62)
Annual average dust loss rate, $g/m^2 \cdot year$	19.2
Dust : ore concentration ratio	2.5
Crushers	
Dust collector removal efficiency, %	99
Exhaust air ore concentration, g/m^3	0.2
Primary crusher exhaust airflow, m^3/min (ft^3/min)	170 (6000)
Secondary crusher exhaust airflow, m^3/min (ft^3/min)	368 (13,000)
Fraction of time operational	0.444
Dust : ore concentration ratio	2.5
Fine ore blending	
Dust collector removal efficiency, %	99
Exhaust air ore concentration, g/m^3	0.2
Exhaust airflow, m^3/min (ft^3/min)	230 (8000)
Days of operation per year	340
Dust : ore concentration ratio	2.5
Yellow cake drying and packaging	
Fraction U to yellow cake	0.90
Fraction Th to yellow cake	0.05
Fraction Ra and Pb to yellow cake	0.002
Dust collector removal efficiency, %	99
Yellow cake dust release rate, kg/hr (lb/hr)	0.06 (0.123)
Fraction of time operational	0.172
Tailings impoundment system[b]	
Fraction U to tailings	0.10
Fraction Th to tailings	0.95
Fraction Ra and Pb to tailings	0.998
Total area, ha (acres)	27.7 (68.5)
Effective area subject to dusting, ha (acres)	5.5 (14)
Annual average dust loss rate, $g/m^2 \cdot year$	192
Dust : tails concentration ratio	2.5

[a]Parameter values presented here are those selected by the staff for use in its radiological impact assessment of the Shootering Canyon Uranium Project. They represent conservative selections from ranges of potential values in instances where insufficient data has been available to be more specific.

[b]For additional parameter values, see Appendix D.

Table 3.5. Estimated annual releases of radioactive materials resulting from the Shootering Canyon Uranium Project

Source	Annual releases, curies[a]			
	U-238	Th-230	Ra-226	Rn-222
Ore storage pile	3.39×10^{-5}	3.39×10^{-5}	3.39×10^{-5}	22.3×10
Primary crusher	5.61×10^{-3}	5.61×10^{-3}	5.61×10^{-3}	6.54
Secondary crusher	1.22×10^{-2}	1.22×10^{-2}	1.22×10^{-2}	6.54
Fine ore blending	1.57×10^{-2}	1.57×10^{-2}	1.57×10^{-2}	6.54
Rod mill				45.8×10
Yellow cake operations	2.12×10^{-2}	1.18×10^{-3}	4.72×10^{-5}	
Tailings system	7.52×10^{-4}	7.15×10^{-3}	7.52×10^{-3}	2.47×10^{3}

[a]Releases of other isotopes in the U-238 decay chain are included in the radiological impact analysis. These releases are assumed to be identical to those presented here for parent isotopes. For instance, the release rate of U-234 is taken to be equal to that for U-238.

3.3 INTERIM STABILIZATION, RECLAMATION, AND DECOMMISSIONING

3.3.1 Interim stabilization

3.3.1.1 Mill tailings area

Interim *stabilization* is defined as measures to prevent the dispersion of tailings particles by wind and water outside the immediate tailings retention area. Such measures will be required at the Shootering Canyon mill during the 15 years of operation.

As a license condition, the staff will require that the applicant immediately implement an interim stabilization program that minimizes dispersal (via airborne particulates) of blowing tailings to the maximum extent achievable. The effectiveness of this control measure will be checked at least weekly by means of a documented inspection.

3.3.1.2 Other areas

The use of underground mining techniques limits land disturbance to rock-waste dump areas, mine service facilities, and roads. Rock-waste dumps will be located along the canyon wall adjacent to the mine portals. The dumps will be sited such that natural flood flows within the canyon will not be obstructed by the dump. The tops of the waste piles will be sloped to facilitate drainage, and the side slopes of the piles will form at the natural angle of repose. No additional stabilization measures are planned. Approximately 4 ha (10 acres) of land will be affected at the Tony M Mine; the mine serving the northeast ore body will have similar land requirements.

3.3.2 Reclamation

3.3.2.1 Mill tailings area

In accordance with the Utah Mined Land Reclamation Act of 1975 and the requirements of the NRC, the applicant has prepared a reclamation plan for the tailings area. The goal of the applicant's plan is to meet the performance objectives for tailings management (Sect. 10.3.1). Reclamation would commence after cessation of milling operations as soon as the tailings area had dried sufficiently to allow movement of equipment over the pile.

The proposed reclamation program calls for a 1.8-m (6.0-ft) layer of compacted clayey materials (borrowed from exposed portions of the Summerville Formation near the site) and a 0.6-m (2.0-ft) layer of sandy soil material over the tailings area.[1] Staff calculations show the proposed cover is sufficient to reduce the radon flux to twice background and the gamma radiation to background levels. (See Appendices F and G.) A 0.3-m (1.0-ft) layer of coarse gravel and rock will be placed over the cap for protection against erosion. The cap will be designed to resist damage by differential settlement of the tailings.

The reclaimed impoundment is designed to mitigate the effects of erosion. The coarse rock and boulders covering the surfaces of the tailings area and the downstream face of the impoundment dam will resist gullying and water sheet erosion. Sediment laden runoff from the 89-ha (220-acre) drainage basin above the dam will pond over the tailings cap. Ponded water would be dispersed by evaporation because the underlying cap would have a low permeability and the remaining sediments carried into the impoundment would add to the thickness of the cap. This process would lead to conditions conducive to natural establishment of a vegetative cover. Revegetation of this area will be entirely dependent upon natural secondary succession. The face of the impoundment dam will be covered with a 1.5-m (5-ft) of large rock, 50% of which will be coarser than 30 cm (12 in.).[1] The proposed plan to revegetate cover for the tailings impoundment does not meet State requirements for revegetation.[38]

Because the cap would be thick [2.75 m (9 ft)] and topped with riprap and because of the aridity of the region, the staff has concluded that root penetration into the tailings is not likely. Thus the possibility of adverse impacts associated with the upward migration of radionuclides and toxic elements through plant root systems is reduced. The periodic collection of runoff over the impoundment will prevent dessication of the clay cap and therefore limit the development of shrinkage cracks. The rapid evaporation of collected runoff and the small hydraulic head over the cap will limit the infiltration of water through the tailings.

After reclamation, two spillways would be constructed to protect the dam and the tailings cap against erosion and flood flows. One spillway would be excavated in the sandstone of the left abutment of the dam to direct drainage to the downstream portion of the impoundment basin. The other spillway would be excavated in the sandstone formation along the northwest corner of the impoundment. This spillway would divert drainage to Lost Spring Wash. Both spillways would have crest elevations 0.9 m (3 ft) above the level of the tailings cap and would be sized to pass the probable maximum flood. However, until sediment deposition fills in the impoundment to the level of the spillway crests, spillway flows would be rare events. The proposed spillways will promote the deposition of additional sediment over the tailings cap, providing additional protection against erosion.

3.3.2.2 Mine and mill areas

In accordance with the Utah Mined Land Reclamation Act of 1975 and the requirements of the NRC, the applicant has prepared reclamation plans for the mine and other mill site areas. At the end of operations, all buildings and facilities in the mine camp and service area will be dismantled and removed from the site. Building foundations will be leveled, and the disturbed areas will be regraded to preproject contours.

Access roads constructed for exploration and development drilling activities will be closed by bulldozing earth and rock barriers across them at gullies, bluffs, and other strategic locations. Natural weathering will return these road tracks to conditions similar to those existing before construction. Mine access and haul roads in existence prior to project construction will be left intact after the close of the project.

At project termination it is anticipated that the mill structures, tanks, and other facilities will be decontaminated, dismantled, and removed from the site. Foundations will be leveled, and the resulting waste will either be used in the filling of depressions on the site or be removed to an approved landfill site. All depressions in the mill site area will be filled and the entire area graded so that site runoff will drain into the tailings area.

Several characteristics of the project area, and southeastern Utah in general, make it very difficult to reestablish the vegetation rapidly. The most significant factors are the arid climate and the poorly developed soil. The applicant plans to redistribute at least 0.3 m (1 ft) of previously stockpiled topsoil over all disturbed areas except the access road and tailings impoundment area. Then these areas will be graded, fertilized, and seeded with native species. Proposed plant species include sage (*Artemisia* spp.), Indian ricegrass (*Oryzopsis hymenoides*), and Mormon tea (*Ephedra torreyana*) (ER, Sect. 9.3). With the exception of Mormon tea, the species selected by the applicant are not prevalent in the area.

The staff recommends that the applicant follow revegetation techniques, including species and mixture of seed, similar to those suggested by Plummer.[39] Some fast-growing, introduced species such as pubescent wheatgrass, crested wheatgrass, and alfalfa could be used to help stabilize the reclaimed areas, but the greatest percentage of seeds should be native species. Additionally, the seed should be obtained from those areas that have soil characteristics and climate similar to the project site.[39] In the long term, native vegetation is expected to return to the areas, and such a maintenance-free cover should maximize soil stability.

The mixture of seed can be planted from November through February.[39] However, because of the large number of seed-eating rodents present in the area (Sect. 2.9.1.2), it may be necessary to delay the planting until December. Reclamation should begin as soon as practicable and continue throughout the life of the project. In doing so, portions of the borrow areas disturbed during construction could be in their thirteenth year of reclamation by the time mill operation ceases. Also, any knowledge gained by previous reclamation efforts could be applied to those areas yet to be reclaimed.

Because soil fertility is low (Sect. 2.8), it may be necessary to analyze the nutrient content of the soil and, if needed, to apply appropriate fertilizer prior to seeding. Because reclamation of blackbrush communities, which are present at the site, is not usually successful where annual average precipitation averages less than 25 cm (10 in.) and because annual average precipitation at the mill site is only about 18 cm (7 in.) (Sect. 2.1.2), it may be necessary to irrigate the reseeded areas for initial stand establishment. Topsoil at the site contains very little organic matter. As the presence of organic matter and mulches in the soil increases infiltration and reduces erosion and evaporation, thereby encouraging seed germination and plant growth, it may be necessary to crimp mulch into the soil of all disturbed areas prior to seeding. Revegetated areas will be monitored (Sect. 6.2.2).

The staff notes that the information developed in the Generic Environmental Impact Statement on uranium milling being written by NRC could be used to modify or change the procedures proposed herein. The generic statement will contain the results of ongoing research to assess the environmental impacts of uranium mill tailings ponds and piles and will suggest means for mitigating any adverse impacts. The current NRC licensing action regarding the Shootering Canyon mill will be subject to revisions based on the conclusions of the Final Generic Environmental Impact Statement on uranium milling operations and any related rule making.

The applicant will be required to make financial surety arrangements to cover the costs of reclaiming the tailings disposal area and of decommissioning the mill.

At the time of termination of the operating license, the NRC will require that the land on which the tailings are stored be subject to the following specific restrictions:

- The holder of the possessory interest will not permit the exposure and release of tailings material to the surrounding area.
- The holder of the possessory interest will prohibit erection of any structures for occupancy by man or animals.
- Subdivision of the covered surface will be prohibited.
- No private roads, trails, or rights-of-way may be established across the covered surface.

3.3.3 Decommissioning

Near the end of the useful life of this project and prior to the termination of the license, the NRC will require a detailed decommissioning plan for the Shootering Canyon mill, which will contain plans for decontamination, dismantling, and removing or burying all buildings, machinery, process vessels, and other structures and cleanup regrading and revegetation of the site. This detailed plan will include data from radiation surveys taken at the site and plans for any mitigating measures that may be required as a result of these surveys and NRC inspections. Before release of the premises or removal of the buildings and foundations, the licensee must demonstrate that levels of radioactive contamination are within limits prescribed by NRC and the then-current regulations. Depending on the circumstances, the NRC may require that the applicant submit an Environmental Report on decommissioning operations prior to termination of the license.

REFERENCES FOR SECTION 3

1. Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif., Aug. 29, 1978.

2. V. B. Guthrie, Ed., *Petroleum Products Handbook*, McGraw-Hill, New York, 1960.

3. Ref. 1, p. 47.

4. M. B. Sears et al., *Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing "as Low as Practicable" Guides — Milling of Uranium Ores*, Report ORNL/TM-4903, vol. 1, Oak Ridge National Laboratory, Oak Ridge, Tenn., May 1975, Table 9.12.

5. R. C. Merritt, "The Extractive Metallurgy of Uranium," Colorado School of Mines Research Institute, Golden, Colorado, 1971, p. 253.

6. Ref. 4, p. 122.

7. K. J. Schiager, "Analysis of Radiation Exposures On or Near Uranium Mill Tailings Piles," *Radiol. Data Rep.* 12: 17-28 (1971).

8. U.S. Environmental Protection Agency, *Environmental Analysis of the Uranium Fuel Cycle*, Report EPA-520/9-73-003, Washington, D.C., 1973.

9. U.S. Atomic Energy Commission, *Environmental Survey of the Uranium Fuel Cycle*, Report WASH-1248, April 1974.

10. U.S. Energy Research and Development Administration, *U.S. Nuclear Power Export Activities*, Report ERDA-1542, April 1976.

11. D. A. Nussbaumer and D. F. Harmon, "The United States Atomic Energy Commission's Regulatory Control Programme for Uranium Milling," reprint from *Radiological Health and Safety in Mining of Nuclear Materials*, vol. II, International Atomic Energy Agency, Vienna, 1964, pp. 519-533.

12. E. C. Tsivoglow and R. L. O'Connell, *Waste Guide for the Uranium Milling Industry*, U.S. Department of Health, Education, and Welfare, Technical Report W62-12, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 1962.

13. R. G. Beverly, "Unique Disposal Methods are Required for Uranium Mill Waste," *Min. Eng.* 20: 52-56 (1968).

14. Winchester Laboratory, Topical Report, *January 1960 Summary Report on I. The Control of Radium and Thorium in the Uranium Milling Industry. II. Radium-226 Analysis Principles, Interference and Practice. III. Current Winchester Laboratory Projects*, U.S. Atomic Energy Commission Report WIN-112, National Lead Col., Inc., Feb. 1, 1960.

15. U.S. Department of Health, Education, and Welfare, *Process and Waste Characteristics at Selected Uranium Mills*, Public Health Service, Technical Report W62-17, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 1962, 94 pp.

16. K. E. Tame et al., *Disposal of Liquid Waste in the Durango-Type Uranium Milling Flowsheet*, U.S. Bureau of Mines, Report of Investigation 5874, 1961.

17. K. E. Tame et al., *Disposal of Radioactive Waste in the Vitro-Type Uranium Milling Flowsheet*, U.S. Bureau of Mines, Report of Investigation 6011, 1962.

18. K. E. Tame et al., *Radioactive Waste Disposal in the Shiprock-Type Uranium Milling Flowsheet*, U.S. Bureau of Mines, Report of Investigation 6045, 1962.

19. K. E. Tame and J. B. Rosenbaum, *Disposal of Liquid Waste in the Resin-in-Pump Type Uranium Milling Flowsheet*, U.S. Bureau of Mines, Report of Investigation 6114, 1962.

20. K. E. Tame, *Radioactivity in Alkaline Leach Milling Process*, U.S. Bureau of Mines, Report of Investigation 6346, 1964.

21. R. G. Beverly, "Radium and Thorium Behavior in Uranium Milling Circuits — Statement of Air and Water Concentration Limits Prescribed in Part 20," presented at the Symposium on Radio-chemical Problems in Uranium Milling, Grand Junction, Colorado, Oct. 5 and 6, 1960.

22. W. B. Harris et al., *Environmental Hazards Associated with the Milling of Uranium Ore — A Summary Report*, U.S. Atomic Energy Commission Report HASL-40 (REV), New York Operations Office, Health and Safety Laboratory, Revised Nov. 14, 1958.

23. *American Standard Radiation Protection in Uranium Mines and Mills (Concentrators)*, sponsored by Atomic Industrial Forum, Inc., and National Safety Council, American Standards Association Inc., New York, approved Oct. 3, 1960.

24. A. Whitman and E. S. Porter, *Chemical Stream Pollution from Uranium Mills*, U.S. Atomic Energy Commission Report WIN-99, National Lead Co., Inc., June 13, 1958.

25. R. D. Lynn and Z. E. Arlin, "Deep Well Construction for the Disposal of Uranium Mill Tailing Water by the Anaconda Co. at Grants, New Mexico," *Trans. Min. AIME* 223: 230-237, 1962.

26. G. R. Yourt, "Radiological Control of Uranium Mine and Mill Wastes," pp. 107-120 in *Ontario Industrial Waste Conference Proceedings*, No. 13, 1966.

27. D. F. Little et al., "Two Years' Milling at Bicroft Uranium Mines Ltd.," *Trans. Min. AIME* 220: 458-468, 1961.

28. W. L. Lennemann and F. E. McGinley, "Advances in Uranium Ore Processing," *Min. Congr. J.* 45(7): 59-63, 1959.

29. W. D. Arnold and D. J. Crouse, "Radium Removal from Uranium Mill Effluents with Inorganic Ion Exchangers," *Ind. Eng. Chem. Process Des. Dev.* 4(3): 333-337, 1965.

30. U.S. Department of Health, Education, and Welfare, "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin," Federal Water Pollution Control Administration, Region VIII, Denver, Colorado River Basin Water Quality Control Project, March 1966.

31. R. H. Kennedy, "Comparison of Foreign and Domestic Uranium Ore Milling Practices," presented at the Tenth Annual Minerals Symposium, sponsored by the Colorado Plateau Section AIME, Grand Junction, Colorado, May 8, 1965.

32. "Radiation Regulation No. 2," Regulation of the Colorado State Department of Public Health Requiring Stabilization of Uranium and Thorium Mill Tailing Piles.

33. *Erosion Control Uranium Mill Tailing Project, Monticello, Utah*, U.S. Atomic Energy Commission Report RMO-3005, Grand Junction Office, Dec. 20, 1963.

34. *Supplement to the Report of the Monticello Mill Tailing Erosion Control Project, Monticello, Utah*, U.S. Atomic Energy Commission Report Supplement to RMO-3005, Grand Junction Office, Apr. 20, 1966.

35. H. J. Paas, Jr., *Radiological Appraisal of the Monticello Project San Juan County, Monticello, Utah*, U.S. Atomic Energy Commission Report IDO 12049, Idaho Operations Office, February 1966.

36. R. Havens and K. C. Dean, *Chemical Stabilization of the Uranium Tailings at Tuba City, Arizona*, U.S. Bureau of Mines, Report of Investigation 7288, 1969.

37. "Environmental Survey of Uranium Mill Tailings Pile, Tuba City, Arizona," *Radiol. Health Data Rep.* 9(11): 475-487, 1968.

38. State of Utah, Department of Natural Resources, Division of Oil, Gas, and Mining, *Oil and Gas Conservation Act: Mined Land Reclamation — Changes and Adoptions to the General Rules and Regulations*, adopted on March 22, 1978; effective June 1, 1978.

39. A. P. Plummer, *Restoring Big-Game Range in Utah*, Utah Division of Fish and Game, Publication No. 68-3, Salt Lake City, 1968.

4. ENVIRONMENTAL IMPACTS

4.1 AIR QUALITY

4.1.1 Construction

The major air pollutants associated with construction of the mill facility will be gaseous emissions from internal combustion engines and fugitive dust generated from moving vehicles and wind erosion. In general, these emissions will not produce significant impacts on the air quality of the region.

The maximum expected emission rate for any of the major air pollutants (NO_2, SO_2, CO, and hydrocarbons) from each piece of construction equipment is less than 0.2 g/sec.[1] Using conservative χ/Q (sec/m^3) values (Appendix E, Table E.1), the staff calculated the annual average atmospheric concentration of each pollutant per construction vehicle to be less than 1 $\mu g/m^3$ at the mill-site claim boundary in the direction of the prevailing wind. Such concentrations are approximately two orders of magnitude less than applicable Federal and State air quality standards (Table 4.1). Annual average atmospheric concentrations of these pollutants at the nearest potential residence (Ticaboo Subdivision) are expected to be even less, 0.03 $\mu g/m^3$. Considering the short duration of construction (14 months) and the low atmospheric concentrations of emissions, the staff's opinion is that emissions from internal combustion engines should not significantly impact air quality of the region.

Table 4.1. Federal and State of Utah air quality standards

Pollutant	Averaging time[a]	Primary standard	Secondary standard
Nitrogen dioxide[b]	Annual	0.05 ppm (100 $\mu g/m^3$)	0.05 ppm (100 $\mu g/m^3$)
Sulfur dioxide	Annual	0.03 ppm (80 $\mu g/m^3$)	
	24 hr	0.14 ppm (365 $\mu g/m^3$)	
	3 hr		0.5 ppm (1300 $\mu g/m^3$)
Suspended particulates	Annual geometric mean	75 $\mu g/m^3$	60 $\mu g/m^3$
	24 hr	260 $\mu g/m^3$	150 $\mu g/m^3$
Hydrocarbons (corrected for methane)	3 hr 6 to 9 AM	0.24 ppm[c] (160 $\mu g/m^3$)	0.24 ppm (160 $\mu g/m^3$)
Photochemical oxidants	1 hr	0.08 ppm (160 $\mu g/m^3$)	0.08 ppm (160 $\mu g/m^3$)
Carbon monoxide	8 hr	9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)
	1 hr	35 ppm (40 mg/m^3)	35 ppm (40 mg/m^3)

[a] All standards except annual average are not to be exceeded more than once a year.

[b] Nitrogen dioxide is the only one of the nitrogen oxides considered in the ambient standards.

[c] Maximum 3 hr concentration between 6 and 9 AM.

Source: ER, Table 2.7-7.

Fugitive dust associated with construction of the facility will average about 2.3 to 4.6 MT/ha (1 to 2 tons/acre) per month.[2] Based on a land requirement of about 140 ha (350 acres), construction activities are expected to create about 100 to 200 g/sec of particulates. Annual average atmospheric concentrations of particulates were calculated by the staff using the χ/Q values (Appendix E, Table E.1) for the 16 compass directions at a distance of 2.4 km (1.5 miles). The average of these 16 concentrations indicates that particulate loading caused by construction will range from 26 to 52 $\mu g/m^3$. The addition of these concentrations to those of the natural background (Sect. 2.2) will result in occasional violation of State and Federal air quality standards (Table 4.1); however, these are conservative calculations because the χ/Q values assume a point source. The construction activities actually will be widespread, creating many scattered diffuse sources. Furthermore, the larger dust particles will deposit rapidly, another condition not accounted for in the calculation. Although dust may cause occasional localized degradation of the air quality at the site, the duration will be only during the 14-month construction phase. To minimize fugitive dust, all haul roads and active working surfaces will be watered or treated with stabilizing agents (ER, Sect. 4.6).

4.1.2 Operation

Air quality during operation of the facility could be affected by atmospheric releases principally from the crushers, sampling bins, feeders, building and processing boiler, diesel generator, tailings disposal system, and ore stockpiles. Estimates of emissions from each primary source and their release heights are listed in Table 4.2. In addition, insignificant quantities will be released from other sources including the ore transport systems, acid leach system, solvent extraction process, yellow cake precipitators and thickeners, and drying furnace.

Table 4.2. Emission rates, sources, and release heights of major air pollutants associated with operation of the Shootering Canyon Uranium Project

Air pollutant and source	Average emission rate (g/sec)	Release height[a] (m)
Suspended particulates		
Crushers, sampling bins, and feeders	0.3	24
Boiler	0.001	11
Diesel generator	0.62	11
Ore stockpiles	0.31	1
Tailings	0.005	1
NO_x		
Diesel generator	8.7	11
Boiler	0.016	11
SO_2		
Diesel generator	0.58	11
Boiler	0.107	11

[a]Release heights were chosen to reflect the maximum resultant air concentrations.

Sources: ER, Tables 3.5-1 and 3.5-2; Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif., Aug. 29, 1978; and this Environmental Statement, Sect. 3.

Atmospheric dispersion coefficients (χ/Q) for each release height are listed in Appendix E, Tables E.1 through E.3. Assuming all processes are operating concomitantly, annual average atmospheric concentrations of particulates, SO_2, and NO_x at the property boundary to the north were calculated by the staff to be approximately 2, 26, and 3 $\mu g/m^3$ respectively. These concentrations are well below applicable Federal and State air quality standards (Table 4.1). The applicant calculated the maximum ground-level atmospheric concentrations of the major pollutants using the Environmental Protection Agency Valley Model (ER, Supplement S2, Sect. 5.3). Results are as follows (ER, Table S2-5.3-1): particulates, annual average = 5 $\mu g/m^3$, 24-hr average = 76 $\mu g/m^3$; SO_2, annual average = 2 $\mu g/m^3$, 24-hr average = 15 $\mu g/m^3$, 3-hr average = 140 $\mu g/m^3$; NO_2, annual average = 30 $\mu g/m^3$; CO, 8-hr average = 380 $\mu g/m^3$, 1-hr average = 93 $\mu g/m^3$; hydrocarbons, 3-hr average = 100 $\mu g/m^3$. These values are substantially below the applicable Federal and State standards (Table 4.1). To minimize dust emissions from the tailings impoundment, the applicant will keep the tailings surface wet at all times.[3] Also, ore that is delivered to the patio but not immediately processed will be stockpiled and wet with a sprinkler system to minimize wind dispersion of particulates.[3] The sprinkler heads are easily transported from one place to another and will be used as required to control visible dust emissions during transfer operations and/or windy conditions.[4] Haul roads will be watered with conventional watering trucks as required by wind and/or traffic conditions.[4]

Although operation of the mill facility should not have a significant impact on air quality, Utah's Air Conservation Regulations[5] require that air pollution control equipment and processes be selected and operated to provide the highest efficiencies and lowest discharge rates that are reasonable and practical. Although the degree of control is subject to approval by the State Air Conservation Committee, the control must be a minimum of 85%. Utah regulations also restrict the sulfur content of oil, used as fuels, to 1.5% or less.

Regulations promulgated by the U.S. Environmental Protection Agency[6] require any major source of air pollutants to comply with the Prevention of Significant Deterioration (PSD) regulations. Initial indications are that suspended particulates associated with operation of the mill will exceed the 24-hr PSD allowable increment. The applicant will be required to make modifications to bring the level of suspended particulates into compliance with PSD regulation.

4.2 LAND USE

4.2.1 Land resources

4.2.1.1 Land use and aesthetics

The construction and operation of the proposed mine and ore processing facility will affect approximately 140 ha (350 acres) (Table 4.3). The major impact will be conversion of low-density grazing and open-space areas to industrial use (ER, p. 4-4). A secondary impact, the development of the Ticaboo Subdivision in School Section No. 16, will convert a square mile of open space area into a small commercial and residential center. Although efforts have been made, at least by the developers of Ticaboo, to minimize the visual impact on the landscape, the presence of the mill and mine as well as the subdivision will fundamentally alter the existing visual landscape. These impacts, however, have not been determined as unacceptable by the State of Utah, nor have they been judged unacceptable in an independent study.

4.2.1.2 Agricultural

Construction and operation of the mill facility will disturb about 140 ha (350 acres) of land (Table 4.3). Based on an estimated average of 0.022 animal unit months (AUMs) per acre (Sect. 2.5.1.2), this loss equals about 8 AUMs, or a loss of potential grazing land for eight cattle or 40 sheep for one month each year the land is disturbed. Based on the capacity of the tailings impoundment, the mill has the potential to operate for a total of 20 years. The tailings impoundment dam, however, will be constructed in two stages. The first-stage dam will be sufficient to impound tailings for about seven years. At this time, the second stage will be constructed, and portions of the borrow areas will again be disturbed. The borrow areas probably will not be reclaimed until the second stage of construction is completed. The actual duration of disruption of the land will depend upon the time required for construction, the length of time between disturbance and reclamation, and the length of time it takes for a suitable vegetative cover to become established. Furthermore, because of the difficulty expected in reclaiming land in this area (Sect. 6.2), a realistic estimate of the amount of time between the end of construction and the return of the land to its existing climax communities is at least 35 years for those portions of the borrow areas disturbed during construction and 50 years for the remaining disturbed areas (ER, Sect. 4.8). Because the access roads will not be reclaimed, this area can be considered a permanent loss of agricultural land. The applicant does not plan to reseed the tailings impoundment area; the final cover of this area will consist of about 0.3 m (1 ft) of sand, gravel, and cobbles.[4] Any vegetation

Table 4.3. Approximate land requirements for the Shootering Canyon Uranium Project

Area	Expanse to be disturbed	
	ha	acres
Process plant, ore storage yard, and access road	18	44
Tailings impoundment	28	70
Borrow areas A, B, C, and D[a]	37	92
Borrow area E[b]	19	48
Borrow area F[c]	34	85
Aggregate borrow area	4	10
Total	140	349

[a] Assumes a total of 686,700 m^3 (898,100 yd^3) of borrow material with an average depth of cut of 1.8 m (6 ft).

[b] Assumes 237,300 m^3 (310,300 yd^3) of borrow material with an average depth of cut of 1.2 m (4 ft).

[c] Assumes 1,147,000 m^3 (1,500,100 yd^3) of borrow material with an average depth of cut of 3.4 m (11 ft).

Sources: Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif., Aug. 29, 1978; Plateau Resources, Ltd., *Tailings Management Plan and Geotechnical Engineering Studies, Shootering Canyon Uranium Project, Garfield County, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., September 1978.

that becomes established on the tailings impoundment will be the result of natural secondary succession. It is expected that such vegetation would take considerably longer to become established, if at all, and would consist primarily of invader, weedy species that are undesirable for grazing. Consequently, the 28 ha (70 acres) required for the tailings impoundment should also be considered as a long-term loss of rangeland unless other reclamation plans are implemented (Sect. 6.2). All remaining disturbed areas will be reclaimed to return the land to its original use as rangeland and wildlife habitat (Sect. 6.2).

Diversion of about 140 ha (350 acres) of rangeland from its present use for each year of disturbance represents an incremental loss of less than 0.003% of the private rangeland in Garfield County. Such a loss is believed to be relatively insignificant. With successful reclamation (Sect. 6.2), about 80% of this land can be returned to its original grazing capacity.

4.2.2 Historical and archaeological resources

Because there are no historical sites closer than 8 km (5 miles) from the project site, no effects from the project on such sites are expected to occur. A small area of lithic scatter, a portion of which would have been disturbed by road construction, was found on the site (Sect. 2.5.2.3). In the opinion of the State archaeologist, the site does not have the potential to be listed in the National Register; however, all artifacts in the area to be disturbed will be salvaged by the State of Utah.

After consultation with the State Historic Preservation Officer, the NRC has determined that the Shootering Canyon Uranium Project will not affect any properties included in or eligible for inclusion in the National Register (See Appendix H).

4.3 WATER

4.3.1 Surface water

The construction and operation of the uranium mill should have minimal impact on the surface waters of the project site and vicinity. During construction of the mill, the ground surface will be disturbed by grading, excavation, road access, spoil and topsoil storage, and other construction-related activities. The soils of the project vicinity are normally subject to erosion due to lack of consolidation and poor vegetative cover (Sects. 2.8 and 2.9.1). The construction activities will result in increased turbidity levels in the lower portions of Shootering and Hansen creeks because of greater erosion during rainstorms. The applicant plans to minimize the potential for erosion by seeding disturbed areas, grading to control runoff velocities, constructing dikes around surface soil stockpiles to cause ponding of rainfall, and disposing of sanitary effluents through underground septic systems. In addition, the entire area of the ore processing facility will be graded and shaped so that all runoff will drain into the tailings impoundment. The tailings impoundment will collect runoff from the mill site and the drainage basin above it. Consequently, the primary source of increased turbidity will be from road construction.

During the infrequent periods of flow, the streams in the project area are normally highly turbid (Sect. 2.6.1). Although it is not possible to quantify the increase in suspended solids concentrations that will result from construction-related erosion, it is not expected to be great.

The site will be graded so that all surface runoff from the mill will drain into the tailings impoundment and be retained there. Sanitary waste discharged at an estimated average rate of 0.2 m^3/min (62 gpm), will be treated in septic tanks and dispersed through buried leach fields. Retention of runoff from the upper portion of the Shootering Creek drainage basin could result in a reduction in both the volume and suspended solids concentration of storm-induced flows below the tailings impoundment. The staff does not anticipate significant impacts on surface-water quality from any of these events.

There will be no planned, direct, surface discharges from the tailings impoundment during operation of the mill. A minimum embankment freeboard of either 3.4 or 4.0 m (11 or 13 ft) will be maintained during mill operation to contain within the impoundment all upstream runoff resulting from a design storm,[7] which is considered to be the probable maximum 6-hr precipitation (PMP) plus 40% of the 6-hr PMP plus the 100-year 6-hr precipitation, all occurring in direct succession. The freeboard will also be sufficient to avoid overtopping caused by wave action coincident with the design flood. Only in the event that this sequence of storms is exceeded during operation will runoff be discharged from emergency spillways in the embankment.

Overtopping of the tailings embankment by major floods occurring after the cessation of activities at the site will be prevented by a spillway channel 3.7 m (12 ft) below the final crest of the dam. Because dried tailings within the impoundment will be capped by compacted clay and covered with rock, discharges from the spillway at this time are not expected to have a significant impact on surface water quality.

Project operations will have no noticeable effect on the amount of water reaching Lake Powell. It is also considered unlikely that surface waters will be contaminated by seepage from the tailings impoundment.

4.3.2 Groundwater

The applicant will pump an average of 1.9×10^3 m^3/day (348 gpm; 538 acre-ft/year) of water from wells completed in the Navajo aquifer. There are no other local users of water from this aquifer, which eventually discharges into Lake Powell south of the site (Fig. 1.1). The Carmel Formation, an effective aquiclude, lies between the Navajo aquifer and the Entrada sandstone that forms the basin in which the tailings impoundment is located. Project operation will have no noticeable effect on the amount of water reaching Lake Powell, and potential contamination of the water in the Navajo Formation is not credible.

As described in Sect. 3.2.4.7, the applicant proposes to line the tailings impoundment with a compacted clay liner and to install and operate systems for drainage and neutralization of tailings liquids. Although the effectiveness of such drainage and neutralization systems has not yet been demonstrated, no potential groundwater contamination by radionuclides and only minor potential for intrusion of other inorganic materials into the groundwater table some 30 m (100 ft) below the impoundment is expected.

If the proposed liner and drainage system perform as expected, seepage from the impoundment would be negligible. However, if these systems do not function properly, the compacted liner must be capable of minimizing seepage. Therefore, the liner will be required to have a permeability no greater than 1×10^{-7} cm/sec (0.1 ft/year). The maximum seepage rate from the tailings disposal area, without operation of the drainage system, would then be approximately 6.8×10^4 m^3 (55 acre-ft) per year, or about 185 m^3/day (34 gpm). Because of the calcite content of the Entrada sandstone underlying the proposed tailings disposal site, it is expected that tailings liquid would be neutralized either in the impoundment or in the bedrock under the impoundment.

It is considered unlikely that any measurable contamination of the groundwater, about 30 m (100 ft) below the impoundment, in the Entrada would occur. It is equally unlikely that any present surface water sources would be affected or that new seeps would appear in Shootering Canyon as a result of the project. Because of the net evaporation rate in the area, the staff expects essentially no seepage from the tailings after reclamation.

4.4 MINERAL RESOURCES

In the ore to be processed, no minerals besides uranium are present in quantities that permit extraction under present processing costs and product price levels. In the future if these minor ore constituents (e.g., vanadium) are needed, the tailings impoundment could be mined and processed. The staff considers that no impact on mineral resources other than uranium will occur.

4.5 SOILS

Construction and operation of the facility will disturb about 140 ha (350 acres) (Table 4.3). Soils over most of the site (including all borrow areas except F as shown in ref. 8, Fig. 5) are generally sandy in texture, modified in some places by gravel or cobble at the surface (Sect. 2.8). Except for a greater bulk density with depth, horizon development is generally not apparent (Sect. 2.8). The undifferentiated soil profile with poor moisture-holding capacity and little organic content characterizes the low natural fertility of the topsoil.

About 0.3 to 0.6 m (1 to 2 ft) of loose, fine-sand topsoil will be removed from the plant site[8] and used as fill in the ore storage area.[4] Topsoil in the impoundment area, also largely drift sand, will be used as borrow in construction of the tailings impoundment dam.[4] The access road will be constructed over existing topsoil. Therefore, all topsoil on these areas will be effectively lost. The top 0.6 m (2 ft) of soil will be removed from all borrow areas and stockpiled on portions of the borrow areas not utilized initially.[8] Removal of topsoil will disrupt existing physical, chemical, and biotic soil processes. Although topsoil will be replaced upon termination of the project operation (Sect. 6.2), a temporary decrease in natural soil productivity is probable.[9]

Removal of topsoil and natural vegetation will accelerate wind and water erosion. Generally, these impacts will be the greatest during the construction phase, which is expected to last 14 months. To minimize fugitive dust resulting from construction activity, the applicant will water and/or treat with stabilizing agents all haul roads and active working surfaces (ER, Sect. 4.6). The stockpiled topsoil will be protected from wind and water erosion by an emulsion spray.[8] In addition, it is expected that annual plants will become established and will aid in preventing erosion of the stockpiles.

Soil compaction resulting from grading and operation of heavy equipment will increase runoff, erosion, and sedimentation. No ditches will be provided for diverting runoff, because all runoff from areas above the impoundment areas, including runoff from the plant area, will flow directly into the tailings impoundment. Although sediment transfer will be increased within the site, the location of the mill facilities and tailings impoundment (Fig. 2.4) should minimize sediment transfer from the site. All borrow areas except F (ref. 8, Fig. 5) will essentially be basins; therefore, sediment transport is not expected to occur from these areas. Any water accumulating in these borrow areas is expected to seep downward and/or evaporate. Borrow area F exists naturally as a cliff.[8] To minimize erosion and sedimentation from this area the staff recommends creating a sediment catch basin on the downgrade side of this borrow area prior to removal of material.

During operation of the mill, soil over much of the site will be stabilized by gravel and the presence of structures. In addition, the topography of the area allows runoff from the site to accumulate in the tailings impoundment. After mill operations cease, the applicant plans to place gravel, cobbles, and boulders on the face of the impoundment dam to protect it from erosion.[8]

Upon terminating operations, the applicant plans to grade and reseed all remaining disturbed areas except the access road and tailings impoundment area. The access road will be left in place to be used during periodic monitoring and maintenance visits. The tailings impoundment will be reclaimed to meet NRC's radiological safety standards (Regulatory Guide 3.8). The applicant's proposal includes the establishment of vegetation on this area through natural secondary succession; however, these plans do not meet the revegetation requirements of Utah's Oil and Gas Conservation Act,[10] and the staff has recommended appropriate action (Sect. 6.2). Generally, the State reclamation law requires establishment of a soil medium that is capable of sustaining vegetation without irrigation or continuing soil amendments (Sect. 6.2). Assuming reclamation efforts will be successful, long-term impacts to the soil are not expected to be significant.

4.6 BIOTA

4.6.1 Terrestrial

The primary impact of construction and operation of the mill and tailings disposal system will result from loss of habitat. Although some variation exists in the type of vegetation that will be removed, predominately a blackbrush/Mormon tea association, the area is not known to be critical habitat for any wildlife species in the area. Therefore, because similar rangeland is common throughout the region (Sect. 2.5), it is expected that the temporary inaccessibility of this relatively small parcel of land to wildlife, while representing an incremental loss, will not significantly reduce the amount of habitat for any wildlife populations.

Land clearing, operation of heavy equipment, and other construction activities will destroy small animals that move too slowly to escape or that retreat to burrows for protection. Other animals will be displaced and may be lost because of predation or increased competition for food, territory, and other habitat requirements. Although many of these species are important members of the food chain, their population densities are believed to be low, and their loss on the site would represent a relatively insignificant regional impact. Habitat that will be disturbed as a result of construction and operation of the mill represents less than 2% of similar habitat within a 4.8-km (3-mile) radius of the site.

Suspended particulate matter will be emitted into the air by construction activities (Sect. 4.1). These particulates will eventually be deposited in part on the surrounding vegetation, thereby reducing plant vigor or causing the plants to be less palatable. Gaseous emissions from internal combustion engines may also interfere with the physiological processes of the vegetation. Although the magnitude of these potential impacts is not known, it is expected to be negligible. No significant deleterious effects have been demonstrated at other construction projects of similar or greater magnitude. Moreover, if any impacts do occur from fugitive dust and/or gaseous emissions, they should be minor and short-term.

Few data are available to demonstrate the effects of noise on wildlife, and much of what is available lacks specific information concerning noise intensity, frequency, and duration of exposure.[11] Probably, the noisiest period of construction will be during construction of the tailings impoundment dam. Some typical ranges of sound levels from common construction activities are listed in Table 4.4. Such noise is not expected to seriously affect the area wildlife. The noise initially may cause migration by some wildlife away from the immediate site vicinity, but those that remain or return will generally become habituated to construction noises and activities.[11]

Table 4.4. Sound levels from construction equipment

Source	Sound level, dB(A) at indicated distance from source				
	15 m	30 m	61 m	152 m	305 m
Trucks, cranes, bulldozers, etc., with diesel-type internal combustion engines	70–95	64–89	58–83[a]	50–75	40–69
Air compressors and other stationary sources, typically diesel powered	76–86	70–80	6- 74	56–66	50–60
Pile driver	105	99	93	85	79
Front-end loaders	73–86	67–80	61–74	53–66	47–60

[a]Sound levels above 80 dB(A) are usually produced by a combination of several pieces of equipment operating at the same time.

Source: U.S. Senate, *Report to the President and Congress on Noise*, Senate Document 96-63, U.S. Government Printing Office, Washington, D.C., 1972.

Because the tailings level in the pond will rise at a rate that would likely preclude the establishment of rooted vegetation and because the water will be high in dissolved solids even after partial neutralization with mine wastes, it is not expected that wildlife will use the area even though it is the only perennial surface water within several miles. A few waterfowl or other birds may rest on the impoundment for a short time during migration, however, and raptors may seek prey around the impoundment. Although potentially harmful amounts of radionuclides and other contaminants will be present in the tailings pond, the effects of occasional wildlife usage of this water is unknown. The staff, therefore, recommends that the applicant monitor the use of the impoundment by wildlife (Sect. 6.5.1). The tailings disposal area and mill site will be surrounded by a wire fence designed to restrict entry of large mammals. Following termination of the mill operations, the tailings disposal area will remain fenced until released from its status as a restricted area.

Increased human population associated with construction and operation of the mill will adversely affect most wildlife in the area. Although some species may benefit from large human populations, most of the larger mammals will abandon habitats in close proximity to intense human activity. Additional stress will be placed on the terrestrial biota as a result of greater hunting pressure (both legally and illegally) and destruction of habitat by off-road recreational vehicles. Increased wildlife losses are expected to occur as a result of greater vehicular travel on highways.

None of the proposed endangered plant species[12] with documented distributions in San Juan County[13] are expected to occur on the facility site or in the immediate vicinity (Sect. 2.9.1.1). Although the endangered[14] American peregrine falcon (*Falco peregrinus anatum*) and bald eagle (*Haliaeetus leucocephalus*) range in the vicinity of the site, lack of suitable habitat indicates a low probability of these species utilizing the project site for feeding or nesting. Therefore construction and operation of the proposed mill should have no significant impact on endangered species.

4.6.2 Aquatic

Because there are no permanent aquatic habitats between the proposed mill site and Lake Powell (Sect. 2.9.2) and construction and operation of the mill will produce no direct discharge, project operation is not expected to affect either the amount or the quality of the water reaching Lake Powell. Localized increases in erosion and turbidity (Sect. 4.3.1) expected to have an effect on aquatic biota in Lake Powell; therefore, no unacceptable impact to aquatic biota is predicted.

4.7 RADIOLOGICAL IMPACTS

4.7.1 Introduction

The primary sources of radiological impact to the environment in the vicinity of the proposed Shootering Canyon Uranium Project are naturally occurring cosmic and terrestrial radiation and naturally occurring radon-222. The average whole-body dose rate to the population in the site vicinity, including doses from natural background radiation and diagnostic medical procedures, is estimated to be about 176 millirems/year (see Sect. 2.10).

This section describes the results of the staff's analysis of the mill-contributed incremental radiological impacts to the environment and the population in the vicinity of the Shootering Canyon project. This analysis is primarily based on the estimated annual releases of radioactive materials given in Table 3.5 and the models, data, and assumptions discussed in Appendix D. Detailed analyses of the radiological impacts of mill operations to nearby individuals and the entire population within 80 km (50 miles) have been performed. All potential exposure pathways likely to result in significant fractions of the mill's total radiological impact have been included (Fig. 4.1). Consideration has also been given to the occupational exposure received by mill employees and to radiation exposure of biota otner than man.

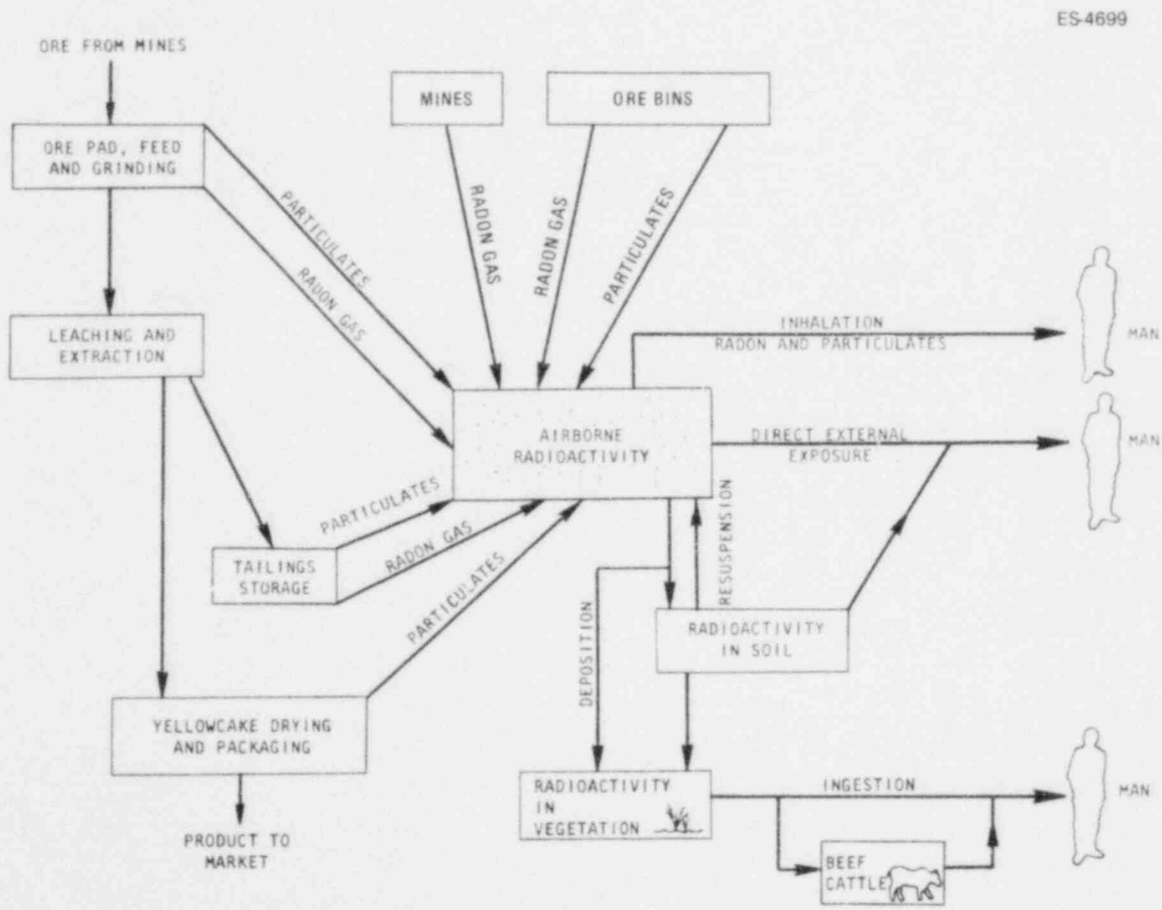


Fig. 4.1. Sources of radioactive effluents from the mill and exposure pathways to man.

4.7.2 Exposure pathways

Potential environmental exposure pathways by which people could be exposed to radioactive mill effluents are presented schematically in Fig. 4.1. Estimates of dose commitments to man have been based on the proposed plant design and actual characteristics of the site environs. The staff's analysis has included considerations of radioactive particulate and gaseous releases to the atmosphere.

The mill will not release radioactive waste directly into surface waters. However, the potential for the contamination of groundwater by seepage of leached radionuclides from the ore storage pile does exist. Routine sampling of nearby wells and springs will be performed to monitor the potential seepage. Although there is a possibility of some seepage of radioactive liquids from the tailings impoundments into the groundwater system, this possibility is considered remote, and no significant contribution to dose via liquid pathways is expected. Furthermore, the applicant will be required to conduct environmental and other monitoring programs to provide early detection of any seepage that might occur and to take appropriate mitigating measures.

Environmental exposure pathways of concern for airborne effluents from the Shootering Canyon mill include inhalation of radioactive materials in the air, external exposure to radioactive materials in the air or deposited on ground surfaces, and ingestion of contaminated food products (vegetables and meat).

4.7.3 Radiation dose commitments to individuals

At present, the nearest residents to the proposed site are the Plateau Resources, Ltd., employees living at the mine camp about 5.6 km (3.5 miles) north of the mill site (ER, Fig. 2.7-2) and the residents at Bullfrog Basin Marina [21 km (13 miles)] south of the facility (ER, Plate 2.2-1). The nearest residence when mill operations begin will be located at the proposed Ticaboo townsite 4.2 km (2.6 miles) south-southwest of the mill site (Fig. 3.1).

The facility will be located on mill site claims. Approximately 89% of the surrounding land of Garfield County is Federally owned. Land uses around the mill site include grazing and recreation (Glenn Canyon National Park). It is assumed that beef cattle could be grazed 1.3 km (0.8 mile) north of the proposed facility and that the meat could be eaten by local residents. The calculated ingestion doses for consumption of beef grazed at this location are comparable to those for other nearby locations at which grazing could occur.

Table 4.5 presents a summary of the individual dose commitments calculated for mine camp residents, for future residents of the town of Ticaboo, and for residents of Bullfrog Basin Marina. Residents of Ticaboo and the marina were assumed to ingest vegetables grown close to home and meat from cattle grazing at the location identified above. The resulting ingestion doses are listed. No ingestion doses for mine camp residents are included because it is expected that the camp will be shut down by the time mill operation is started. Inhalation and external doses calculated for the mine camp location are included in the event that occupancy by some individuals is required temporarily after mill start up for dismantling the existing facility and campsite.

4.7.4 Radiation dose commitments to populations

The annual doses to the population estimated to exist within 80 km (50 miles) of the site in the year 2000 are presented in Table 4.6 along with estimated annual doses to the same population from natural background radiation sources. Population dose commitments resulting from the operation of the Shootering Canyon Uranium Project represent no more than about 4% of the doses from natural background sources.

4.7.5 Evaluation of radiological impacts on the public

All radiation doses calculated to result to the surrounding population from uranium milling operations at the Shootering Canyon site are small fractions of those arising from naturally occurring background radiation (see Table 4.6). They are also small when compared to the average medical and dental x-ray exposures currently being received by the public for diagnostic purposes.

Table 4.5. Annual dose commitments to individuals from radioactive releases from the Shootering Canyon Uranium Project

Location	Exposure pathway	Dose (millirems per year)			
		Total body	Bone	Lung	Bronchial epithelium[a]
Mining camp, 5.8 km north	Inhalation	0.119	3.60	6.64	29.7
	External from cloud	0.323	0.323	0.323	
	External from ground	0.388	0.388	0.388	
	Total	0.830	4.31	7.35	29.7
Ticaboo, 4.2 km south-southwest	Inhalation	0.045	1.35	2.66	35.0
	External from cloud	0.360	0.360	0.360	
	External from gound	0.160	0.160	0.160	
	Ingestion, vegetable	0.063	0.759	0.063	
	Ingestion, meat[b]	0.675	6.91	0.675	
	Total	1.30	9.54	3.92	35.0
Bullfrog Basin Marina, 21 km south	Inhalation	0.002	0.066	0.119	0.564
	External from cloud	0.010	0.010	0.010	
	External from ground	0.007	0.007	0.007	
	Ingestion, vegetable	0.003	0.037	0.003	
	Ingestion, meat	0.675	6.91	0.675	
	Total	0.697	7.03	0.814	0.564

[a]Doses to the bronchial epithelium result from the inhalation of the short-lived radioactive daughters of Rn-222.

[b]Meat ingestion doses result from ingestion of the meat of cattle grazed 1.3 km north of the mill.

Table 4.6. Annual population dose commitments[a] within an 80-km (50-mile) radius of the mill site

Receptor organ	Dose (man-rems/per year)	
	Plant effluents	Natural background[b]
Total body	1.50	329
Lung	10.5	329
Bone	6.13	329
Bronchial epithelium	66.0	1632

[a]Based on a projected year-2000 population of 3262.

[b]The estimated natural background dose rate to the whole body is 101 millirems/year. The bronchial epithelium dose from naturally occurring radon-222 is assumed to be 500 millirems/year (Sect. 2.10).

Calculated annual individual dose commitments are only small fractions of present NRC limits for radiation exposure in unrestricted areas, as specified in 10 CFR Part 20, "Standards for Protection Against Radiation." Dose commitments to actual receptors are also well below limits specified in the EPA's "Radiation Protection Standards for Normal Operations of the Uranium Fuel Cycle" (40 CFR Part 190), which is to become effective for uranium milling operations in December 1980. Table 4.7 provides a comparison of maximum calculated annual dose commitments with the radiation exposure limits of 10 CFR Part 20 and 40 CFR Part 190.

As indicated in Table 4.7, the radiation dose commitments to the organs of the individuals living nearby fall below both NRC and EPA limits. However, these doses are contingent on the applicant's capacity to control the tailings pile emissions, as stipulated in Sect. 3, as well as other mitigating procedures involving the wetting of ore piles and enclosure of the ore bins. To ensure that offsite doses are maintained below the permissible limits, the staff will require the applicant to (1) implement a monitoring and control program at the tailings impoundment involving groundwater seepage, dusting of particulates, etc., and (2) perform and document land use surveys to determine any variations in land use (e.g., for grazing, residence, and well locations).

Table 4.7. Comparison of annual dose commitments to individuals with radiation protection standards

Receptor organs	Estimated annual dose commitments[b]	Radiation protection standards	Fraction of standards
	Mining camp, 5.6 km north		
	Present NRC regulation (10 CFR Part 20)		
Total body	0.830 millirem per year	500 millirems per year	0.0017
Bone	4.31 millirems per year	3000 millirems per year	0.0014
Lung	7.35 millirems per year	1500 millirems per year	0.0049
Bronchial epithelium	0.0003 WL[a]	0.033 WL	0.010
	Future EPA standards (40 CFR Part 190)[b]		
Total body	0.135 millirem per year	25 millirems per year	0.0054
Bone	3.60 millirems per year	25 millirems per year	0.14
Lung	6.63 millirems per year	25 millirems per year	0.27
Bronchial epithelium	29.7 millirems pr year	NA[c]	NA
	Ticaboo, 4.2 km south-southwest		
	Present NRC regulation (10 CFR Part 20)		
Total body	1.30 millirems per year	500 millirems per year	0.0026
Bone	9.54 millirems per year	3000 millirems per year	0.0032
Lung	3.92 millirems per year	1500 millirems per year	0.0026
Bronchial epithelium	0.0004 WL	0.033 WL	0.012
	Future EPA standards (40 CFR Part 190)		
Total body	0.788 millirem per year	25 millirems per year	0.032
Bone	9.00 millirems per year	25 millirems per year	0.36
Lung	3.37 millirems per year	25 millirems per year	0.13
Bronchial epithelium	35.0 millirems per year	NA	NA

[a] Radiation standards for exposures to Rn-222 and daughters are expressed in working levels (WL), that is, the amount of any combination of short-lived radioactive decay products of Rn-222 in 1 liter of air that will release 1.3×10^5 MeV of alpha particle energy during their decay to Pb-210 (radium D).

[b] Doses computed for evaluation of compliance with 40 CFR Part 190 are less than total doses because dose contributions from Rn-222 released from the site, and any radioactive daughters that grow in from released Rn-222, have been eliminated. Limits in 40 CFR Part 190 do not apply to Rn-222 or its radioactive daughters.

[c] Not applicable; 40 CFR Part 90 does not include doses from Rn-222 daughters.

4.7.6 Occupational dose

Uranium mills are designed and built to minimize exposure to radiation of both the mill workers and the general public. In addition, occupational exposures for workers are monitored and are kept below NRC limits, in accordance with the requirement of maintaining such exposures as low as is reasonably achievable.

Special studies[15] at selected mills have shown that the exposures of mill workers to airborne radioactivity are normally below 25% of the maximum permissible concentrations given in Appendix B of 10 CFR Part 20 and that external exposures are normally less than 25% of 10 CFR Part 20 limits.[15,16] A recent review[17] of mill exposure data by the NRC staff has indicated that only a few uranium mill employees may have exceeded, over a one-year period, 15 to 20% of the permissible exposure to ore dust, 25% of the permissible exposure to yellow cake, or 10% of the permissible exposure to radon concentrations. Except for a few individuals, the combined exposure of an average worker to these radioactive components over a one-year period probably does not exceed 25% of the total permissible exposure.

4.7.7 Radiological impact on biota other than man

Although no guidelines concerning acceptable limits of radiation exposure have been established for the protection of species other than man, it is generally agreed that the limits for humans are also conservative for those species.[18-25] Doses from gaseous effluents to terrestrial biota (such as birds and mammals) are quite similar to those calculated for man and arise from the same dispersion pathways and considerations. Because the effluents of the mill will be monitored and maintained within safe radiological protection limits for man, no adverse radiological impact is expected for resident animals.

4.8 SOCIOECONOMIC IMPACTS

The proposed site of the Shootering Canyon Uranium Project is in a remote area in southeastern Utah where the local labor supply within daily commuting distance is not sufficient to support the construction and operation of the mill. As a consequence, labor for the project must migrate to the area.

Providing housing for both the construction and the operation work forces is a major problem confronting the applicant (Sect. 4.8.1). In addition, the importance of the relationship between a satisfactory social environment for workers and its effect on turnover rates, absenteeism, and worker productivity has been recognized by the company. The applicant concluded that it would be economical and within the company's interest to support the efforts of a private developer to create the Ticaboo Subdivision, a "new town" 4.2 km (2.6 miles) south of the mill site.[4]

The staff considered two other options, one of which was hiring a work force from Hanksville. The absence of housing and services at Hanksville, however, means that any major influx of people into the community would create both major dislocations in the provision of existing services and severe financial problems for Wayne County, which unlike Garfield County would receive no tax benefits from the mill. The other option considered by the staff was the expansion of the existing mining camp. This option is also unsatisfactory because of the location of the camp in a potentially hazardous flash flood area. More importantly, the likelihood that the company would develop a relatively stable work force in a short period of time by either alternative option is greatly reduced. The development of a housing project that provides, with public and private support, a small service infrastructure appears to be a satisfactory solution. The development of such a community, however, is always risky, and its viability in the absence of the mill project is a major question. The presence of Bullfrog Marina and the demand for motel rooms, retail products, and recreation homes that might be generated by the expanding tourist population (Sect. 2.4.1.3) increase the feasibility of this type of community. Thus, discussion of the socioeconomic impacts of the proposed project will assume that plans for the development of the Ticaboo Subdivision continue. Because projects such as Ticaboo do not develop without careful planning and investment of time and money by interested parties prior to construction, however, the staff felt it necessary to provide an independent assessment of the feasibility of the Ticaboo development so that major impacts could be defined (Appendix C).

4.8.1 Population increase and distribution

4.8.1.1 Construction period

The population in the eastern part of Garfield County is expected to increase by 500 to 600 people as a consequence of the proposed construction of the Shootering Canyon mill, the operation of the Plateau Resources mines, and the development of the Ticaboo Subdivision. Most of this population will live either temporarily or permanently at the Ticaboo Subdivision, the mining camp, or Bullfrog Marina (Fig. 1.1). Only a few workers will commute on a daily basis from Hanksville. This influx (Sect. 2.4) will result in a peak population during the construction period of between 700 and 800 people.

The above estimates were derived using the following information and assumptions. Consultants for the applicant[4] estimated a peak construction work force of approximately 225 workers and an average work force of 180 by assuming 75% of the workers (peak load) to be single (or married with families absent) and 25% to be married with families present.* In addition, it was assumed that the latter workers would settle permanently in the area in anticipation of obtaining permanent employment at the mill after construction.[4]

For the construction of Ticaboo, it is estimated that 20 to 40 construction workers would be needed (Ticaboo Development Corporation, Wayne County, Utah, personal communication). Forty workers would be present at the beginning of the construction period for Ticaboo; this number would be reduced to approximately 20 after completion of most of the major structures in the community.

Mining and mill employment will probably increase during the construction phase until the full operations work force is obtained at the end of the construction period.[4] The staff assumes that the mining work force will expand to approximately 100 by peak, a 30% increase over employment in September 1978 (Sect. 2.4.3.3). The staff also assumes that many of the old and new mine workers will try to obtain permanent housing and will bring their families during this period. Based on the worker profiles of miners at the mining camp in September 1978, 50% of the work force will be married.[4]

To calculate the population so that families of workers are included, a 3.6 multiplier was used.† An additional 15 service workers were added on the assumption that at peak, some service workers would be present (e.g., motel employees and school teachers). Fifty percent of the service workers were assumed to be single.

The above calculation predicts a population influx of approximately 550 persons. Given the uncertainty in estimating population impacts, the staff felt it was appropriate to give a range of between 500 and 600 in-migrants.

4.8.1.2. Operations period

The operation of the mine and mill will result in an estimated permanent population at Ticaboo of approximately 900 people. Total population in the area, including Bullfrog Marina, will be over 1000 people. If Ticaboo becomes a "second home" development, the population will be even higher than the above estimates until the mill shuts down.

Estimates for total population at Ticaboo are based on the following information and assumptions. The applicant expects a permanent operating force of between 225 and 250 people.[4] Using the maximum estimate, the staff accepted the assumption made by Plateau Resources that 85% of the 250 workers would have families present.[4] If a multiplier of 3.6 is used, the direct population increase generated by the mine and mill would be approximately 800 people. Assuming that 35 service workers in-migrate,‡ 85% of whom are married, an additonal 107 people would be added to the above 800 for a total of 907.

---

*This assumption varies from data obtained for the Old West Regional Commission by Mountain West Research, Inc.[26] This group studied worker profiles at 14 different construction projects. The average percentage of single-status workers for all projects was approximately 50%. Mining employment by Plateau Resources in 1978, however, indicated that approximately 70% of the workers were of single status. The staff concluded that, given the remoteness of the site and uncertainty as to the availability of housing, the 75% estimate, although somewhat high, was acceptable. The range of projected population influx allows for some variation in this estimate.

†Mountain West Research, Inc., found a 3.59 average family size for new construction workers who are married.

‡Consultants for Plateau Resources assumed that many spouses of mine and mill workers would take service jobs, thus reducing the number of in-migrating service workers.

In the opinion of the staff, the anticipated permanent population of 900 people will not be attained at Ticaboo until the work force has stabilized several years after construction is completed. Because of uncertainty concerning the availability of housing and of satisfactory services, the number of in-migrants with families in the immediate postconstruction phase may be less than that associated with normal mill operations projects. The staff expects the population at Ticaboo after construction is ended to be slightly higher than it was at peak — approximately 700 people.

4.8.2 Social organization

4.8.2.1 Housing

Aside from the mining camp facilities, there is at present no housing available for the influx of workers caused by the construction of the Shootering Canyon Uranium Project. The construction of the Ticaboo Subdivision with a 72-unit motel, trailer pads, and lots for the construction of single-unit or multiunit modular or site-framed housing is expected to satisfy this housing demand. The staff's estimates of total population in the area during peak construction, however, suggest that the demand for temporary housing (assuming all single-status workers double up) will not be satisfied by the motel unit (Table 4.8). Workers will either have to bring their own trailers or other arrangements will need to be made — for example, the construction of an apartment complex or the provision of rental trailers. The applicant estimates that half of the permanent units (as many as 130 during the construction period) will be trailers and half will be houses.[27] If fewer workers decide to live in permanent units, the demand for temporary housing will increase from the estimated 95 units, and adjustments will need to be made.

Table 4.8. Housing requirements for workers during construction of the Shootering Canyon Uranium Project

Schedule	Mill-related employment	Number of housing units required[a]	Type of housing
1st month (Ticaboo construction start-up)	40 Ticaboo construction	20, T[b]	Recreational housing at Bullfrog
	70 miners	55, T	Mining camp
3rd month (mill construction start-up)	40 Ticaboo construction	20, T	Recreational housing at Bullfrog
	70 miners	55, T	72-unit motel/trailer space
4th month (mill construction start-up)	20 Ticaboo construction	10, T	Recreational housing at Bullfrog
	70–100 miners	50–60, T/P	Mining camp/trailers; Ticaboo housing
	20–50 mill construction	10–25, T	72-unit motel
8th month	20 Ticaboo construction	10, T	Recreational housing
	100 miners	50–60, P	Trailers/houses
	180 mill construction	56, P; 62, T	Trailers/houses; 72-unit motel
12th month (peak mill construction)	20 Ticaboo	10, T	Recreational housing
	100 miners	75, P	Trailers/houses
	225 mill construction	56, P; 88, T	Trailers/houses; motel/trailers
16th month	20 Ticaboo	10, T	Recreational housing
	125 miners	70, P	Trailers/houses
	180 mill construction	56, P; 62, T	Trailers/houses; motel
22nd month	20 Ticaboo	10, T	Recreational housing
	250 permanent operating mill and mine	190–250, P	Trailers/houses
		10, T	Motel
	20 mill construction		
24th month	225–250 permanent operating	190–250, P	Trailers/houses
	30 service	30–35, P	Trailers/houses

[a] Assumes single-status workers double up; approximate number.

[b] T = temporary; P = permanent.

In the operations phase, there will be a demand for between 210 and 280 permanent units, half to be satisfied with mobile homes and half with conventional housing. If the development of the Ticaboo Subdivision proceeds as planned and if workers purchase homes in the subdivision, the predicted demand for housing will be satisfied eventually. In the interim, temporary trailer facilities and the motel are expected to absorb the demand.

4.8.2.2 Services

No public or private service infrastructure presently exists within the impact area for those individuals who will reside there either temporarily or permanently as a consequence of the construction of the uranium mill. Meeting these needs requires heavy investments in time and money. Many of the initial capital costs (impacts) of the Ticaboo Subdivision will be borne by the private developer and other providers in the private sector. In addition, the formation of a new community in Garfield County and the State of Utah places additional responsibilities on those jurisdictions to provide public services.

Although final arrangements have not been made, the following discussion summarizes current plans as to how many of these services will be provided.

Sewer and water

The Ticaboo development corporation plans to install a domestic water system conforming to the standards of the State Health Department. Adequate water is available, a well has been drilled, and the water tested.[28] Costs for such a system are estimated at $500,400 for the complete project and $268,900 for the commercial area alone.[27]

The Ticaboo sewer system will require central sanitary sewer facilities with treatment lagoons (to be located on Bureau of Land Management land). Sanitary sewer facilities at Ticaboo are estimated at $438,000 for the total project and $273,100 for the first plan of development.[27]

The current plan for financing the sewer and water system calls for the formation of a special service district and the issuance of tax-exempt bonds. Such bonds would finance at least 75% of all capital improvement costs for the water and sewer systems.[3] This type of financing will allow these costs to be amortized over a 20-year term at an approximate interest rate of 6.5% per annum.[3]

Solid waste disposal

The proposed method of solid waste collection and disposal for citizens of Ticaboo will be weekly curbside pickup with direct haul to a sanitary landfill. The location of the landfill is presently undetermined, although there are negotiations under way with the National Park Service. The Ticaboo Development Corporation will provide the truck, which will eventually be purchased by the special service district. Costs for solid waste disposal will be borne by individual users.[28]

Roads and streets

The private developer will bear the initial costs for construction of necessary streets and roads. The County Commissioners have already granted a variance permitting streets to be built without curbs.[29] Total road surface area is estimated to be 58,900 m^2 (633,600 ft^2). Average annual cost for road maintenance, to be borne by the county, is expected to be $9750.[28]

Electricity and telephone

The all-electric homes at Ticaboo will need a reliable electric supply. In the short term, separate electric generation and transmission facilities will be provided by the developer. Utah Power and Light, the principal utility in Utah, is expected to eventually manage and operate facilities at Ticaboo. At present there is no telephone service at the site. Negotiations are being made for the provision of this service.

Police

The mine, ore processing facility, and Ticaboo will fall under the jurisdiction of the Garfield County Sheriff's Department. The population influx will require the addition of a full-time deputy sheriff. Garfield County is interested in establishing a bi-county agreement with Cain and Wayne counties. The estimated annual cost of $16,000 for police service includes the salary for one officer, costs of vehicle operation, and maintenance.[3]

Fire protection

Current plans call for the formation of a rural fire district, serviced by a 12- to 15-man volunteer force with one fire truck and a fire-fighting facility. Estimated capital costs for establishing the fire-fighting facility are $27,000.[3]

Commercial services

The Ticaboo development corporation proposes a commercial area of approximately 1000 m^2 (11,000 ft^2). The corporation expects to attract a grocery, gas station, and one general retail store. Most major expenditures will be made at the more distant and developed service centers.

Social services

An extensive study of the social services required by population at Ticaboo is discussed in the Utah State Foundation assessment of the Ticaboo development.[30] The staff assumes, however, that many of the categorical services will not be readily available to the population on the site at Ticaboo for several years.

Medical services

The influx of a new population to the area may result in an upgrading of existing medical services (see Sect. 2.4). Such a population may provide the support to sustain a primary care clinic or the part-time services of a doctor. Without such additional services, the new population will be without satisfactory medical services.

Schools

During the construction period, current plans call for children of construction workers and of mine workers to attend school at Bullfrog Basin Marina. In anticipation of the influx of new students, the Park Service has hired an additional teacher and brought in another trailer to serve as a classroom. The staff estimates that, based on previous assumptions about population influx, school attendance at Bullfrog Marina could increase by as many as 80 students during the construction phase.*

Plans exist for the construction of a permanent school facility at Ticaboo which would be ready for use when the mill begins operation. This facility, a permanent building with modular classrooms, will accommodate pupils at all grade levels. Estimates for the cost of the facility have ranged from $1.6-2.2 million based on a school population estimate of 300 pupils. The current estimate indicates a cost of $1.3-1.5 million and assumes a smaller enrollment. During the initial phases of the operational period, the staff expects the enrollment to range between 130 and 160.†

---

*This number is determined using a 0.3 multiplier for school age children. The current mining population of 70 workers would be expected to increase school attendance by approximately 22 students.

†This number is determined using a school-age population multiplier of between 0.46 and 0.6.

Financing school construction has presented a number of problems for Garfield County, Plateau Resources, and the Ticaboo Development Corporation. While property taxes generated by the mill will eventually pay for the capital costs of construction of the school, such taxes will not be available until one to two years after construction of the mill. To solve the problem, a number of options have been explored including a conventional general bond issue, the establishment of a nonprofit corporation that would issue tax-exempt financing, and the use of a tax-exempt lease arrangement.[3] In addition, the applicant has expressed a willingness to prepay sales and use taxes.

4.8.3 Political organization

The proposed construction of the uranium mill and the development of the Ticaboo Subdivision has affected the political organization within Garfield County and the State of Utah. Not only have these projects required actions to be taken by various agencies at the State level,[27] but they have led to additional complexity in the political organization within the county. The formation of the special service district and the proposed bi-county agreement to share police services are two major examples.

4.8.4 Economic organization

4.8.4.1 Employment

All direct employment for both the construction (225 workers) and operations (250 workers) has been or will be recruited to the area. The recruiting distance for jobs at the mine and mill is about 400 km (250 miles). This area includes Grand Junction, the Colorado Plateau area, Blanding, Monticello, Hanksville, Richfield, Panguitch, Green River, Moab, Price, Salt Lake City, Grants, and Albuquerque. Competition from other projects in the region as well as the particular employment conditions of this project make predicting impacts on specific labor markets difficult.

Indirect employment will create an additional demand for 30 to 100 workers. Although some of these will be recruited from the same labor markets as the mill, mine, and construction workers, many will come to the area as part of the families of those workers directly employed.

4.8.4.2 Income

Table 4.9 lists the wage schedule by skill level for the operation of the Shootering Canyon mill and mine. The average monthly wage for miners in Utah is \$1500 to \$1833 and for mill workers \$1000 to \$1500. These estimates also indicate that the mill and mine may provide moderately good-paying jobs for a small number of workers over a 10- to 15-year period. Incomes, however, may not be sufficient to purchase conventional housing, given current estimates at Ticaboo, without being supplemented by the incomes of additional wage earners in the families.

The payroll for the required work force over a 14-month construction period of the mill and mine has been estimated at \$10,575,000 with disposable income estimated at about \$7,000,000 (ER, p. 4-1). The payroll for the construction and site preparation of Ticaboo has been estimated at \$400,000. The estimate for the mill construction payroll may be low, as it reflects a low estimate of the number of construction workers (170) necessary for the mill and a shorter construction period.

With the exception of rent and food purchases, most expenditures will be made outside the project area and outside of Garfield County. With the development of the proposed Ticaboo Subdivision during the operations phase, housing, limited goods, and services should be available locally, keeping a greater proportion of the operation's payroll within Garfield County. However, purchases of durable goods, such as automobiles and household appliances, and most recreation and entertainment expenditures will likely be made outside the immediate area. One estimate for income generated annually by the project results in a total annual income of \$3,580,000 of which \$1,074,500 will be spent locally for goods and services other than housing (ER, p. 4-12).

Expenditures in the construction of the mill and mine facilities for supplies and equipment should be in excess of \$10,000,000. Expenditures for construction and site development of

Table 4.9. Wage schedule for personnel during operation of the Shootering Canyon Uranium Project, 1978 dollars

Skill level	Gross monthly income ($)	Disposable monthly income[a] ($)	Monthly income for housing cost[b] ($)
Supervisor	1735	1388	347
Miner	1500	1200	300
Miner assistant	1240	1000	250
Mechanic, electrician, equipment operator (A)	1400	1120	280
Mechanic, electrician, equipment operator, carpenter (B)	1300	1040	260
Laborer or trainee	[illegible]	760	190
Kitchen, office, or warehouse worker	750	600	150

[a]Disposable monthly income assumed to be 80% of gross monthly income.

[b]The allowable income for housing is assumed to be 25% of the disposable income.

Ticaboo should be approximately $1,100,000. The distribution of this income will have a regional impact and will affect primarily larger supply markets such as found in Salt Lake City. Some additional employment will be generated by these expenditures.

4.8.4.3 Revenues

Tax revenues will be generated primarily from the following sources: property taxes levied against the mill and mine property; tax levies against residential and commercial property at Ticaboo; local sales taxes (at three-fourths of 1%); income taxes against salaries of workers; and taxes on motor vehicles and miscellaneous property of workers and families.

The mine is currently not paying any property taxes to the county. Increases in assessed valuation during 1979 and 1980 will result in tax revenues to the county and county school district in 1980 and 1981. If the current property tax levy of 51.50 mills is assumed, the uranium mill and mine is expected to generate between $250,000 and $600,000 annually from 1980 to 1995 (ER, p. 8-30).

Projections of county revenues for the Ticaboo Subdivision are difficult because of uncertainties as to actual distribution of housing between mobile homes and conventional units. The property tax revenues will be approximately $34,900 for a worker population of 200.[30]

Regardless of the uncertainties in estimating future taxes, the staff expects that for a number of years the combined property tax revenues from the mill and mine in addition to Ticaboo will represent over one-third of the property tax revenues generated for the county.[30]

Utah sales taxes paid on equipment and supplies during the construction period will range between $200,000 and $400,000 depending on the amount of purchases made within the State and based on a 4.75% sales tax rate. A fraction of this amount, equivalent to three-fourths of the 4.75% will be distributed to the local communities in which purchases are made.

The workers employed directly in construction as well as those employed by the mill and mine will be subject to Federal and State income taxes. Taxes on the salaries of nonbasic employees will also contribute income tax revenues. Estimated annual State and Federal income taxes from projected related employment are approximately $250,000. Utah land use taxes should generate an additional $175,000 in revenue to the state (ER, p. 8-2). An additional source of revenue for San Juan County is the ore buying station located outside of Blanding which will supply uranium ore for the mill after operation commences.

4.8.4.4 Public financing of Ticaboo

A number of efforts at estimating costs and revenues have be undertaken by the applicant and consultants for the private developer of Ticaboo.[4,28,30] A major problem, which emerged from each effort, was the timing of revenues to meet initial capital costs, particularly those related to the construction of the school at Ticaboo. In the long run, property taxes generated by the facility will be sufficient to finance the school's construction as well as other service costs; however, in the short run, the revenues are not readily available. This problem is common in the development of energy projects.[31] The applicant has looked into a number of options including a conventional general obligation bond issue, the establishment of a nonprofit corporation that would issue tax-exempt financing, the use of a tax-exempt lease arrangement, and the prepayment of taxes. Although the relative benefits of each of these arrangements have not been thoroughly evaluated, the staff believes that it is important to reduce the risk to the local taxpayers as much as possible.

The future of the uranium industry and of this mill, as well as the prosperous development of Ticaboo, cannot be guaranteed. Assuming a public debt based on anticipated revenues from the uranium project would appear unwise. Without question such a decision shifts the major cost and risk of the development from the applicant and the private developer to the general public.[32]

4.8.5 Transportation

The development of the mill and mine will result in an increase in motor traffic in the area. Current traffic levels indicate that such an increase will not result in any major problems. The increased economic activity as well as an increase in tourism to Glen Canyon National Park will also result in an increase in air traffic to Hanksville.

4.8.6 Recreation

The major impact on recreation in the area will be increased visitation and use of facilities at Bullfrog Basin Marina, Glen Canyon National Park. The effects of the increase are several. Eventually, the combined impact of a permanent population at Ticaboo and increased visitation will change the quality of the park facilities either as a consequence of increased usage of existing facilities or of the expansion of park facilities.* Both situations would most likely result in an expansion of the number of park personnel.

Currently mine employees seeking recreation normally head to Bullfrog Marina, increasing law enforcement problems, requiring emergency medical aid, and putting increased pressure on swim beaches, rental equipment, and picnic areas. During the construction phase, the increase in population should exacerbate the law enforcement and medical problems, although after the development of Ticaboo, additional services provided to the subdivision should augment those provided by the Park Service. The population during the construction phase will also put additional pressure on other park services, specifically its rental housing, store, and school.

Expansion of the population in the area will also result in an increase in such resource consumptive activities as hunting, four-wheel driving, and "pot hunting" (illegal archaeological exploration).

4.8.7 Conclusions

At the project site, housing and community services must be provided for both construction and operation work forces. In the initial project stages, a motel and trailers will provide housing. Subsequently, mobile homes and permanent housing will be added. The staff estimates that a permanent population of about 900 persons will develop at Ticaboo after several years.

The Ticaboo development corporation expects to provide a domestic water system and sewer facilities financed by tax-exempt bonds, issued by a special service district which will also provide

---

*The National Park Service Concept Plan calls for the construction of a 100-unit motel and a 100-space recreational vehicle park by 1981.

solid waste disposal facilities. Roads and streets, which will be provided by the developer, will be maintained by the county. Electric service will be installed by the developer although Utah Power and Light may eventually manage and/or purchase these facilities. A commercial area is planned for a grocery, retail store, and gasoline station. Social services and medical services are unestablished. During the construction period, worker's children are expected to attend school at Bullfrog Basin Marina. A permanent school is planned at Ticaboo, but the financing for this facility has not yet been formalized.

The quality of life at Ticaboo, and indeed its survival, are dependent on the timely and satisfactory development of the above needs. The applicant and local and State governmental entities are cooperatively planning together to see that these needs are met.

Most of the revenues to provide government-supplied services will be property taxes (mill, mine, residential, and commercial properties) and a share of the State sales tax. In the long run, property taxes will be sufficient to finance school construction and other service costs, but they will not be available in early stages of the project. Several options are available to finance the required services with amortization over an extended period. The staff has not explored the relative advantages of these options but does believe that financial arrangements can be made with increased cooperation of the applicant.

If these arrangements are accomplished, the major impact of the Shootering Canyon project will involve the social and economic stresses involved in any construction project. The development of a new community in an isolated area may exacerbate or minimize these stresses. To offset these social costs, the project will provide employment opportunities not previously available over an extended period of time.

The socioeconomic impacts which will occur when the Shootering Canyon project operations are terminated cannot be evaluated because the socioeconomic development of Ticaboo over the long term cannot be forecast.

REFERENCES FOR SECTION 4

1. U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emission Factors*, 2nd ed., Office of Air Quality Planning and Standards, Research Triangle Park, N.C., 1976.

2. U.S. Environmental Protection Agency, *Fugitive Dust — Sources, Emissions, and Control*, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., 1973.

3. M. B. Bennedsen, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," Sept. 15, 1978.

4. M. B. Bennedsen, "Responses to NRC questions on the Environmental Report for the Shootering Canyon Uranium Project," Aug. 29, 1978.

5. State of Utah, Division of Health, *Air Conservation Regulations*, Salt Lake City, May 22, 1977.

6. *Fed. Regist.* 43(118): 26380-26410 (June 19, 1978).

7. U.S. Nuclear Regulatory Commission, Regulatory Guide 3-11, Rev. 1.

8. Plateau Resources, Ltd., *Tailings Management Plan and Geotechnical Engineering Studies, Shootering Canyon Uranium Project, Garfield County, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif. September 1978.

9. U.S. Environmental Protection Agency, *Assessment of Environmental Aspects of Uranium Mining and Milling*, Report EPA-600/7-76-036, Washington, D.C., 1976.

10. State of Utah, Department of Natural Resources, Division of Oil, Gas, and Mining, *Oil and Gas Conservation Act: Mined Land Reclamation — Changes and Adoptions to the General Rules and Regulations*, adopted March 22, 1978; effective June 1, 1978.

11. U.S. Environmental Protection Agency, *Effects of Noise on Wildlife and Other Animals*, Report NTID300.5, Office of Noise Abatement and Control, Washington, D.C., 1971.

12. "Endangered and Threatened Wildlife and Plants, " *Fed. Regist.* 41(117): 24524-24572 (1976).

13. S. L. Welsh, N. D. Atwood, and J. L. Reveal, "Endangered, Threatened, Extinct, Endemic, and Rare or Restricted Utah Vascular Plants," *Great Basin Nat.* 35(4): 327-376 (1975).

14. "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 42(135): 36419-36431 (1977).

15. B. R. Metzzer, "Nuclear Regulatory Commission Occupational Exposure Experience at Uranium Plants," *Conference on Occupational Health Experience with Uranium*, Report ERDA-93, Washington, D.C., 1975.

16. International Atomic Energy Agency, *Safety Series No. 43, Manual on Radiation Safety in Uranium and Thorium Mines and Mills*, IAES, Vienna, 1976.

17. Presentation to the Environmental Subcommittee of the Advisory Subcommittee on Reactor Safeguards, Occupational Radiation Exposure Control at Fuel Cycle Facilities, January 26, 1978, by the Chief, Fuel Processing and Fabrication Branch, U.S. Nuclear Regulatory Commission.

18. S. I. Auerbach, "Ecological Considerations in Siting Nuclear Plants. The Long-Term Biota Effects Problem," *Nucl. Saf.* 12: 25-35 (1971).

19. *Proceedings of the Environmental Plutonium Symposium*, Report LA-4756, Los Alamos Scientific Laboratory, Los Alamos, N. Mex., 1971, and *A Proposed Interim Standard for Plutonium*, Report LA-5483-MS, Los Alamos Scientific Laboratory, Los Alamos, N. Mex., 1974.

20. *Enewetak Radiological Survey*, USAEC Report NVO-140, Nevada Operations Office, Las Vegas, Nev., 1973.

21. N. A. Frigerio, K. F. Eckerman, and R. S. Stowe, "Background Radiation as a Carcinogenic Hazard," *Radiat. Res.* 62: 599 (1975).

22. A. H. Sparrow et al., "Chromosomes and Cellular Radiosensitivity," *Radiat. Res.* 32: 915 (1967).

23. *Radioactivity in the Marine Environment*, Report of the Committee on Oceanography, National Academy of Sciences-National Research Council, Washington, D.C., 1971.

24. R. J. Garner, "Transfer of Radioactive Materials from the Terrestrial Environment to Animals and Man," *Environ. Control* 2: 337-385, 1971.

25. S. E. Thompson, *Concentration Factors of Chemical Elements in Edible Aquatic Organisms*, USAEC Report UCRL-50564, rev. 1, October 1972.

26. Mountain West Research, Inc., *Construction Worker Profile, Final Report: A Study for the Old West Regional Commission*, December 1975.

27. State of Utah, Department of Natural Resources, Division of State Lands, "Special Use Lease Agreement No. 399," July 3, 1978.

28. W. T. Maughan, *Supplement to the November 1977 Environmental Assessment Report of the Proposed Ticaboo Subdivision*, memorandum, January 1978.

29. "Minutes of Special County Commission Meeting to Discuss Ticaboo Townsite," Sept. 5, 1978.

30. Utah State University Foundation, *Ticaboo Environmental Assessment Report*, Logan, Utah, Nov. 10, 1977.

31. Keith Moore et al., "Administrators Guide to Siting and Operation of Uranium Mining and Milling Facilities," Chap. 5 in *Socioeconomic Impacts*, Stone and Webster Engineering Corporation, May 1978. [Prepared for Webster Interstate Energy Board under Contract No. 68-01-4490 to U.S. Environmental Protection Agency.]

32. For a review of the variety of risks associated with boom towns, see John S. Gilmore et al., *Analysis of Financing Problems in Coal and Oil Shale Boom Towns*, Denver Research Institute, July 1976. [Prepared for Federal Energy Administration under Contract No. CO-04-50 197-00.]

5. ENVIRONMENTAL EFFECTS OF ACCIDENTS

The occurrence of accidents related to operation of the Shootering Canyon Uranium Project will be minimized through the proper design, manufacture, and operation of process components and through a quality assurance program designed to establish and maintain safe operations. In accordance with the procedures set forth in the appropriate regulations, Plateau Resources, Ltd., has submitted applications containing descriptions of the facility design, the organization of the operation, and the quality assurance program. These documents, together with the Environmental Report and supplements, will be reviewed by various agencies to ensure that there is a basis for safe operations at the site. Moreover, those agencies will maintain surveillance over the plant and its individual safety systems by conducting periodic inspections of the facility and its records and by requiring reports of effluent releases and deviations from normal operations.

Despite the above precautions, accidents involving the release of radioactive materials or harmful chemicals have occurred in operations similar to those proposed by the applicant. In this assessment, therefore, accidents that might occur during milling operations have been postulated and their potential environmental impacts evaluated. Section 5.1 deals with the postulated accidents involving radioactivity, and Sect. 5.2 deals with those not involving radioactive materials. The probabilities of occurrence and the nominal consequences are assessed, using the best available estimates of probabilities and realistic assumptions regarding release and transport of radioactive materials. Where information adequate for a realistic evaluation was unavailable, conservative assumptions were used to compute environmental impacts. Thus, the actual environmental impacts of the postulated accidents would be less, in some cases, than the effects predicted by this assessment.

Exposure pathways considered in estimating dose commitments resulting from accidental releases were inhalation and immersion in contaminated air. It was assumed that exposure through the ingestion and surface pathways could be controlled if necessary.

5.1 MILL ACCIDENTS INVOLVING RADIOACTIVITY

The specific activities of the radioactive materials handled at the mill are extremely low: $\approx 10^{-9}$ Ci/g for the ore and tailings and $\approx 10^{-6}$ Ci/g for the refined yellow cake product.* The quantities of materials handled, on the other hand, are relatively large: 225 MT (248 tons) of yellow cake per year, representing ≈ 140 Ci of radioactivity. These very low specific activities require the release of exceedingly large quantities of material to be of concern; driving forces for such releases will not exist at the proposed Shootering Canyon Uranium Project.

Guidelines have not been published for the consideration of accidents at the uranium mills. Therefore, the postulated plant accidents involving radioactivity are considered here in the following three categories:

1. trivial incidents (i.e., those not resulting in a release to the environment),
2. small releases to the environment (relative to the annual release from normal operation), and
3. large releases to the environment (relative to the annual release from normal operations).

---

*In contrast to the relatively high specific activities of a number of prominent radionuclides (i.e, $\approx 10^{-1}$ Ci/g for plutonium-239 and $\approx 10^{-3}$ Ci/g for cobalt-60).

Trivial incidents include spills, ruptures in tanks or plant piping containing solutions or slurries, and rupture of a tailings disposal system pipe in which the tailings slurry is released into the tailings pond. Small releases would result from failure of the air cleaning system serving the concentrate drying and packaging area, a fire or explosion in the solvent extraction circuit, or an explosion in the yellow cake dryer. Large releases would result from a major tornado strike or a tailings dam failure.

For most of the postulated cases resulting in a release to the environment, the analysis gives the estimated magnitude of the release, the corresponding maximum individual dose at various distances from the mill, and the estimated annual likelihood of occurrence. The latter estimates are based on a diversity of sources, including incidents on record, chemical industry statistics, and failure prediction methodologies. Data and models for the behavior of radiation in accident situations were taken from the AIRDOS-II computer code[1] and from the International Commission on Radiological Protection (ICRP)[2] and were updated by dose conversion factors based on the lung model of the ICRP Task Group on Lung Dynamics.[3]

During the three decades of nuclear facility operations, the frequency and severity of accidents have been markedly lower than in related industrial operations. The experience gained from the few accidents that have occurred has resulted in improved engineering safety features and operating procedures, and the probability that similar accidents might occur in the future is very low. Based on analysis, it is believed that even if major accidents did occur, there would probably not be a significant release of contamination offsite, and radiological exposures would be too small to cause any observable effect on the environment or any deleterious effect on the health of the human population.

5.1.1 Trivial incidents

These accidents may include any rupture or leakage in storage tanks or piping associated with the facility. They are not expected to result in releases of radioactivity to the environment.

5.1.1.1 Minor leakage of tanks or piping

Uranium-bearing slurries and solutions will be contained in several tanks comprising the leach, washing, precipitation and filtration, and solvent extraction stages of the mill circuit. Human error during the filling or emptying of tanks or the failure of valves or piping in the circuit would result in spills that might involve the release of several hundred pounds of contained uranium to the room; however, the overflow will be collected in sumps designed for this type of spill, and sump pumps will be used to return the materials to the circuit. Therefore, a rupture in a process tank or a leaking pipe would not affect the environment.

5.1.1.2 Major pipe or tank rupture

All mill drainage, including that from chemical storage tanks, will flow into a catchment basin upstream from the tailings impoundment site. The mill will deliver approximately 28.3 MT (31.3 tons) of solids per hour and approximately 34.7 m^3 [34.7 MT (38.3 tons)] of solution per hour to the tailings cell. Should the rupture of a pipe in the tailings distribution system occur, the liquid would flow into the catchment basin where it could be pumped to the tailings cell. Chemicals could be recovered, transferred to the tailings cell, or neutralized in the catchment basin. Residue from a slurry loss would be cleaned up and the contaminated soil removed to the tailings retention area.

5.1.2 Small releases

The following accidents, due to human error or equipment failure, would release small quantities of radioactive materials to the environment. The estimated releases, however, are expected to be small in comparison with the annual release from normal operations.

5.1.2.1 Failure of the air cleaning system serving the yellow cake drying area

Because of the system designs, this type of accident is unlikely to occur or to go undetected. A loss of water pressure to the scrubber or the failure of the fan drive would sound an alarm. However, in the event of electrical or mechanical failure, it was estimated that approximately 17.3 kg of U_3O_8 would be lost from the stack over an 8-hr shift (0.18 kg in 5 min). All of this insoluble uranium was assumed to be in the respirable size range.

Because the meteorological data at the time of the postulated accident is unpredictable, it was assumed that for this stack release the conservative meteorological conditions of 1 m/sec wind speed and a Pasquill type-B stability would exist. It was also assumed that all the material was distributed over a single 22.5° sector. The maximum dose commitments to the nearest resident [4.2 km (2.6 miles) from the point of release] were as follow: total-body, 0.012 millirem; bone, 0.3 millirem; lung, 5.6 millirems, and kidney, 0.088 millirem.

5.1.2.2 Fire in the solvent extraction circuit

The solvent extraction circuit will be located in a separate building that is isolated from other areas due to the large quantities of kerosene present. From chemical industry data, the probability of a major fire per plant-year[4] is estimated to be 4×10^{-4}. However, at least two major solvent extraction circuit fires are documented in the literature, one of which destroyed the original solvent extraction circuit at one mill in 1968.[4] There have been approximately 540 plant-years of mill operation in the United States, equivalent to about 320 plant-years handling 390,000 MT (430,000 tons) of ore per year. Thus, judging from historical incidents, the likelihood of a major solvent extraction fire at the proposed mill is assumed to fall in the range of 4×10^{-4} to 4×10^{-3} per year.

In the event of a major fire, it is conservatively assumed from previous estimates[5,6] that 1% of the uranium contained in the organic phase or approximately 0.43 kg (0.93 lb) would be released into the environment. It was assumed that the conservative meteorological conditions of 1 m/sec wind speed and a Pasquill type-D stability would exist for the ground-level release. It was also assumed that all the material was distributed over a single 22.5° sector. The maximum dose commitments to the nearest resident [4.2 km (2.6 miles) from the point of release] were as follow: total-body, 0.0002 millirem; bone dose, 0.004 millirem; lung dose, 0.08 millirem; and kidney, 0.0013 millirem.

5.1.3 Large releases

The following incidents might release large quantities of radioactive materials to the environment compared with annual releases from normal operations. By virtue of complex and highly variable dispersion characteristics, however, the individual impacts will not necessarily be proportional to the total amount of radioactivity released to the environment.

5.1.3.1 Tornado

The probability of occurrence of a tornado at the Shootering Canyon Uranium Project is negligible. Using closest available data, the probability is approximately 3.2×10^{-5} (ref. 7 and ER, p. 2-128). The area is categorized as Region 3 in relative tornado intensity;[7] that is, for a "typical" tornado, the wind speed is 385 km/hr (239 mph), of which 305 km/hr (190 mph) is rotational and 79 km/hr (49 mph) is translational. None of the mill structures are designed to withstand a tornado of this intensity.

The nature of the milling operation is such that little more could be done to secure the facility with advance warning than without it. Accordingly, a "no warning" tornado was postulated. Moreover, because it is not possible to accurately predict the total amount of material dispersed by the tornado, a highly conservative approach was adopted. Because the yellow cake product has the highest specific activity of any material handled at the mill and as much as 1.9×10^4 kg (4.2×10^4 lb) of product may be accumulated at any given time, it is assumed that the tornado lifts 5.7×10^3 kg (1.3×10^4 lb) of yellow cake (30% of the maximum amount of concentrate at the mill[8]).

A conservative model, which assumes that all of the yellow cake is in respirable form, was used for the dispersion analysis.[9] The model assumes that all of the material is entrained in the tornado as the vortex passes over the site. Upon reaching the site boundary, the vortex dissipates, leaving a volume source to be dispersed by the trailing winds of the storm. The material is assumed to exist as a volume source representative of the velocities of the tornado and disperses through an arc of 45°. Because of the small particle sizes postulated, the settling velocity is assumed to be negligible.

The model predicts a maximum exposure at a distance of approximately 4 km (2.5 miles) from the mill, where the 50-year dose commitment to the lungs of an individual is estimated to be approximately 1.5×10^{-7} rem. The 50-year lung dose commitment as a function of distance is plotted in Fig. 5.1.

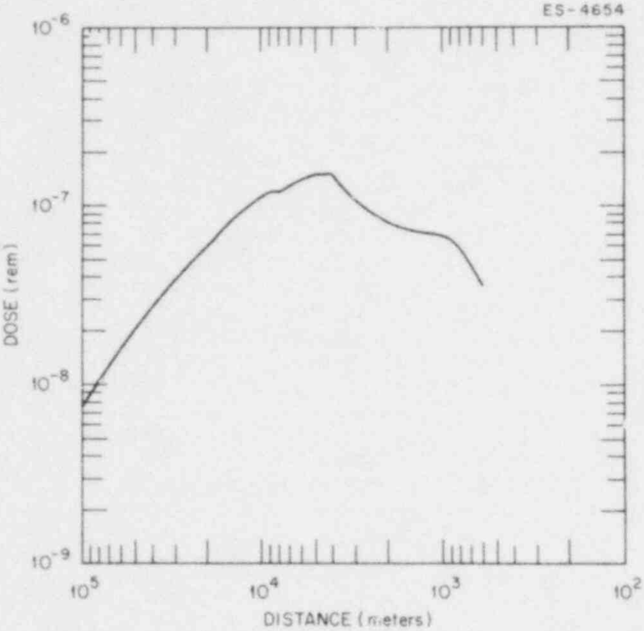


Fig. 5.1. Tornado damage: 50-year dose commitment to the lungs.

5.1.3.2 Release of tailings slurry

The tailings pond will receive tailings slurry and yellow cake purification circuit liquid wastes. A portion of the water in the pond may be recycled for use in the leach circuit. The tailings pond will receive about 680 MT (750 tons) of solids per day of operation. The ultimate capacity of the facility is about 5.0×10^{6} MT (5.5×10^{6} tons) of dry tailings. Inadvertent release of this material to the environment would result from an overflow of the tailings slurry or a failure of the tailings dam. Failure of the tailings dam could be attributed to a destructive earthquake, floodwater breaching, or structural failure.

The facility is designed to minimize the flood hazard. Emergency spillways can divert precipitation runoff around the pond if the dam is near overflow conditions. In addition, the facility will be operated so that the pond will be able to receive the volume from the design flood from NRC Regulatory Guide 3.11 (a probable maximum flood) followed by a 100-year flood and maintain 2 m (7 ft) of freeboard.

The Shootering Canyon Uranium Project is in the Zone One (minor damage) seismic risk category (intensities of V and VI on the Modified Mercalli Scale) (Sect. 2.5.3). The tailings dam is designed to withstand, without damage, an earthquake having an intensity of VI on the Modified Mercalli Scale. However, there is a small probability that an earthquake of intensity VII may occur.[10] The applicant must meet the safety requirements of NRC Regulatory Guide 3.11 and other regulatory agency requirements even though it is highly unlikely that earthquake damage to the dam will occur.

From the foregoing discussion, it is clear that sufficient data are not available to estimate the small probability of the occurrence of a natural disaster with sufficient intensity to result in a release of the tailings slurry to the environment. Even if the probability were known accurately, it would be difficult to predict the magnitude of the release. However, tailings slurry releases have occurred in the past, and the consequences associated with these events have been documented to varying levels of detail in reports to the NRC and will be used to estimate a nominal release. Table 5.1 summarizes recorded incidents during the period 1959-1977.

Table 5.1. Summary of accidental tailings slurry releases, 1959–1977

Cause	Solids released		Liquids released		Reached watercourse
	kg	lb	liter	gal	
Flash flood	14×10^6	3×10^7	1.2×10^7	3×10^6(a)	Yes
Dam failure	9×10^5	2×10^6(a)	9.1×10^5	2×10^5	Yes
Dam failure	5×10^5	1×10^6	4×10^5	1×10^5(a)	No
Dam failure	2×10^5	4×10^5	2×10^5	5×10^4(a)	Yes
Pipeline failure	3×10^5	7×10^5	2×10^5	5×10^4	Yes
Flooding	1×10^8	2×10^8(a)	8.7×10^7	2×10^7	Yes
Pipeline failure	6.4×10^4	1×10^5(a)	6.1×10^4	2×10^4	Small amount
Flooding	2×10^6	4×10^6(a)	1.7×10^6	4×10^5	Yes
Dam failure	1×10^6 to 14×10^6	2×10^6 to 3×10^7(a)	1×10^6 to 11×10^6	3×10^5 to 3×10^6	Yes
Pipeline failure	1×10^5	2×10^5(a)	1.3×10^5	3×10^4	Yes
Dam failure	9×10^3	2×10^4(a)	8×10^3	2×10^3	No
Pipeline failure	No quantitative information				No
Pipeline failure	4.5×10^7	1×10^8	8×10^6 to 30×10^6	2×10^6 to 8×10^6	No
Dam failure	8.2×10^6	1.8×10^7(a)	7.6×10^6	2×10^6	No
Pipeline failure	1.1×10^3	2.5×10^3	1.5×10^4	4×10^3	Roughly 80% of solids and 20% of liquids reached watercourse

[a]Assuming equal weights of solids and liquids released and density of the liquids to be approximately 1.1 kg/liter (9 lb/gal).

Sources: Directorate of Licensing, U.S. Atomic Energy Commission, *Environmental Survey of the Uranium Fuel Cycle*, Report WASH-1248, Fuels and Materials, April 1974; also a Report from Teknekron, Inc., to NRC dated 14 March 1978.

From these historical data, the average release from tailings dam failure or flooding was approximately 1.2×10^7 liters (3.1×10^6 gal) of liquids and 1.4×10^7 kg (3.1×10^7 lb) of solids. Ten of the fifteen releases reached the watercourse, and nine involved dam failure or flooding. Thus, considering the 394 mill-years of operation in the 1959-1977 period, the apparent likelihood of release from the tailings pond to the watercourse is 1×10^{-2} to 2×10^{-2} per plant-year or roughly one release per 30×10^6 MT (33×10^6 tons) of ore processed. This figure is unrealistic for impoundment dams for new facilities because all of the failures listed in Table 5.1 were for structures composed primarily of tailings and were not designed to an engineering standard such as Regulatory Guide 3.11. Present criteria call for carefully engineered structures with design features that take into account such possibilities and probabilities as earthquakes and floods.

The solid tailings are predicted to have a radioisotope composition of approximately 20 μCi of uranium-238 and uranium-234, 231 μCi of thorium-230, and 226 μCi of radon-226 per ton of ore. The chemical and radiological composition of the tailings water as estimated by the staff and the applicant is presented in Table 3.3.

The estimated 1.4×10^7 kg (3.1×10^7 lb) of solid tailings released from the impoundment area as a result of an overtopping or failure of the tailings dam would be expected to settle out below the dam. Because the drainage below the dam is wide and flat, few (if any) solids would be expected to reach Shootering Creek. Under usual no-creek-flow conditions, the 11,200 m^3 (9.1 acre-ft) of liquids released would percolate into the soil before reaching Hansen Creek. If this happens, there would be an extended period (years) when leaching of the stream bed could occur during periods of stream flow. The staff would not expect any observable effects from such leaching although drinking water standards for nonradioactive constituents might be exceeded over short periods.

If the release occurred during stream flow, it is likely that a slug flow of contaminated water (both radiological and nonradiological constituents) would proceed down Hansen Creek to Lake Powell. The subsequent dilution would eliminate any contamination problems within a very short time.

The main radiological concern associated with the deposition of the solid tailings material is the small increase in background radiation levels in the affected and adjacent areas and the eventual transport of these low levels of contamination by stream flow, wind, and rain. These long-term effects may be mitigated by removing the contaminated material from the environment. Accordingly, a measure of the impact associated with the release of the solid tailings from the impoundment is the cost of excavating the area, removing the tailings and contaminated soil, and transporting the material back to the tailings impoundment. Assuming that 15 cm (6 in.) of contaminated soil must be removed along with the tailings and that the average travel distance back to the tailings impoundment is 1.6 km (1 mile), the estimated cost for excavation, removal of contaminated materials, and truck transport of the material to the tailings impoundment is approximately $128,000.

5.2 NONRADIOLOGICAL ACCIDENTS

The potential for environmental effects from accidents involving nonradioactive materials at the Shootering Canyon Uranium Project is small. Failure of a boiler supplying process steam could release low-pressure steam to the room, possibly causing minor injuries to workers, but would not involve the release of chemicals or radioactive materials to the environment. Forced-air ventilation systems are provided in several stages of the process to dilute the chemical vapors emitted and protect the workers from the hazardous fumes. Failure of these ventilation systems might result in the interim collection of these vapors in the building air. Such a failure might adversely affect individual plant employees but would have no persistent effect on the environment.

A number of chemical reagents used in the process will be stored in relatively large quantities on the site. All reagents will be stored within diked areas. Spillage in the mill will be washed down and pumped back into the mill circuit. The only chemical that might seriously impact on the environment is ammonia. A break in the external piping of the anhydrous ammonia tank would not result in a release, because an excess flow valve would automatically close on a drop in pressure, thus preventing the escape of ammonia. It is possible that the line carrying ammonia to the storage tank from the tank truck could be ruptured, in which case the release rate would be limited to 100 g/sec of the vapor.[11]

Beyond a distance of 10 km (6 miles), the resulting concentration would be below the 60 $\mu g/m^3$ short-term air quality standard derived from State of Colorado regulations (at 1/30 threshold limit values).[12] Beyond a distance of 700 m (2300 ft) from the mill, concentrations of ammonia from the accident would be less than the 40,000 $\mu g/m^3$ needed to produce a detectable odor and the 69,000 $\mu g/m^3$ concentration recommended as the limit for prolonged human exposure.[13] Thus, the ammonia would neither be noticed by nor pose a health risk to offsite residents.

5.3 TRANSPORTATION ACCIDENTS

Transportation of materials to and from the mill can be broken down into three categories: (1) shipments of ore from the mine to the mill, (2) shipments of refined yellow cake from the mill to the uranium hexafluoride conversion facility, and (3) shipments of process chemicals from suppliers to the mill. An accident for each of these categories has been postulated and analyzed. The results are given in the following discussion.

5.3.1 Shipments of yellow cake

Refined yellow cake product is generally packaged in 55-gal, 18-gage drums holding an average of 364 kg (800 lb) and classified by the Department of Transportation as type A packaging (49 CFR Parts 171-189 and 10 CFR Part 71). It is shipped by truck an average of 2100 km (1300 miles) to a conversion plant, which transforms the yellow cake to uranium hexafluoride for the enrichment step of the light-water-reactor fuel cycle. An average truck shipment contains approximately 45 drums, or 16 MT (17.5 tons) of yellow cake. Based upon the Shootering Canyon mill capacity of 248,300 MT (273,750 tons) of ore annually and yellow cake yield of 224 MT (246 tons), approximately 14 such shipments are required annually.

From published accident statistics,[14,15] the probability of a truck accident is in the range of 1.0×10^{-6} to 1.6×10^{-6} per kilometer (1.6×10^{-6} to 2.6×10^{-6} per mile). Truck accident statistics include three categories of traffic accidents: collision, noncollision, and other events. Collisions involve interactions of the transport vehicle with other objects, whether moving vehicles or fixed objects. Noncollisions are accidents in which the transport vehicle leaves the transport path or deviates from normal operation in some way, such as by rolling over on its top and side. Accidents classified as other events include personal injuries suffered on the vehicle, records of persons falling from or being thrown against a standing vehicle, cases of stolen vehicles, and fires occurring on a standing vehicle. The likelihood of a truck shipment of yellow cake from the mill being involved in an accident of any type during a one-year period is approximately 0.04.

The ability of the materials and structures in the shipping package to resist the combined physical forces arising from impact, puncture, crush, vibration, and fire depends on the magnitude of the forces.[16] These magnitudes vary with the severity of the accident, as does the frequency with which they occur. A generalized evaluation of accident risks by NRC classifies accidents into eight categories, depending upon the combined stresses of impact, puncture, crush, and fire. On the basis of this classification scheme, conditional probabilities (i.e., given an accident, the probabilities that the accident is of a certain magnitude) of the occurrence of the eight accident severities were developed. These fractional probabilities of occurrence for truck accidents are given in Column 2 of Table 5.2. To assess the risk of a transportation accident, it is necessary to know the fraction of radioactive material that is released when involved in an accident of a given severity. Two models are postulated for this analysis, and the fractional releases for each model are shown in Columns 3 and 4 of Table 5.2. Model I assumes complete loss of the drum contents; Model II, based upon actual tests, assumes partial loss of the drum contents. The packaging is assumed to be type A drums containing low specific activity (LSA) radioactive materials. Considering the fractional occurrence and the release fractions (loss) for Model I and Model II, the expected fractional release in any given accident is approximately 0.45 and 0.03 respectively.

For Model I and Model II, the quantity of yellow cake released to the atmosphere in the event of a truck accident is estimated to be about 7400 kg (16,200 lb) and 500 kg (1100 lb) respectively. Most of the yellow cake released from the container would be deposited directly on the ground in the immediate vicinity of the accident. Some fraction of the released material, however, would be dispersed to the atmosphere. Expressions for the dispersal of similar material to the environment based on actual laboratory and field measurements have been developed.[15] The following empirical expression was derived for the dispersal of the material to the environment via the air following an accident involving a release from the container:

$$f = 0.001 + (4.6 \times 10^{-4})[1 - \exp(-0.15ut)]u^{1.78} ,$$

where

f = the fractional airborne release,
u = the wind speed at 15.2 m (50 ft) expressed in meters per second, and
t = the duration of the release, in hours.

Table 5.2. Fractional probabilities of occurrence and corresponding package release fractions for each of the release models for LSA and type A containers involved in truck accidents

Accident severity category	Fractional occurrence of accident	Model I	Model II
I	0.55	0	0
II	0.36	1.0	0.01
III	0.07	1.0	0.1
IV	0.016	1.0	1.0
V	0.0028	1.0	1.0
VI	0.0011	1.0	1.0
VII	8.5E-5	1.0	1.0
VIII	1.5E-5	1.0	1.0

Source: U.S. Nuclear Regulatory Commission, *Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Models*, Report NUREG-0170, Office of Standards Development, February 1977 (draft).

In this expression, the first term represents the initial "puff" immediately airborne when the container is failed in an accident. Assuming that the wind speed is 5 m/sec (10 mph) and that 24 hr are available for the release, the environmental release fraction is estimated to be 9×10^{-3}. If insoluble uranium (all particles of which are in the respirable size range) is assumed and a population density of 160 people per square mile (which is characteristic of the eastern United States) is supposed,[17] the consequences of a truck accident involving a shipment of yellow cake from the mill would be a 50-year dose commitment* to the general population of approximately 13 and 0.9 man-rems to the lungs for Models I and II respectively.

In a recent accident (September 1977), a commercial truck carrying 50 steel drums of uranium concentrate overturned and spilled an estimated 6800 kg (15,000 lb) of concentrate on the ground and in the truck trailer. Approximately 3 hr after the accident, the material was covered with plastic to prevent further release to the atmosphere. Using the above formula and values of wind speed for a fractional airborne release for this 3-hr duration of release, approximately 56 kg (123 lb) of U_3O_8 would be released to the atmosphere. The consequence of this accident would be a 50-year dose commitment to the general population of 11 man-rems for a population density of 160 people per square mile. This dose commitment can be compared to a 50-year integrated lung dose of 1427 man-rems from natural background.

The applicant has submitted to the NRC an emergency action plan for yellow cake transportation accidents. This emergency action plan is intended to ensure that personnel, equipment, and materials are available to contain and decontaminate the accident area.

5.3.2 Shipments of ore to the mill

Uranium ore will be shipped to the ore stockpiles adjacent to the mill in 27-MT (30-ton) trucks. Equal quantities of ore will be shipped to the mill from the Tony M mine, 7.24 km (4.5 miles) away, and from the proposed Northeast mine 12 km (7.5 miles) away. The average shipping distance is approximately 9.7 km (6 miles). Based upon the projected mill capacity

*Doses integrated over a 50-year commitment following exposure.

of 680 MT (750 tons) of ore daily, approximately 9100 trips would be required annually. Although the ore will be shipped on private roads, it is assumed that the probability of a truck accident is in the range cited in the previous section. Therefore, the estimated likelihood of an ore truck being involved in an accident during a one-year period is roughly 0.11; however, because of the low specific activity and ease with which the contaminant can be removed, the radiological impact is considered to be insignificant.

Each month the mill will also receive up to 3970 MT (4380 tons) of ore shipped from an ore buying station located south of Blanding, Utah. The most significant potential impact of transporting ore from the ore buying station is spillage of radioactive material as the result of transportation accidents. The probability of a truck accident is about 1.6×10^{-6} to 2.6×10^{-6} per mile. It is estimated that eight to ten trucks will transport ore five days per week, 52 weeks per year. The maximum cumulative distance driven by all trucks with a load of ore on board is approximately 420,000 km (260,000 miles) per year. Consequently, there is a potential for the loaded ore trucks to have 0.40 to 0.65 accident per year.

The statistics used in this analysis include all types of accidents, and an accident involving a uranium ore truck would not necessarily result in the spillage of any ore. However, if a spill did occur, it is unlikely that significant amounts of radionuclides would be released to the environment.

The trucks used to haul ore from the ore buying station commmonly carry a maximum of 27 MT (30 tons) of material. Assuming an average ore grade of 0.10% uranium oxide (approximate average grade of the ore received at the ore buying station to date), a delivery truck would carry a maximum of about 30 kg (66 lb) of uranium oxide. Even if the entire load were spilled, it would be difficult for significant amounts of this radioactive material to enter the environment because it is relatively insoluble and is not likely to be easily dispersed by wind. In addition, the ore would be valuable and easy to clean up.

5.3.3 Shipments of chemicals to the mill

Truck shipments of anhydrous ammonia to the mill, if involved in a severe accident, could conceivably result in a significant environmental impact. Weekly shipments of anhydrous ammonia will be made annually from a supplier located approximately 320 km (200 miles) from the mill (ER, p. 7-10).

The annual U.S. production of anhydrous ammonia shipped in that form is approximately 6.9×10^{6} MT (7.6×10^{6} tons). It is estimated that about 26% of the shipments are made by truck (the remainder by rail, pipeline, and barge). Assuming that the average truck shipment is 19 MT (21 tons), approximately 93,000 truck shipments of anhydrous ammonia are made annually. According to accident data collected by the Department of Transportation, there are about 140 accidents per year involving truck shipments of anhydrous ammonia. For an estimated average shipping distance of 560 km (350 miles), the resulting accident frequency is roughly 2.7×10^{-6} per kilometer (4.3×10^{-6} per mile). Data from the Department of Transportation also reveal that a release of ammonia [an average of 770 kg (1700 lb)] resulted from approximately 80% of the reported incidents and that an injury to the general public occurred in roughly 15% of the reported incidents that involved a release (most of the injuries were sustained by the driver).

Utilizing these data, the probability of an injury to the general public resulting from an average shipment of anhydrous ammonia is roughly 3×10^{-7} per kilometer (4.8×10^{-7} per mile). This estimate is probably too high for shipments in the vicinity of the Shootering Canyon mill because of the relatively low population density. Nevertheless, accepting this estimate, the likelihood of an injury to the general public resulting from shipments of ammonia to the mill is predicted to be roughly 5×10^{-3} per year.

REFERENCES FOR SECTION 5

1. R. E. Moore, *The AIRDOS-II Computer Code for Estimating Radiation Dose to Man for Airborne Radionuclides in Areas Surrounding Nuclear Facilities*, Report ORNL-5245, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1977.

2. "Recommendations of the International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation," *Health Phys.* 3: 1-380 (1960).

3. ICRP Task Group on Lung Dynamics, "Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract," *Health Phys.* 12: 181 (1966).

4. Directorate of Regulatory Standards, U.S. Atomic Energy Commission, *Environmental Survey of the Uranium Fuel Cycle*, Report WASH-1248, April 1974.

5. Battelle Northwest Laboratories, *Considerations in the Assessment of the Consequences of Effluents from Mixed Oxide Fuel Fabrication Plants*, Report BNWL-1697, Richland, Washington, June 1973.

6. Directorate of Licensing, U.S. Atomic Energy Commission, *Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program*, Report WASH-1535, December 1974.

7. E. H. Markee, Jr., and J. G. Beckerley, *Technical Basis for Interim Regional Tornado Criteria*, Report WASH-1300, U.S. Atomic Energy Commission, May 1970.

8. Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif., Aug. 29, 1978, p. 108.

9. F. C. Kornegay, Ed., *Condensed Proceedings of the Symposium on the Dispersion of Particulate Matter by Natural Vortices, held at Argonne National Laboratory, Argonne, Illinois, August 1976* (in preparation).

10. G. R. Scott, *Quarternary Faulting and Potential Earthquakes in East-Central Colorado*, U.S. Geological Survey Paper 70-C, 1970.

11. U.S. Nuclear Regulatory Commission, *Final Environmental Statement Related to Operation of Bear Creek Project*, Docket No. 40-8452, June 1977.

12. Colorado Air Pollution Control Commission, "Regulation to Control the Emissions of Chemical Substances and Physical Agents," Regulation No. 8, effective May 1, 1974.

13. F. A. Patty, *Industrial Hygiene and Toxicology*, 2d ed., rev., vol. II, *Toxicology*, David W. Fassett and Dan Irish, Eds., Interscience, New York, 1963.

14. Directorate of Regulatory Standards, U.S. Atomic Energy Commission, *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Plants*, Report WASH-1238, December 1972.

15. Battelle Northwest Laboratories, *An Assessment of the Risk of Transporting Plutonium Oxide and Liquid Plutonium Nitrate by Truck*, Report BNWL-1846, Richland, Washington, August 1975.

16. U.S. Nuclear Regulatory Commission, *Final Environmental Statement on Transportation of Radioactive Materials by Air and Other Modes*, Report NUREG-0170, December 1977.

17. U.S. Bureau of the Census, *Statistical Abstract of the United States: 1976*, 97th ed., 1976.

6. MONITORING PROGRAMS

6.1 AIR QUALITY

For one year beginning in July 1977, total suspended particulate matter was monitored at the applicant's mine camp, which is located in Shootering Canyon approximately 5.6 km (3.5 miles) north of the proposed mill site. Every sixth day, 24-hr samples were collected at one location according to the National Air Sampling Network schedule; a high-volume particulate sampler was used. No other pollutants were monitored by the applicant. The Utah Bureau of Air Quality operates a monitoring station for total suspended particulate matter and sulfur dioxide at Bullfrog Basin Marina, approximately 16 km (10 miles) south of the proposed plant site. The nearest monitoring station for nitrogen dioxide and ozone is located at Page, Arizona, approximately 110 km (70 miles) southwest of the site. The applicant will be required to conduct a monitoring program to collect onsite meteorological data (e.g., wind speed and direction at 1-hr intervals), the results of which will aid in the determination of compliance with 10 CFR Part 190.

The applicant did not present an operational monitoring program for nonradiological air quality. Because no significant impacts to air quality due to operation of the facility are expected (Sect. 4.1), the staff does not require an operational monitoring program for air quality.

6.2 LAND RESOURCES AND RECLAMATION

6.2.1 Land resources

6.2.1.1 Land

The applicant acquired land-use data from the U.S. Bureau of Land Management, the Utah State University Foundation, and onsite visits (ER, Sect. 6.1). No other special methodology was required. The staff plans to condition the license to require the licensee to conduct and document a land use survey on an annual basis.

6.2.1.2 Historical, scenic, and archaeological resources

The existing condition of the site was determined as described in Sect. 2.5.2. As stated in Sect. 4.2.2, additional monitoring should not be necessary; however, should artifacts or cultural objects be discovered during the construction stage, the State Historic Preservation Officer must be notified immediately as provided for in the Utah State Antiquities Act of 1973 and Public Law 93-291.

6.2.2 Reclamation

The applicant's proposed plan to assure reestablishment of the vegetation consists of a visual inspection of the reseeded areas each summer for three years. If seedlings do not become established on the site within a year after seeding or are washed out during the three-year inspection period, the area will be reseeded.[1] The staff believes that these methods are not sufficient to ensure stand establishment and self-perpetuation and concurs with the methods required by the State of Utah Division of Oil, Gas, and Mining in Reclamation Regulation, Rule M-10,[2] which indicate that revegetation will be deemed accomplished and successful when the species

1. have achieved a surface cover of at least 70% of the representative vegetative communities surrounding the operation (vegetation cover levels shall be determined by the operator using professionally accepted inventory methods approved by the Division),

2. have survived for at least three growing seasons,

3. are evenly distributed, and

4. are not supported by irrigation or continuing soil amendments.

The staff believes that by adherence to the reclamation requirements of the State[2] and recommended techniques offered by Plummer[3] the revegetation procedures and monitoring programs should be adequate to ensure successful reclamation. Sufficient records must be maintained by the applicant to furnish evidence of compliance with all monitoring. The applicant will be required to file a performance bond with the State of Utah to ensure performance of land reclamation.[2]

6.3 WATER

6.3.1 Surface water

6.3.1.1 Preoperational monitoring

Surface-water samples were collected in July and August 1977 from five stations in the vicinity of the project site. The locations of these stations are shown on Fig. 1.1 and the physical, chemical, radiological, and bacteriological constituents measured are listed in Table 2.8.

6.3.1.2 Operational monitoring

Operational monitoring of surface waters will initially be confined to quarterly samples from Lost Springs (north of the site) and several seeps along Shootering Creek (ER, Sect. 6.2). Any surface seepage that develops as a result of the tailings impoundment will also be sampled and analyzed quarterly. To compare the water quality of these springs and seeps to baseline conditions, all parameters measured in the preoperational study (Table 2.9) will be measured in the quarterly operational monitoring program.

6.3.2 Groundwater

6.3.2.1 Preoperational

Groundwater quality in the local area was determined by the applicant by sampling and analyzing springs and wells (Fig. 1.1 and Table 2.9). In addition, six wells will be completed near the tailings impoundment (Fig. 6.1). These monitoring wells will be drilled to the top of the Carmel Formation, then sampled and analyzed to provide baseline data for comparison purposes during the operational monitoring program. All of the parameters reported on Table 2.9 will be measured.

6.3.2.2 Operational

The monitoring wells shown on Fig. 6.1 will be sampled on a quarterly basis and the analytical results compared to baseline data to detect potential groundwater contamination until reclamation is completed. The applicant is also required to submit a plan to mitigate such contamination if it is observed.

Documented visual inspections, at least monthly, shall be made along the Shootering Canyon sidewall next to the impoundment to ensure that no surface seeps have developed. If seepage is noted, the applicant shall provide a plan to mitigate such seepage.

The applicant shall also continue to monitor the springs and wells shown on Fig. 1.1.

6.4 SOILS

Soils in the vicinity of the proposed plant site and tailings impoundment were initially delineated on a map; these delineations were based on the reflective differences of land surfaces from color aerial photographs and on field observations of topography and bare rock.

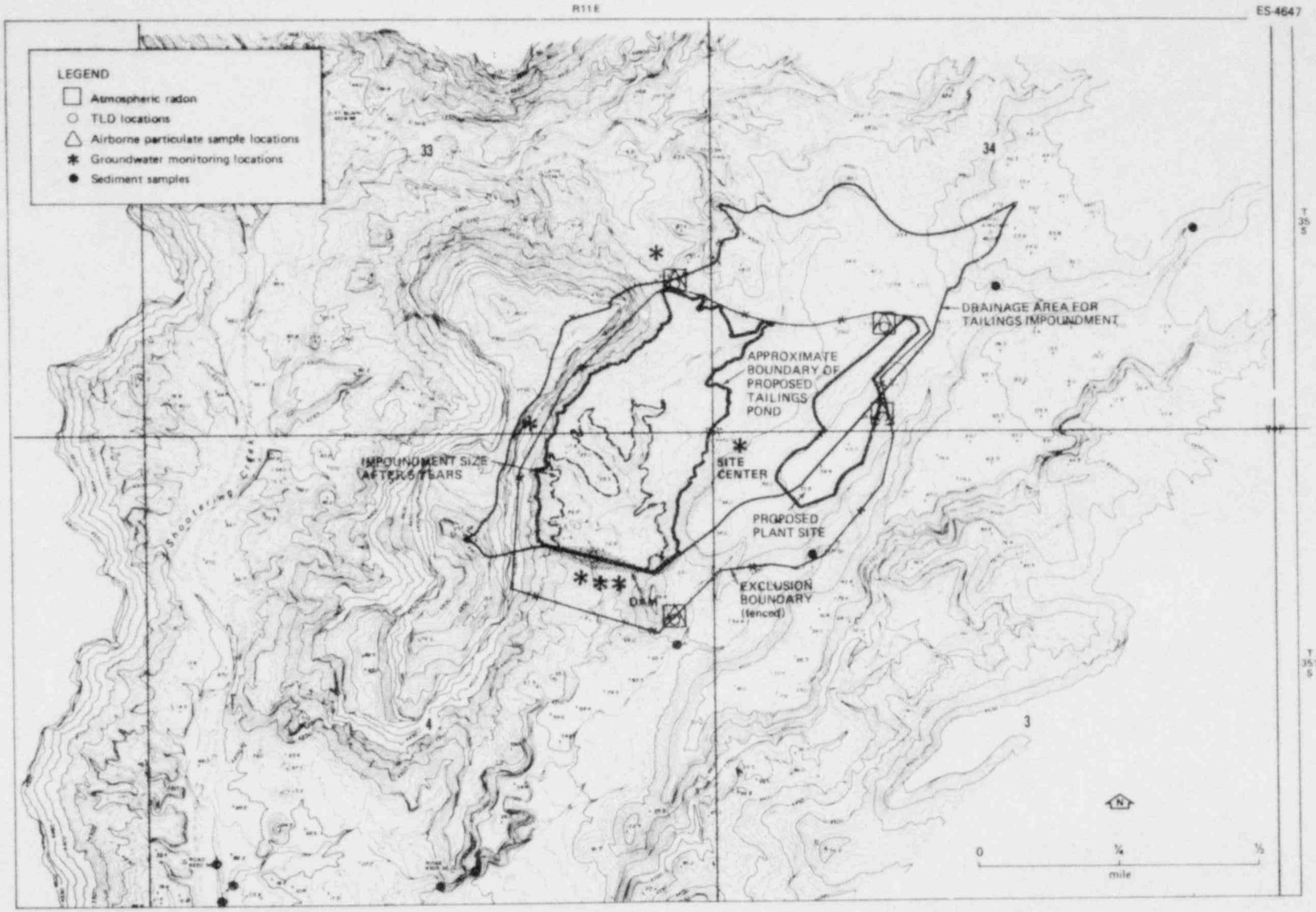


Fig. 6.1. Preoperational monitoring locations for thermoluminescent dosimeters, airborne particulates, groundwater, and atmospheric radon. Source: Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif., Aug. 29, 1978, Fig. 1.

Soils were sampled during July and September 1977 (ER, Sect. 6.1) at a total of 21 sites (Fig. 2.4). Soils were sampled to a depth of 1 m (3 ft) unless bedrock was reached at a shallower depth. Characteristics recorded at each soil sampling site included slope, erosion, depth, texture, consistency, and color (ER, Sect. 6.1). Based on this information, five major soil mapping units were delineated on the proposed tailings impoundment and plant site. Sieve analysis and ion exchange capacity were conducted on only one sample that was taken in the vicinity of the western abutment of the tailings dam.

6.5 BIOTA

6.5.1 Terrestrial

Terrestrial ecological characteristics of the site were studied from July 19 to July 22 and from October 4 to October 7, 1977.[1] This study was supplemented by information from the Utah Division of Wildlife Resources and from the published literature (ER, Appendix E).

Perennial vegetation was surveyed at the tailings impoundment and plant site (Fig. 6.2) using the line-intercept and belt-transect methods (ER, Appendix E). Density by species was determined by counting individuals within a belt of 1 m (3 ft) on either side of the line transect. Species composition was also recorded within this area. Cover by species (expressed as a percentage) was determined by measuring the distance of the transect intercepted by the plant

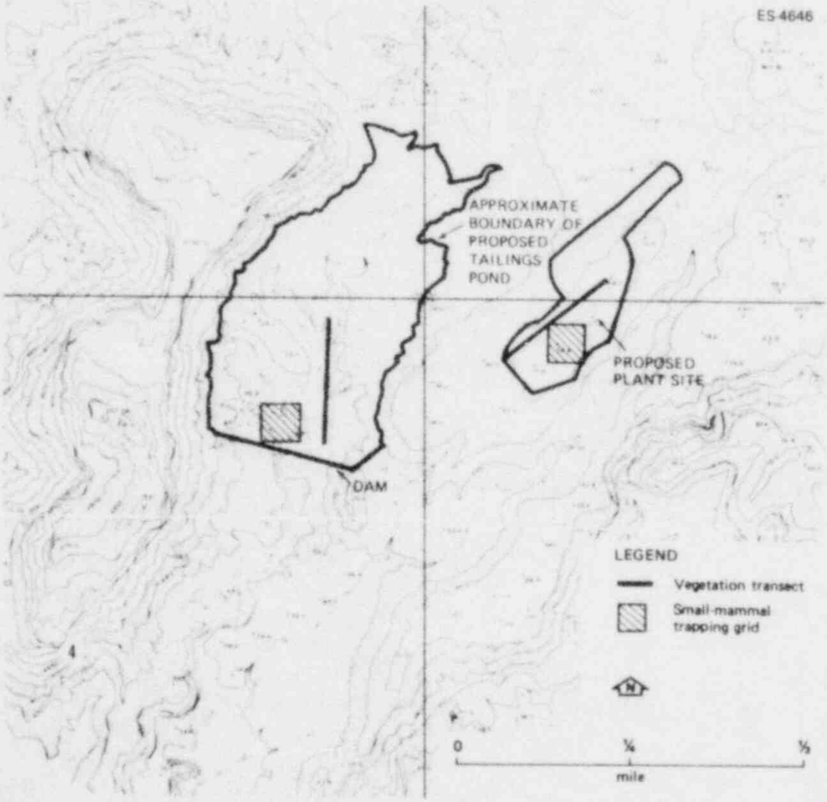


Fig. 6.2. Location of vegetation transects and small mammal trapping grids at the proposed Shootering Canyon Uranium Project. Source: Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif., Aug. 29, 1978, Fig. E-1.

foliage. Estimates of herbaceous cover by species were made within 0.1-m^2 quadrats placed at 10-m (33-ft) intervals along each transect. Transects were located by randomly establishing a starting point and then placing ten 30-m (98-ft) transects in a continuous fashion, generally in a north-south direction. To further reduce sampling biases, transects were alternately directed at a 45° angle from the north-south baseline.

Species composition and relative abundance of small mammals were assessed by placing two live-trap grids on the site for three consecutive nights in July and two consecutive nights in October (Fig. 6.2). In July, grids consisted of six rows and six columns of traps; in October the design consisted of a 49-trap square grid. All traps were spaced 15 m (49 ft) apart. The presence of medium-sized mammals (e.g., rabbits or coyotes) was determined from direct observations and examination of signs (e.g., tracks, scat, or dens). Information regarding use of habitat within the project vicinity by big-game mammals, upland game birds, and other wildlife species of interest was obtained from the Utah Division of Wildlife Resources and from published literature. Songbirds were recorded along the same transects as those used for the vegetation survey (Fig. 6.1). Raptor surveys were conducted by scanning the slopes of the highly eroded bench to the west and north of the tailings impoundment site. The presence of amphibians and reptiles was noted on an opportunistic basis.

Information from the Utah Division of Wildlife Resources and from published literature generally reflects observations and measurements made over a period of years. Supplemented with onsite investigations following periods of increased soil temperature and precipitation, the information presented by the applicant should be sufficient to determine the probable impacts to the terrestrial ecological characteristics of the area due to construction and operation of the facility.

The applicant has not presented a detailed operational, terrestrial monitoring program. Vegetation and wildlife in the vicinity will be qualitatively assessed when samples of vegetation and wildlife are collected for the radiological monitoring (ER, Sect. 6.2). If any changes in the plants or animals (such as unusual discoloration or dieback of plants or any unusual changes in the health or behavior of animals) are thought to be due to operation of the facility, additional investigations will be conducted to confirm the presence and to determine the cause for such changes. The NRC and Utah Division of Wildlife Resources should be contacted immediately if any of these unusual changes occur and should be kept informed of all associated additional investigations. Test results from samples collected in the vicinity of the facility could be compared to those from unaffected control areas in similar vegetation types of wildlife habitats at some distance from the facility. The changes could then be assessed to determine the need for appropriate mitigating measures.

Although potentially harmful amounts of radionuclides and other contaminants in the tailings impoundment are not expected to result in any significant impacts to waterfowl and shorebirds, the actual extent of this impact cannot be quantified (Sect. 4.6.1). The staff recommends, therefore, that the applicant monitor the use of the impoundment by waterfowl and shorebirds during the fall and spring migration periods. Daily records should include the number and species using the impoundment, as well as length of use and behavior. These data should be submitted to NRC on a yearly basis for evaluation to determine if there is a need for continued monitoring and/or mitigating measures.

6.5.2 Aquatic

The applicant has neither conducted a sampling program for aquatic biota nor proposed preoperational or operational sampling programs. Because of the lack of aquatic habitat (Sect. 2.6.1), subsequent paucity of aquatic biota (Sect. 2.9.2), and the low probability that the aquatic habitat could be impacted significantly by mill construction and/or operation (Sect. 4.6.2), an aquatic biota monitoring program is not considered necessary by the staff.

6.6 RADIOLOGICAL

6.6.1 Preoperational program

A preoperational radiological monitoring program is being developed at the proposed Shootering Canyon Uranium Project to establish the baseline radiation levels and concentrations of radioactive materials occurring in air, biota, and soil and in regional surface water and local groundwater. The sampling program is ongoing, and results are incomplete. The preoperational monitoring program will conform to that recommended by NRC and shown in Table 6.1.

6.6.2 Operational effluent and environmental monitoring program

The objectives of the effluent monitoring program are to ensure that the proposed mill discharges are as low as reasonably achievable, to develop criteria that can be used in the design of new operational procedures, and to aid in the interpretation of the results of such other studies as the environmental monitoring program. The procedures for controlling effluent release and performing monitoring and surveys will conform to applicable U.S. Government regulations. The program that will be implemented (Table 6.2) will consist of measurements of radioactivity in the air, surface water and groundwater, soil, and biota.

Table 6.1. Preoperational monitoring program

Type of sample	Sample collection			Sample measurement	
	Number	Location	Type and frequency	Test frequency	Type of measurement
Air					
Particulate	3	Locations onsite at or near site boundaries	Continuous; weekly	Quarterly composites of samples	Natural uranium, Ra-226, Th-230, and Pb-210
Particulate	1	Locations offsite including nearest residences	Continuous; weekly	Quarterly composites of samples	Natural uranium, Ra-226, Th-230, and Pb-210
Particulate	1	Background location remote from site	Continuous; weekly	Quarterly composites of samples	Natural uranium, Ra-226, Th-230, and Pb-210
Radon gas	5	At same locations where particulates are sampled	Continuous (one week per month; same period each month); samples collected for 48-hr intervals	Each 48-hr sample	Rn-222
Water					
Groundwater	6	Wells located around future tailings disposal area and any future mine sites (emphasis on down gradient)	Grab; quarterly	Quarterly; semiannually	Dissolved natural uranium, Ra-226, Th-230; dissolved Pb-210 and Po-210
	1 (from each well)	Wells within 2 km of tailings disposal and mining areas (could be used for potable water or irrigation)	Grab; quarterly	Quarterly; semiannually	Total and dissolved natural uranium, Ra-226, Th-230; total and dissolved Pb-210 and Po-210
	1	Well located up gradient from disposal area for background	Grab; quarterly	Quarterly; semiannually	Dissolved natural uranium, Ra-226, Th-230; dissolved Pb-210 and Po-210
Surface water	1 (from each body of water)	Onsite or offsite streams (Shootering Creek, Lost Springs Wash, etc.) which may be potentially contaminated by direct surface drainage or tailings impoundment failure	Grab; quarterly	Quarterly	Suspended and dissolved natural uranium, Ra-226, Th-230
			Grab; semiannually	Semiannually	Suspended and dissolved Pb-210 and Po-210
Vegetation (forage)	3	Grazing areas near the mill site in different sectors having the highest predicted particulate concentrations during milling operations	Grab; three times during grazing season	Three times	Natural uranium, Ra-226, Th-230, Pb-210, and Po-210
Food (crops, livestock)	3 (of each type)	Within 5 km of mill site	Grab; three times during harvest or slaughter	One time	Natural uranium, Ra-226, Th-230, Pb-210, and Po-210
Fish	Each body of water	Collection of game fish (if any) from streams in the site environs which may be contaminated by surface runoff or tailings impoundment failure	Grab; semiannually	Two times	Natural uranium, Ra-226, Th-230, Pb-210, and Po-210

Table 6.1 (continued)

Type of sample	Sample collection: Number	Sample collection: Location	Sample collection: Type and frequency	Sample measurement: Test frequency	Sample measurement: Type of measurement
Site survey					
Gamma dose rate	80	150-m intervals to a distance of 1500 m in each of eight directions from a point equidistance between the milling area and tailings pond	Gamma dose rate; once prior to construction	One time	Pressurized ionization chamber or properly calibrated portable survey instrument
	10	150-m intervals in both horizontal and vertical transverses across the milling areas	Gamma dose rate; once following preparation of milling site	One time	Pressurized ionization chamber or properly calibrated portable survey instrument
	5	At same locations as used for collection of particulate samples	Gamma dose rate; quarterly	Quarterly	Pressurized ionization chamber or properly calibrated portable survey instrument
Surface soil	40	300-m intervals to a distance of 1500 m in each of eight directions from a point equidistance from mill and tailings pond sites	Grab; once prior to site construction	One time	All samples for Ra-226; 10% of samples for natural uranium, Th-230, and Pb-210
	6	300-m intervals in both a horizontal and vertical transverse across the milling area	Grab; once following site preparation	One time	All samples for Ra-226; one sample for natural uranium, Th-230, and Pb-210
	5	At same locations as used for collection of air particulate samples	Grab, once prior to site construction	One time	Natural uranium, Ra-226, Th-230, and Pb-210
Subsurface soil profile	5	750-m intervals in each of four directions from a point equidistance from the mill and tailings pond sites	Grab; once prior to site construction	One time	All samples for Ra-226, one set of samples for natural uranium, Th-230, and Pb-210
	1	At center of mill building area	Grab, once following site preparation	One time	Natural uranium, Ra-226, Th-230, and Pb-210
Sediment	2 (from each stream)	Upstream and downstream of waters that may receive surface water runoff from potentially contaminated areas or that could be affected by tailings impoundment failure	Grab, once following spring runoff and once in late summer following period of extended low flow	Two times	Natural uranium, Ra-226, Th-230, and Pb-210
Radon-222 flux	10	At center of mill site and at 750 and 1500 m in each of four directions from the site	Two- to three-day period; one sample during each of three months (normal weather)	Each sample	Rn-222 flux

[a]Nonradiological chemical parameters listed in Table 2.9.

Source: "Branch Position for Preoperational Radiological Environmental Monitoring Program for Uranium Mills," U.S. Nuclear Regulatory Commission, Memorandum from L. C. Rouse, Chief of Fuel Processing and Fabrication Branch, Jan. 9, 1978.

Table 6.2. Operational radiological environmental monitoring program

Type of sample	Sample collection			Sample measurement	
	Number	Location	Method and frequency	Test frequency	Type of measurement
Air					
Particulates	3[a]	At site boundaries and in different sectors having the highest predicted concentrations	Continuous; weekly or more frequently as required by dust loading	Quarterly composite	Natural uranium, Ra-226, Th-230, and Pb-210
	1	At nearest residence	Continuous; weekly or more frequently if required by loading	Quarterly composite	Natural uranium, Ra-226, Th-230, and Pb-210
	1	Control location—more than 15 km from mill site in least prevalent wind direction	Continuous; weekly or more frequently if required by dust loading	Quarterly composite	Natural uranium, Ra-226, Th-230, and Pb-210
Radon gas	5[a]	Same as for air particulates	Continuous; at least one week per month at approximately the same period each month, samples collected for 48-hr intervals	Each 48-hr sample	Rn-222
Particulates	1	Ore crusher stack	Isokinetic and representative[c] semiannual stack sample	Semiannual	Natural uranium, flow rate
				Semiannual for first year	Ra-226, Th-230, Pb-210
	1	Yellow cake dryer and packaging stack	Isokinetic and representative[c] monthly stack sample and either (1) semiannual stack sample or (2) semiannual product (yellow cake) sample	Quarterly	Natural uranium, flow rate
				Semiannual, 1 or 2	(1) Ra-226 and Th-230 or (2) natural uranium, Ra-226, and Th-230
				Semiannual for first year, 1 or 2	Pb-210
Water					
Groundwater	3[a]	Down gradient (hydrologically) and relatively close to the tailings impoundment	Grab; monthly (quarterly after first year)	Monthly; quarterly after first year	Dissolved natural uranium, Ra-226, Th-230, Pb-210, and Po-210; chemicals[d] and TDS[e]
	1	Control location—hydrologically up gradient (not influenced by tailings seepage)	Grab; quarterly	Quarterly	Dissolved natural uranium, Ra-226, Th-230, Pb-210, and Po-210; chemicals and TDS
	1 (from each well)	Each well used for drinking water or watering livestock or crops within 2 km of tailings pond or mine[b]	Grab; quarterly	Quarterly	Total natural uranium, Ra-226, Th-230, Pb-210, and Po-210; chemicals and TDS

Table 6.2 (continued)

Type of sample	Sample collection			Sample measurement	
	Number	Location	Method and frequency	Test frequency	Type of measurement
Surface water	2 (from each stream)	Surface waters passing through or close to the mill; one sample upstream and one downstream of location of potential influence	Grab; quarterly when flowing or following precipitation event	Quarterly when flowing or following precipitation event	Total natural uranium, Ra-226, Th-230, Pb-210, and Po-210; suspended solids
Direct radiation	5	Same as for air particulate samples	Pressurized ionization chamber, properly calibrated portable survey instrument or thermoluminescent dosimeters with two or more phosphors each	Quarterly	Measurement of x-ray and gamma-exposure rates
Soil	5	Same as for air particulate samples	Grab; annually	Annually	Natural uranium and Ra-226
Vegetation or forage	3	From animal grazing areas near mill site which have the highest predicted concentration (including nearest ranches)	Grab; three times during grazing season (i.e., April, July, and October)	Each sample	Ra-226 and Pb-210

[a]Program component from Regulatory Guide 4.14.

[b]If a large number of wells are located within 2 km, only those wells nearest tailings impoundment or the mine need be sampled.

[c]To be taken during operation of the stack ventilation system and the respective process system. Minimum sampling time, 3 hr per stack.

[d]Chemical parameters to be analyzed will be determined from an analysis of samples taken from the tailings pond once mill operations have begun.

[e]TDS = total dissolved solids.

REFERENCES FOR SECTION 6

1. Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif., Aug. 29, 1978.

2. State of Utah, Department of Natural Resources, Division of Oil, Gas, and Mining, *Oil and Gas Conservation Act: Mined Land Reclamation — Changes and Adoptions to the General Rules and Regulations*, adopted on March 22, 1978; effective June 1, 1978.

3. A. P. Plummer, *Restoring Big-Game Range in Utah*, Utah Division of Fish and Game, Publication No. 68-3, Salt Lake City, 1968.

7. UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

7.1 AIR QUALITY

An unavoidable impact of construction and operation of the mill facility will be a slight increase in particulate matter and ambient concentrations of gaseous emissions. Because the concentration of these pollutants must meet the Federal and State air quality standards, the staff feels that they will not contribute significantly to the decline of the regional air quality.

7.2 LAND USE

7.2.1 Land resources

7.2.1.1 Nonagricultural

Area land uses will change as a result of the population growth that would be induced by the proposed mill and any related mining activities. Possible adverse impacts are those that would result from increased traffic on the highways.

7.2.1.2 Agricultural

Construction and operation of the mill will result in an unavoidable loss of nearly 140 ha (350 acres) of potential grazing land. Following project termination, about 20% of this total area will be occupied by the reclaimed tailings impoundment and will be unavailable for grazing. The remaining land will be reclaimed to permit unrestricted use.

7.2.2 Historical and archaeological resources

The limited, known archaeological resources (lithic scatter) on the lands affected by the project can be avoided and/or salvaged. Therefore, if the mitigation proposed in Sect. 4.2.2 is followed, adverse impacts should be minimized.

7.3 WATER

7.3.1 Surface water

Erosion of disturbed soils during construction and operation would minimally impact the local streams and only during heavy, erosion-producing rainfall. No adverse impacts on surface water caused by groundwater transport of tailings materials are expected. Overall, no adverse impacts on surface waters are expected.

7.3.2 Groundwater

Operation of the proposed mill will result in the use of up to 2.9×10^5 m^3 (235 acre-ft) of water (drawn from the Navajo aquifer) per year. The usage of water by the applicant should have no adverse effect on other users. Preoperational and operational monitoring of the groundwater is required (Sect. 6.3.2), and mitigating measures will be taken if groundwater contamination due to seepage (from tailings to the Entrada aquifer) is observed. No adverse impact on groundwater is expected.

7.4 MINERAL RESOURCES

The mining and milling of primary uranium ore deposits will deplete the naturally occurring higher-grade ore bodies. However, if it becomes profitable to reprocess the mill tailings for any of the remaining minerals, this can be easily accomplished. Because there are no other known major mineral deposits of economic value in the mill area, no impacts on other mineral resources are expected.

7.5 SOILS

Construction and operation of the mill facility will disturb about 140 ha (350 acres). Topsoil will be removed from the construction areas and stockpiled for replacement upon termination of operations. However, a temporary decrease in natural soil productivity is probable (Sect. 4.5). Some soil will be unavoidably lost, primarily from wind erosion, but proper mitigating measures (Sect. 4.5) would minimize this impact. Reclamation laws require successful establishment of a soil medium that would be capable of sustaining vegetation without irrigation or continuing soil amendments (Sect. 3.3.2). Long-term impacts on the soil are not expected to be significant.

7.6 BIOTA

7.6.1 Terrestrial

The proposed project will result in a temporary unavoidable loss of about 140 ha (350 acres) of vegetation and a concomitant loss of wildlife (Sect. 4.6.1). Although some vegetation and wildlife loss would be unavoidable, such loss should not result in any long-term adverse impacts.

7.6.2 Aquatic

The impact on limited available aquatic habitat due to mill construction or operation is projected as insignificant (Sects. 4.6.2 and 7.3.1). No adverse impacts on aquatic biota are expected.

7.7 RADIOLOGICAL

Radioactive emissions from transportation, storage, and milling of the ore will increase the level of radioactivity in the surface environment. However, the size of the increase is small compared to the natural background level (Sect. 4.7).

7.8 SOCIOECONOMIC

The infusion of people into the local area will strain certain public services and the housing market, unless these areas are expanded rapidly. Both old and new residents will be affected.

The present consumer prices for goods and services in the area of the site will be stimulated by the project. A rising cost of living primarily affects original residents who have not increased their income at the same rate as energy-development workers.

The general inconvenience caused by expansion to meet the needs of the new residents — such as construction activities, temporary buildings, and decline in services — can rarely be avoided in large projects such as uranium mill construction. The staff expects that such inconveniences will affect many residents in and visitors to the area of the Shootering Canyon Uranium Project and, although these impacts cannot be avoided, they can be minimized through cooperative efforts by Plateau Resources, State governments, and local developers.

8. RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

8.1 THE ENVIRONMENT

8.1.1 Air quality

The short-term increases in suspended particulates during plant construction and the increases in suspended particulates and chemical emissions associated with mill operation are expected to have no impact on the long-term quality of the atmosphere in the region.

8.1.2 Land use

The majority of the land used for construction and operation of the mill facility could be returned to its present use through successful reclamation. The reclaimed tailings impoundment area, however, under present regulations may be unavailable for further productive use.

Although uranium milling is a short-term activity, a mill tailings disposal site will constitute a permanent disturbance of the land surface, rendering it unsuitable for future archaeological investigation. Therefore, any such investigation must be conducted during the initial surface disturbance.

8.1.3 Water use

No changes in the surface-water use patterns are expected to occur as a result of mill operation. Because of the precautions that will be taken to prevent seepage to the Entrada acquifer and because of the large size of the Navajo acquifer from which water will be drawn, no long-term effects on regional groundwater availability and quality are expected to occur.

8.1.4 Mineral resources

Although no mineral resources are known to exist on the site, the mining and milling of uranium ores does not preclude extracting minerals of future economic importance should they be unexpectedly discovered in association with uranium occurrences. The uranium mill tailings could be reworked if economics warrant.

8.1.5 Soils

State regulations require that the reclamation program be designed to return the soils to a condition of productivity consistent with their present use, that is, the production of forage and habitat for livestock and wildlife. The reclamation program will begin as soon as practicable and continue throughout the life of the project. About 30% of the disturbed area could be reclaimed following construction of the second stage of the impoundment dam. Therefore, these areas should be in their thirteenth year of reclaimed productivity by the time mill operations cease.

8.1.6 Biota

8.1.6.1 Terrestrial

Construction of the mill facility is expected to take 14 months. Based on the capacity of the tailings impoundment, the mill could operate 20 years. Assuming 25 years would be required to return the land to its existing climax communities, the majority of the disturbed areas would not be returned to their present productivity for nearly 50 years. About 30% of the total acreage disturbed could be reclaimed following construction of the second stage of the impoundment dam. Therefore, the length of time these areas would be disturbed would be somewhat less, approximately 35 years. Terrestrial vertebrates now inhabiting the project site will either perish or will escape to undisturbed areas surrounding the mill, where populations will be controlled by natural means. After reclamation, the more adaptable individuals and species will repopulate the area as favorable stages in the vegetative succession are reached.

8.1.6.2 Aquatic

The milling operation should not have any short- or long-term effects on aquatic biota.

8.1.7 Radiological

At the end of milling operations, the tailings will be overlain with sufficient natural cover material to meet radon and gamma release standards and then reclaimed. The reclaimed tailings area will constitute a source of radon emission of no more than twice the natural background flux.

8.2 SOCIETY

No significant long-term impacts on the socioeconomic character of existing and future local communities (e.g., Ticaboo) can presently be attributed with certainty to the project. The nature of such impacts will depend on the prevailing community conditions when operations of this mill cease:

1. If the local economy and population continues to grow when the operation terminates and project personnel migrate from the area, the additional housing and public facilities built to accommodate project-related personnel will help to accommodate needs of the expanding economy.
2. If, at project termination, the economic activity and populations of communities are declining and surpluses of facilities and housing exist, some of the resources initially invested to accommodate needs of the Shootering Canyon Uranium Project employees will not have been amortized. This situation could be aggravated if bonds used to finance public facilities directly attributable to this development have not been amortized during the operating (or other taxpaying) life of the project.

9. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

9.1 LAND AND MINERAL

9.1.1 Land

The land occupied by the reclaimed tailings impoundment may not be available for future productive use. This restriction is considered an irreversible commitment of resources.

9.1.2 Mineral

The extraction, processing, and eventual use of the uranium oxide produced by the mill are considered irreversible and irretrievable. Other than the uranium resource itself, several million gallons of fuel oil, and other fuels consumed in the mining and milling operations, no irreversible or irretrievable commitments of mineral resources are anticipated.

9.2 WATER AND AIR

9.2.1 Water

Groundwater and surface waters are not expected to be impacted by the proposed project. Because of the large volume of groundwater available, the use of this groundwater for the mill's water supply is not considered an irreversible or irretrievable commitment of this resource.

9.2.2 Air

Air is not depleted as a result of construction and operation of the mill facility, but there is a potential for the air quality to be impaired primarily as a result of an increase in total suspended particulate matter. However, because the atmosphere is self-cleaning of the pollutants at the anticipated low concentrations, no irreversible or irretrievable commitments of air resources are expected.

9.3 BIOTA

9.3.1 Terrestrial

A total of about 140 ha (350 acres) of soils and associated vegetation will be temporarily disturbed or lost for the life of the project. However, the land and wildlife habitat can be restored in time to acceptable levels as a result of approved reclamation efforts (Sect. 3.3.2). Although current regulations require the tailings impoundment area to remain fenced until it is released from its status as a restricted area, some wildlife will undoubtedly use this area after project termination and reclamation. Therefore, this restriction is not considered an irreversible commitment of resources.

9.3.2 Aquatic

The staff does not expect any irreversible or irretrievable commitment of aquatic biota or habitat from project operation.

9.4 MATERIALS

Chemicals and reagents required by the milling process will be consumed and therefore are considered irretrievable and irreversible commitments of these resources. Use of these materials, however, is considered a minor impact, because, in the volumes consumed, the materials are readily available.

10. ALTERNATIVES

10.1 ALTERNATIVE SITES

The following factors were among those considered in selecting and evaluating mill and tailings disposal sites:

1. accessibility, but with limited public exposure (population doses);
2. proximity to producing mines and known ore bodies for reducing haulage costs and decreasing the impacts associated with ore transport;
3. geotechnical, meteorological, and hydrological factors: (1) direction and intensity of prevailing winds, (2) presence of mineral resources, (3) subsurface structural stability, (4) availability of tailings impoundment construction materials, (5) adequate quantity and quality of materials available for reclaiming the tailings disposal area and other disturbed surface areas, and (6) suitable surface hydrology characteristics;
4. topographical factors such as surface suitability for construction of facilities with minimum alteration of terrain and the size of the drainage area above the tailings impoundment;
5. proximity to natural and man-made areas that could be adversely affected by the construction, operation, and reclamation activities related to the project;
6. existence of unique habitats that might support protected, threatened, or endangered species; and
7. availability of housing and other services to employees.

The staff has determined that the most important factors to be considered during the site selection process are those that ensure an acceptable tailings management program. The NRC tailings management performance objectives for siting and design are listed in Sect. 10.3.1.

10.1.1 Alternative mill and tailings disposal sites

Approximately 90% of the ore for the proposed mill will be supplied by company-owned mines located nearby in Shootering Canyon. Alternative sites for the mill would be optimally located with respect to the ore to be processed to minimize hauling distances, that is, transportation impacts. The applicant initially outlined an area in the region surrounding the Shootering Canyon mines in which a search was made for adequate alternative mill sites (Fig. 10.1). The region considered was bounded by the Glen Canyon National Recreational area to the south and southwest, the Capitol Reef National Park to the west, Lake Powell to the east, and rugged terrain to the north (except along Highway 276). The northern cutoff (up Highway 276) was chosen based on the economics of ore transport and the lack of land having a topography any more suitable than that included in the study area.[1]

The study area was further reduced to a 29-km (18-mile) strip along the west side of Highway 276 as shown in Fig. 10.1. The primary reasons for rejection of other portions of the initial study area are noted on Fig. 10.1. The reduced area was physically searched to determine where potentially satisfactory tailings disposal sites might be located, and the potential sites were screened.

The alternative of returning the mill wastes to the mines from which the ore was extracted, while attractive, was not considered to be feasible, primarily because the nearby mines would

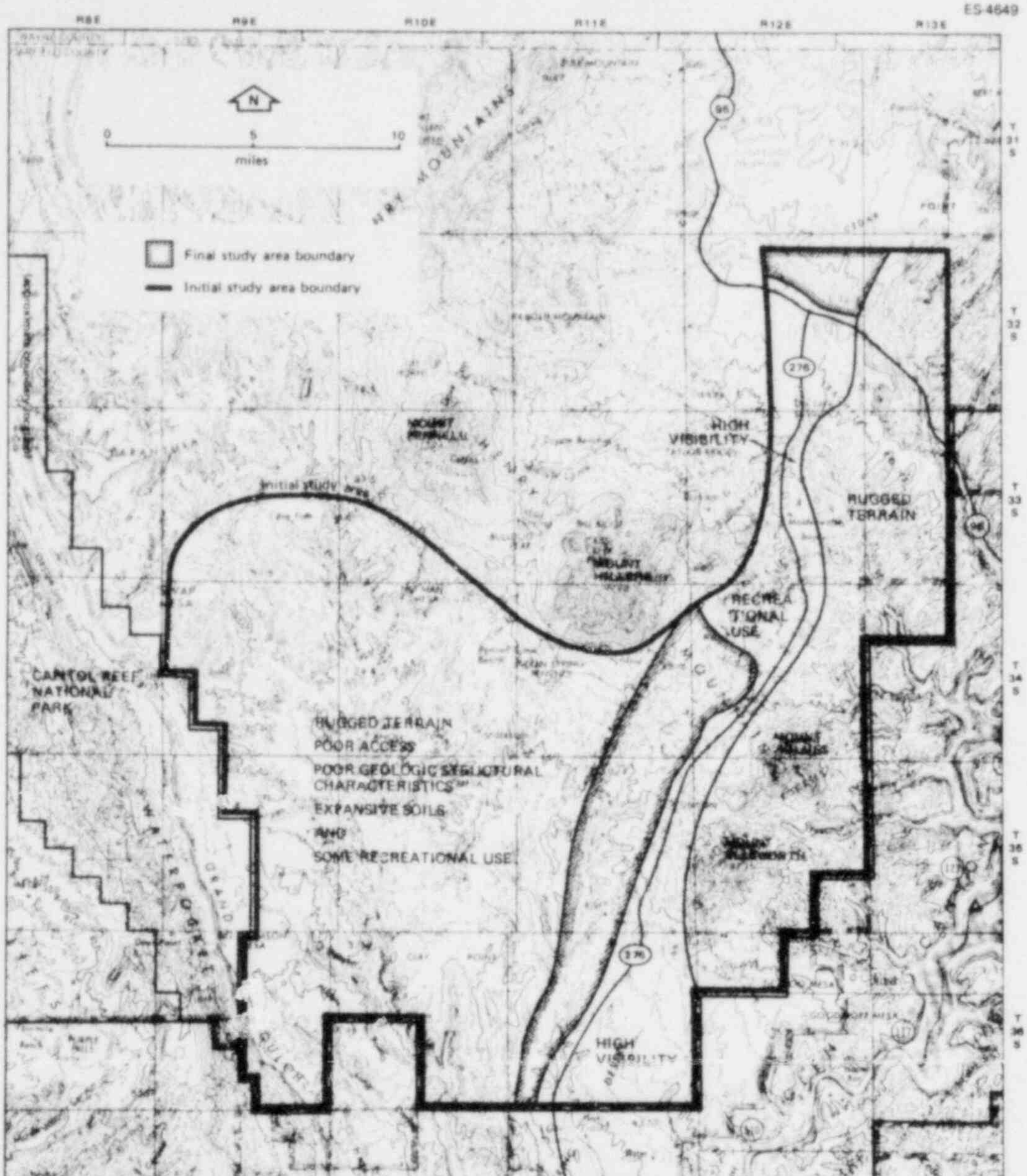


Fig. 10.1. Study area for the Shootering Canyon Uranium Project. Source: Plateau Resources, Ltd., *Preliminary Site Selection Study, Proposed Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., June 1977, Fig. 2.

not have available mined-out areas on a schedule compatible with tailings disposal requirements. In addition, this would make contiguous lower-grade ore bodies less accessible. [Disposal of the tailings in mined-out areas is discussed, in detail, in Sect. 10.3 (Alternative 4).]

After considering primarily transportation impacts, the staff has concluded that other potential alternative sites in this region of southeastern Utah would be no better than those located in the vicinity of the applicant's Shootering Canyon mines.

10.1.2 Alternative tailings disposal sites in the vicinity of the Shootering Canyon mines

The long-term integrity of a tailings impoundment requires a stable geologic environment with a competent foundation and retaining walls. Two formations in the area have the necessary strength, stability, continuity, thickness, and reasonably good engineering properties. These are the Entrada sandstone and the Summerville Formation. Other geologic horizons such as the Brushy Basin and Mancos shale are unsuitable for stable tailings disposal sites (Fig. 2.3).

Both the short- and long-term stability requirements for tailings disposal preclude siting in deep natural drainages that may, at times, carry large volumes of floodwaters. Even tributary drainages with catchment areas that may generate large runoff volumes must be excluded because diversion structures cannot be expected to remain in place over the long periods of time required for stable storage of tailings. These criteria were applied to the areas where the Entrada and Summerville formations outcropped, further reducing the area of potential sites.

The final step in the applicant's screening process was the identification of natural basin configurations that could be used for storage of the 5.0×10^6 MT (5.5×10^6 tons) of tailings wastes that would be created during 20 years of mill operation. The locations of 19 potential storage basins identified by the applicant are shown in Fig. 10.2. These locations were evaluated by the applicant, and all but five of the 19 sites were excluded from further evaluation for the reasons given in Table 10.1. The remaining sites (2, 4, 5, 9, and 10 on Fig. 10.2) were then qualitatively evaluated based on engineering and economic characteristics (Table 10.2). The applicant has proposed site 9 as the optimum tailings impoundment location. The staff visited several of the potential sites and independently reviewed information submitted by the applicant's consultants. Major emphasis was placed on site characteristics that would help to ensure the long-term stability of the reclaimed tailings impoundment.

10.1.3 Evaluation of alternative mill and tailings disposal sites

The staff has concluded that no net environmental advantages would accrue if the mill and tailings disposal facilities were to be located at sites other than the Shootering Canyon site proposed by the applicant; that is, the site proposed for the projected facilities is better, from an environmental standpoint, or at least as suitable as other potential locations. It must be emphasized that this conclusion is possible only because a similar conclusion can be made concerning the acceptability of the proposed tailings management system (Sect. 10.3.2, Alternative 1), which enhances the environmental suitability of the chosen site.

10.2 ALTERNATIVE MILL PROCESSES

10.2.1 Conventional uranium milling processes

The milling processes proposed by the applicant follow conventional procedures and conform with those commonly used by the domestic uranium milling industry. In general, yellow cake is produced by the milling of uranium ore via the following procedure: (1) ore preparation (involving primarily the crushing and grinding of the ore), (2) leaching, (3) separation of pregnant leach liquids from waste solids (tailings), (4) concentration and purification of the uranium by extraction from the pregnant leach solution, (5) precipitation of the uranium from the extract solution, and (6) drying and packaging. The specific manner in which each of these steps, singly or in combination, is accomplished varies from mill to mill, depending on differing ore characteristics. Normally, process decisions are based on overall economic considerations, including costs of controlling chemical and radiological effluents to air, water, and land.

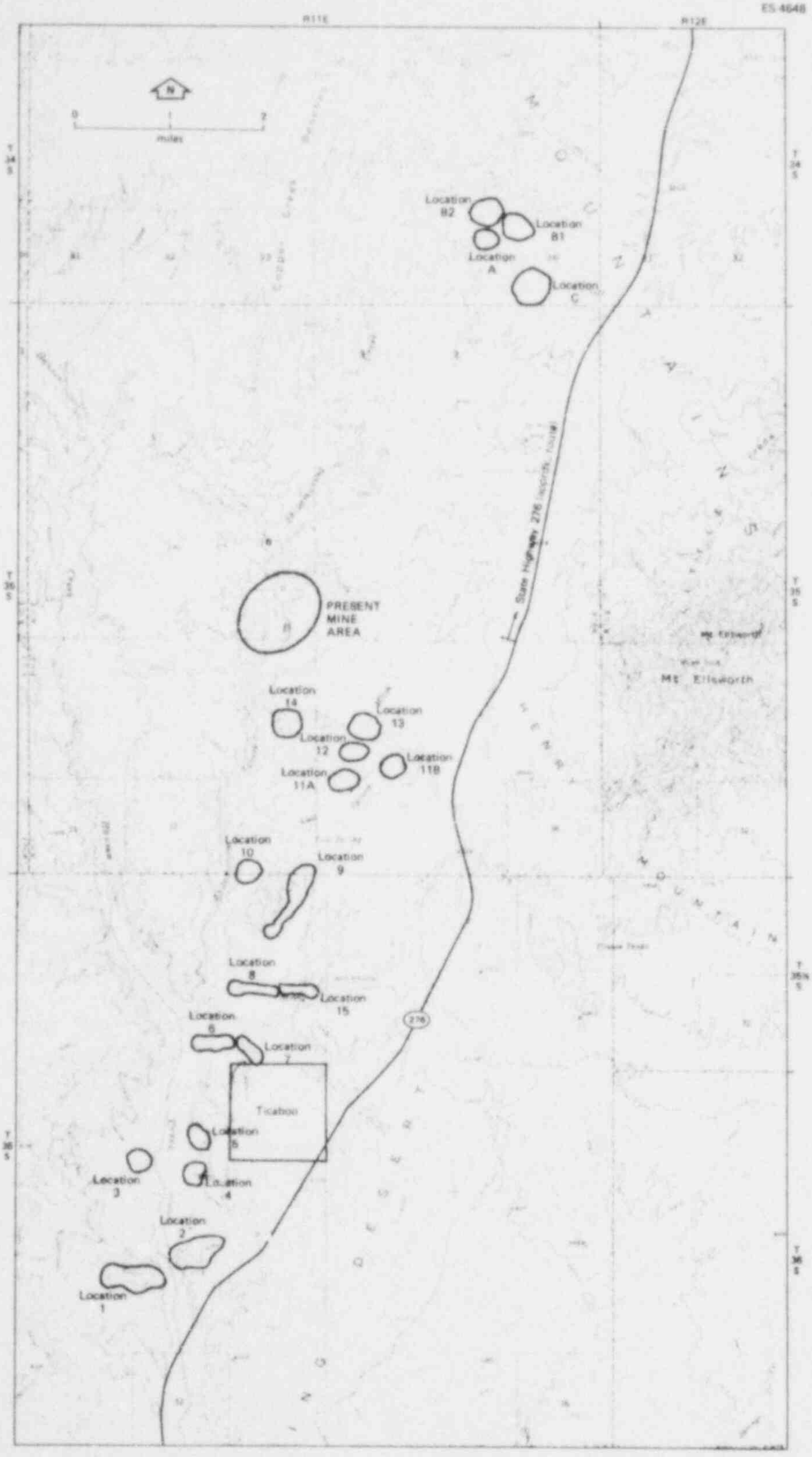


Fig. 10.2. Siting locations for the Shootering Canyon Uranium Project. Source: Plateau Resources, Ltd., *Preliminary Site Selection Study, Proposed Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., June 1977, Fig. 3.

Table 10.1. Summary of screening results for potential plant and tailings impoundment locations, Shootering Canyon Uranium Project

Location	Screening results
1	Screened out: long dam axis; relatively severe drainage control problems; aesthetic sensitivity
2	Acceptable
3	Screened out: area too small
4	Acceptable
5	Acceptable
6	Screened out: air quality problem for potential population center; need for special design
7	Screened out: air quality problem for potential population center; need for special design
8	Screened out: problem with upstream surface drainage control; severe erosion potential
9	Acceptable
10	Acceptable
11	Screened out: visible from highway; poor access; questionable volume
12	Screened out: visible from highway; poor access; erosion problem
13	Screened out: visible from highway; long dam axis; erosion problem
14	Screened out: severe flood protection requirements; poor topography; no convenient plant sites
15	Screened out: severe surface drainage problems; potential ecological impact
A	Screened out: erosion control problems; poor dam foundation and abutments
B	Screened out: erosion control problems; poor dam foundation and abutments
C	Screened out: many dams required; poor topographic enclosure
Junction of Hwys 276 and 95	Screened out: no reasonable location with acceptable access; high visibility; high flooding potential near highway

Table 10.2. Engineering and economic characteristics of potentially acceptable sites for the Shootering Canyon Uranium Project

Characteristic	Location				
	2	4	5	9	10
Number of dams required	1 or 2	At least 2	At least 2	1 or 2	Possibly 2
Access from mine to plant	7 miles; good	6.5 miles; good	6 miles; good	3.5 miles; needs improvement	3' miles; very good
Requirements for flood control protection	Minor	Significant	Significant	None	Significant
Access for building equipment	Very good	Good	Good	Good	Good
Gravity flow from plant to pond	Excellent	Adequate	Adequate	Adequate	Adequate
Length of slurry pipeline	Moderate	Moderate	Moderate	Moderate to long	Short
Foundation and abutment quality	Very good	Good	Good	Good	Good
Availability of building and reclamation materials	Good	Fair	Fair to adequate	Good	Fair to adequate
Tailings pond surface area	Moderate to large	Moderate	Moderate	Moderate to large	Moderate
Requirements for basin lining	Not likely	Not likely	Not likely	Not likely	Not likely
Control of surface drainage inflow	Minor	Minor	Minor	Minor	Minor
Flexibility of engineering design	Good	Fair	Fair	Good	Fair
Expansion capability	Yes	Yes	Yes	Yes	Yes

Crushing and grinding of ore are needed to reduce overall particle size to ensure efficient contact with the uranium-dissolving reagent. Normally, the ore is moved from stockpiles to the crusher by trucks, bulldozers, or by front-end loaders.[2] Conventional crushing equipment usually reduces the size of the ore particles to approximately minus 1.9 cm (0.75 in.). Control of the moisture level in the feed ore is crucial in the crushing process and generally should be less than 10% to prevent crusher malfunctions. In most mills the crushed ore is stored temporarily in bins before further processing. Grinding is usually accomplished by rod or ball mill, with the ore being ground to approximately 28 mesh for acid leaching and to approximately 200 mesh for alkaline leaching.[2] The Shootering Canyon mill will utilize a crushing system consisting of a stationary grizzly [7.6 cm (3 in.) openings], vibrating screen [1.9 cm (0.75 in.)], primary jaw crusher, and secondary crusher to reduce the ore particles to minus 1.9-cm (0.75-in.) mesh size, with approximately 680 MT (750 tons) of the crushed ore being transferred daily from fine-ore storage bins to the rod mill grinding circuit. The rod mill will utilize steel rods in a wet grinding process, operating at approximately 70% solids, to reduce the ore to sand-sized particles. The ore slurry will be gravity-fed to a sump and then pumped to the leaching circuit.

The leaching method chosen for extracting the uranium from the ground ore is heavily dependent on the chemical properties of the ore. Ores containing low levels of basic materials (primarily lime) are usually leached with sulfuric acid. An alkaline leach reagent (normally sodium carbonate-bicarbonate solution) is usually used when the lime content of the ore is high and uneconomical quantities of acid would be required, significantly increasing processing costs. In some processes, acid is added in "stages" to minimize excessive initial frothing and to monitor acid content (pH control). The applicant found the Shootering Canyon ores to be amenable to an acid leaching process and plans to use a two-stage, multiple-tank sulfuric acid agitation leaching system. The ore slurry from the grinding mill will be pumped to the first-stage leaching circuit to be mixed and agitated with a strong sulfuric acid leach solution. The slurry will then be transferred to a decant thickener, with the decant leach liquor (containing the dissolved uranium) from the thickener being conveyed to a solvent extraction circuit. The solids from the thickener will be transferred to the second-stage leaching circuit.

The separation of the pregnant leach solution from waste solids is usually accomplished by thickening or by filtration. The majority of the acid leaching mills in the United States use countercurrent decantation in thickeners for liquid-solid separation.[3] The applicant has also chosen to achieve liquid-solid separation by countercurrent decantation washing and thickening methods. (The belt filtration alternative is described in Sect. 10.2.2). The slurry from the second stage of the leaching circuit will be transported to a series of six thickeners. The waste solids (tailings), which will be transferred from thickener to thic[illegible] will be discharged from the sixth thickener (underflow slurry containing 55% water) to [illegible]ilings disposal area. The leached solids will be contacted countercurrently with barren [illegible]dic wash solution consisting primarily of recycled solvent extraction raffinate, and the resulting pregnant liquor from the thickener circuit will be collected and pumped to the first stage of the leaching system. A flocculating agent will be added to each thickener to increase separation efficiency, and the overflow liquid from a sedimentation thickener between the two leaching stages will be passed through a clarifier and sand filters to remove suspended solids. The filtered liquid will be fed to a solvent extraction circuit.

Concentration and purification of the uranium from the pregnant leach solution is necessary for the production of a high-grade uranium product. This process is usually performed by either a solvent extraction or an ion exchange process. The applicant has chosen a solvent extraction process in which the aqueous uranium-bearing solution is contacted with an organic solution into which the uranyl ions will transfer. The uranium-loaded organic solvent will then be transported to the stripping operation, where the uranium will be stripped from the solvent with an aqueous ammonium sulfate solution. Most of the depleted aqueous solution (raffinate) will be recycled to the countercurrent decantation circuit. The barren organic solution will be returned to the beginning of the solvent extraction circuit.

The milling process generally concludes with the recovery of the uranium from solution by chemical precipitation. When acid leach methods are utilized, the uranium is precipitated by neutralization with a base such as ammonia, lime, magnesia, or hydrogen peroxide.[3] The precipitate is then dewatered, dried, and packaged. At the Shootering Canyon mill, the uranium-rich solution from the stripping operation will be treated with ammonia to neutralize the solution, precipitating ammonium diuranate (yellow cake). The barren ammonium sulfate solution will be filtered and recycled to the stripping stage of the solvent extraction circuit. The precipitate will then be washed, dewatered, dried in a multiple-hearth furnace, crushed to minus 0.6 cm (0.25 in.), and packaged in shipping containers. The drying, crushing, and packaging operations will be isolated and enclosed in an area that is maintained at a negative air pressure to contain and collect (by bag filter and wet scrubbing) most of the airborne U_3O_8 particles.

10.2.2 Uranium milling processes that produce low-moisture tailings

There are several alternative uranium milling processes currently in use in other countries which produce low-moisture tailings that might be amenable to direct burial in unlined disposal retention areas, such as depleted open-pit mines or specially prepared pits. For example, a dewatering method developed by Burns and Roe/Pechiney/Ugine-Kuhlmann utilizes a belt filtration process instead of conventional vacuum drum filters or thickeners to separate the pregnant leach solution from waste solids. The liquid-solid separation method proposed by the applicant will produce tailings that will be approximately 55% water by weight; the rate of discharge will be approximately 680 MT (750 tons) of tailings and 832 MT (917 tons) of liquid per day. If the Pechiney milling technique, which uses a belt filter, were to be implemented, the "cake" would be washed countercurrently in two stages, with the barren tailings being dewatered to a moisture content of approximately 22%. The tailings can be neutralized before filtration or on the belt filter. The tailings would then be conveyed by belt or truck to the tailings disposal site. Because the tailings are essentially "dry," the area required for tailings storage might be reduced, and the problems associated with the control and monitoring of seepage from a disposal site might also be decreased. The possibility of using this type of belt filtration process is dependent on consistent physical characteristics in the ore processed, as this is the basis for the design of the filter.

The applicant considered the use of such a filtering system at the proposed mill but decided that it would be impractical. Because the ores will be leached with acid and a variety of ores will be processed, the applicant concluded that the leached solids produced would be difficult to filter without experiencing major equipment maintenance problems. The applicant has proposed instead to dewater the tailings by means of a pipe drainage system to be installed on the bottom of the impoundment. Although the staff is unconvinced that belt filtration is not feasible, the proposed alternate tailings dewatering procedure is considered acceptable. This dewatering method is discussed in detail, in Sects. 3.2, 4.3, and 10.3 (Alternative 1).

10.2.3 Evaluation of proposed milling process

The milling methods proposed by the applicant are conventional, state-of-the-art techniques utilized in the domestic uranium milling industry and are as environmentally sound as other commonly used processing combinations. Further unforeseen developments, such as increased processing costs due to changes in the characteristics of the ore or changes in the relative costs of reagents, may result in the applicant proposing changes in the mill circuit. When such changes are suggested, the environmental impacts associated with their implementation will be assessed.

10.3 ALTERNATIVE METHODS FOR TAILINGS MANAGEMENT

10.3.1 Introduction

For the purposes of this section, tailings management is defined as control of the tailings and waste solutions following removal of the uranium values. Engineering techniques to control pollutants from tailings, both during operational and postoperational stages of a milling project, have been proposed. The unique characteristics of each facility must be identified, and then appropriate environmental controls must be applied. In preparing this section, the staff has examined alternatives considered by the applicant,[4-8] as well as alternatives considered for other mills.[9-13] Alternatives presently available or feasible (i.e., potentially available with existing technology and at a reasonable cost) are described in Sect. 10.3.2 and evaluated in Sect. 10.3.3. A list of additional alternatives for tailings management that the staff has concluded are not feasible with existing technology is presented in Sect. 10.3.4.

The interim stabilization procedure described in Sect. 3.3.1 is applicable to all tailings management alternatives presented below.

Each alternative tailings management plan has been evaluated against the following set of performance objectives developed by the staff:

Siting and design

1. Locate the tailings isolation area remote from people so that population exposures will be reduced to the maximum extent reasonably achievable.

2. Locate the tailings isolation area so that disruption and dispersion by natural forces is eliminated or reduced to the maximum extent reasonably achievable.

3. Design the isolation area so that seepage of toxic materials into the groundwater system will be eliminated or reduced to the maximum extent reasonably achievable.

During operations

4. Eliminate the blowing of tailings to unrestricted areas during normal operating conditions.

Postreclamation

5. Reduce direct gamma radiation from the impoundment area to essentially background.
6. Reduce the radon emanation rate from the impoundment area to about twice the emanation rate in the surrounding environs.
7. Eliminate the need for an ongoing monitoring and maintenance program following successful reclamation.
8. Provide surety arrangements to ensure that sufficient funds are available to complete the full reclamation plan.

10.3.2 Feasible alternatives for tailings management

Alternative 1: Disposal of neutralized, dewatered tailings in a natural basin closed by an impoundment dam

This alternative involves the construction of a tailings impoundment in a natural basin approximately 0.4 km (0.25 mile) west of the proposed mill site (see Fig. 10.3). The impoundment would be constructed by building an engineered embankment across the open (southern) end of the basin (Fig. 10.4). The tailings disposal area would be sized to store 680 MT (750 tons) of tailings per day produced during 20 years of mill operation [3.2×10^6 m^3 (2600 acre-ft) or 5×10^6 MT (5.5×10^6 tons)] and would be constructed in two stages. The first-stage impoundment would be sized to contain the tailings produced by seven years of mill operation, would cover approximately 16 ha (39 acres), and would require an embankment 26 m (85 ft) high [crest elevation 1351 m (4433 ft)]. For the second phase, the dam crest elevation would be raised to 1361 m. [The final dam would be about 36 m (118 ft) high and would be approximately 460 m (1500 ft) long.] The second-stage impoundment would be 28 ha (68 acres) and would be capable of storing the additional tailings produced during the remaining years of the proposed operation. The initial (first-phase) and final (second-phase) retention dams, which must be constructed to meet the safety criteria in Regulatory Guide 3.11, would be zoned embankments. To minimize erosion, the upstream and downstream zones or "shells" would be constructed of 2:1 sloped segments of pediment boulders, cobbles, gravel, and sand; the sloping core of the dam would be a compacted mixture of local clay, silt, and sand; the transition zones between the core and the outer segments or "shells" would be constructed of locally obtained fine sand (Fig. 10.5). To minimize seepage under the tailings embankment, the core of the dam would be tied to the compacted soil liner on the bottom of the impoundment. Minimum embankment freeboard allowances of 4 m (13 ft) and 3.4 m (11 ft) would be maintained, respectively, for the stage-one and stage-two impoundments to ensure that the impoundment would be capable of containing the surface runoff resulting from a design flood (probable maximum flood series preceded or followed by a 100-year flood), with wind, waves, and runup. In addition, the applicant has proposed construction of emergency spillways (for each dam stage and for final reclamation) to allow passage of storm runoff exceeding the design flood. (A 50-year, 30-min storm was assumed to immediately follow the design flood.)

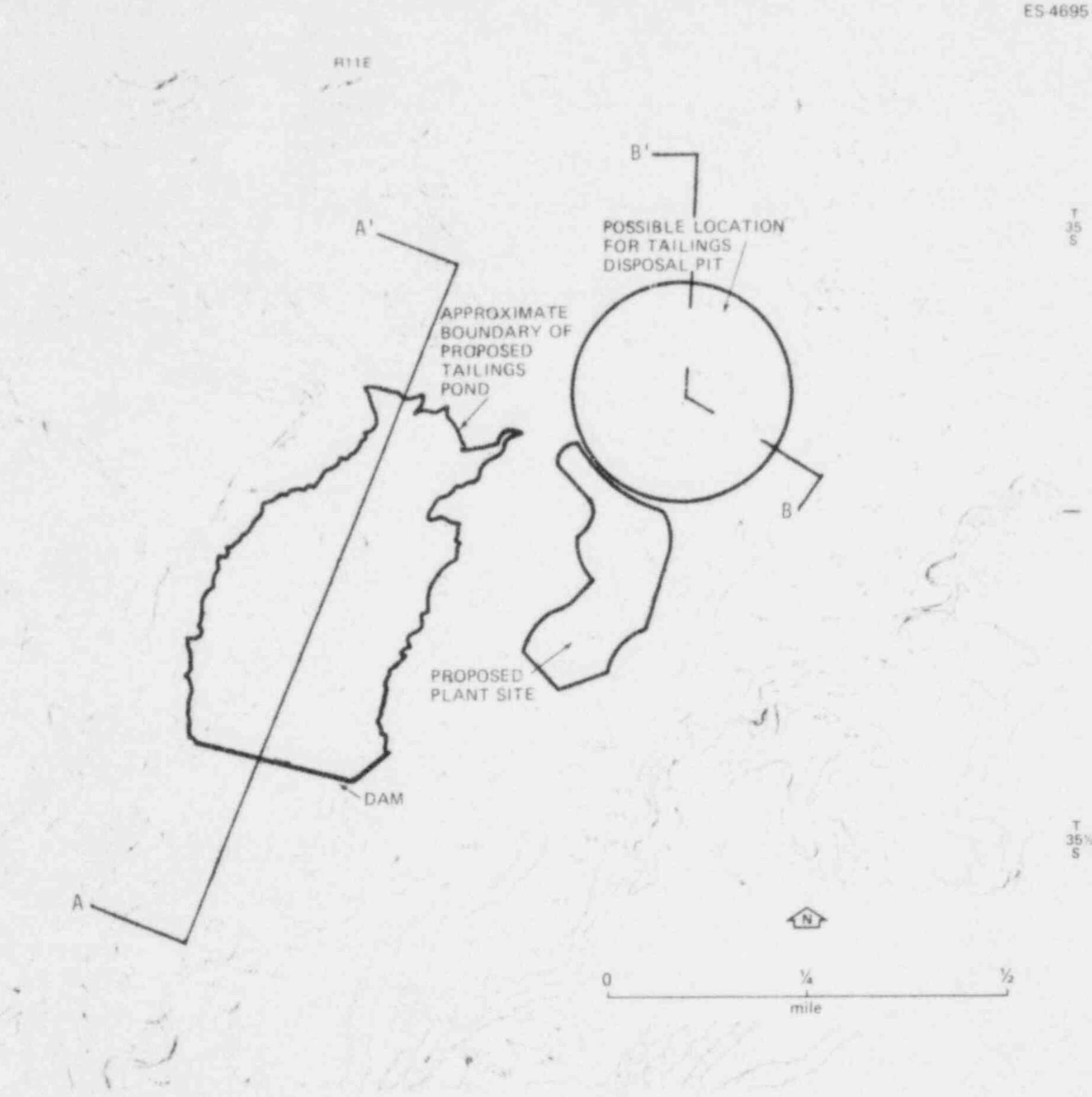


Fig. 10.3. Locations of impoundment pond and pit disposal alternatives for the Shootering Canyon Uranium Project. See also Fig. 10.4. Source: Adapted from Plateau Resources, Ltd., *Evaluation of Tailings Disposal Alternatives, Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., Rev. December 1978, Fig. 2.

To minimize seepage and the potential impacts of seepage of tailings liquids from the tailings impoundment, the applicant has proposed to line the floor of the tailings storage area with a layer of from 0.6 m (2 ft) to about 3 m (10 ft) of compacted, locally obtained, silty clay and to construct and operate tailings drainage and neutralization systems. The liner and neutralization and drainage systems are described in Sect. 3.2.4.7.

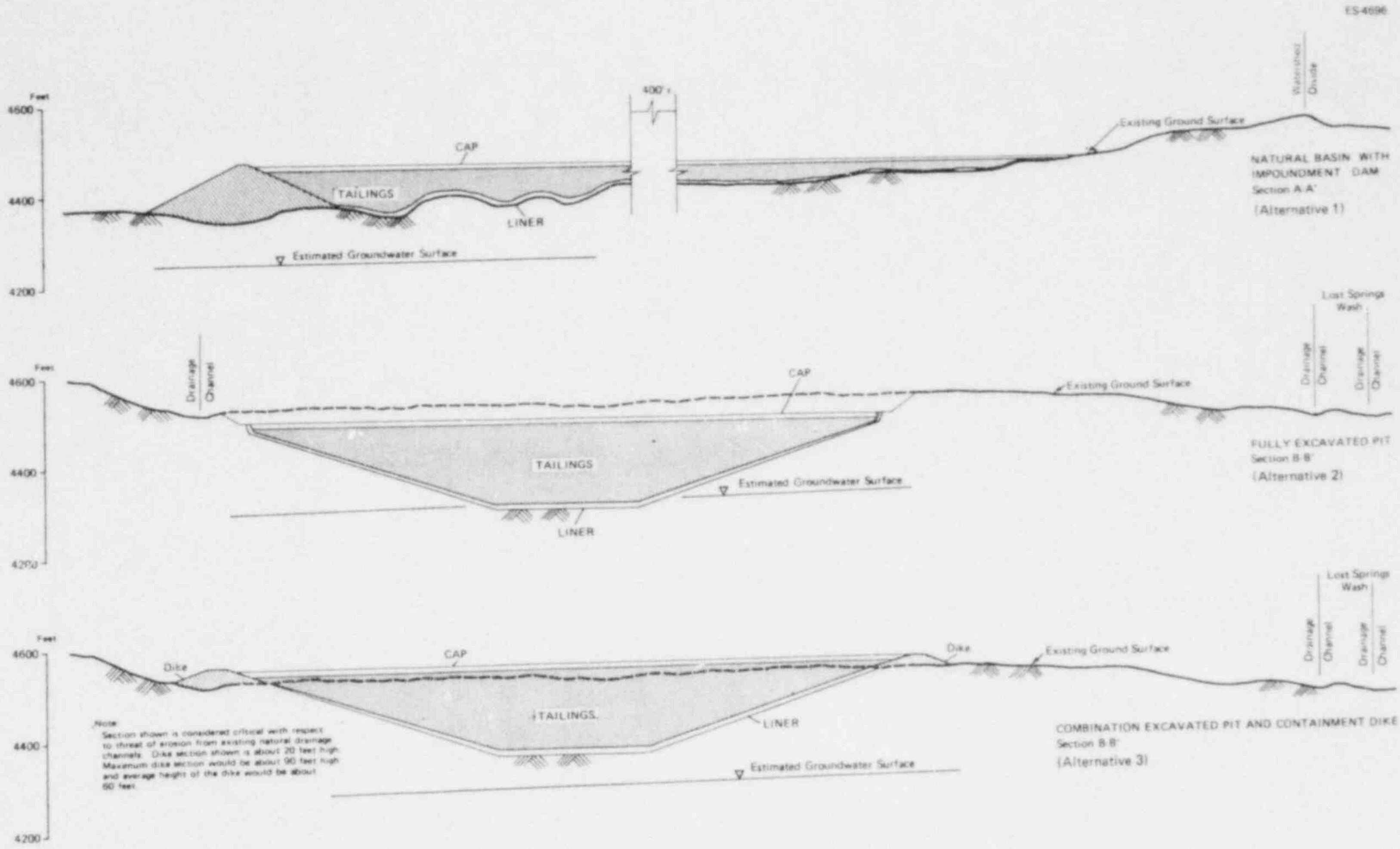
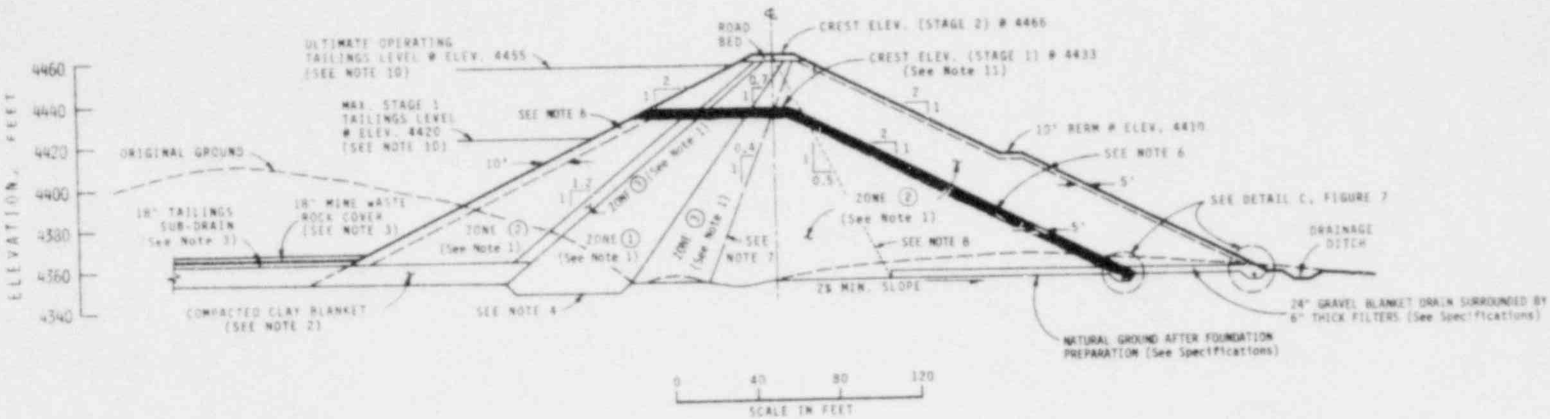


Fig. 10.4. Representative sections through alternative tailings disposal facilities. See also Fig. 10.3. Source: Adapted from Plateau Resources, Ltd., *Evaluation of Tailings Disposal Alternatives, Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., Rev. December 1978, Fig. 3.1.

ES-4651



NOTES:

1. ZONE (1) - SILTY SANDY CLAYEY SOIL (SEE SPECIFICATIONS).
   ZONE (2) - BOULDERS, COBBLES, GRAVELS, SAND. THE MATERIAL OF THIS ZONE TO BE PLACED SO THAT THE FINER PORTION WILL BE ADJACENT TO ZONE (3) AND THE COARSER PORTION WILL BE AT THE OUTSIDE SLOPE SURFACES. (SEE SPECIFICATIONS).
   ZONE (3) - SELECTED FINE SAND (SEE SPECIFICATIONS).
2. THICKNESS OF COMPACTED CLAYEY SOIL BLANKET TO BE 10% OF DISTANCE FROM FINAL GROUND SURFACE TO MAXIMUM DESIGN WATER SURFACE, BUT NOT LESS THAN 2 FEET. (SEE SPECIFICATIONS)
3. PROVIDE 18 INCHES EACH OF TRAFFIC COMPACTED MINE WASTE ROCK AND TAILINGS SUB-DRAIN MATERIAL (SEE SPECIFICATIONS).
4. EXTEND ZONE (1) TO SOUND BEDROCK AS DIRECTED BY GEOTECHNICAL ENGINEER. PROVIDE SLUSH GROUT ON FOUNDATION CONTACT FOR ZONE (1) AS DIRECTED BY GEOTECHNICAL ENGINEER. (SEE SPECIFICATIONS).
6. ZONE OF UPSTREAM AND DOWNSTREAM SLOPE PROTECTION TO CONSIST OF PEDIMENT MATERIAL OF WHICH 50% IS COARSER THAN 12 INCHES (SEE SPECIFICATIONS).
7. DOWNSTREAM BOUNDARY OF ZONE (3) SHOWN IS MINIMUM REQUIREMENT.
8. EXTEND BLANKET DRAIN AND FILTERS FROM TOE TO LINE SHOWN, BUT NOT ABOVE ELEVATION 4445.
10. A MAXIMUM OF 2 FEET OF LIQUID IS TO BE MAINTAINED ON TOP OF TAILINGS.
11. REMOVE PEDIMENT MATERIAL (ROAD BED) OVERLYING ZONES (1) AND (3) PRIOR TO RAISING EMBANKMENT TO ULTIMATE LEVEL.

Fig. 10.5. Proposed design of the tailings dam for the Shootering Canyon Uranium Project. Source: Adapted from Plateau Resources, Ltd., *Tailings Management Plan and Geotechnical Engineering Studies, Shootering Canyon Uranium Project*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., September 1978, Fig. 6.

If the drainage system operates as planned during the first phase (first seven years), the applicant would extend it to the remainder of the disposal area as part of the second phase of the operation. The major advantages of the drainage system would be a reduction in potential seepage losses (due to decreasing the hydraulic head above the impoundment liner), a reduction of project water requirements (equivalent to the amount of tailings liquids recycled to the mill and used to control dusting), and a lower and more uniform moisture content (which should shorten the drying-out period prior to reclaiming the impoundment area).

The major benefit to be derived from neutralization is a substantial reduction in the dissolved solids contained in the tailings solutions. About 90% of the radium, most of the thorium, and much of the copper, cobalt, aluminum, iron, molybdenum, and vanadium would be precipitated from solution, as would sulfate in the form of gypsum.[14] Should residual contaminants preclude recycle of a significant portion of neutralized solution to the process, the reduction in tailings acidity would at least render toxic materials in the wastes less susceptible to leaching and should increase evaporation from the liquids. If percolation of the tailings liquid through the waste rock fails to provide adequate neutralization, the applicant is committed to proposing and instituting procedures to ensure that adequate neutralization occurs. For example, crushed mine waste rock could be added to the tailings slurry as it leaves the plant and prior to deposition in the tailings impoundment, or additional waste rock could be placed on the bottom of the impoundment.

Reclamation would commence after cessation of milling operations as soon as the tailings area had dried sufficiently to allow movement of equipment over the pile. The proposed reclamation program calls for a 1.8-m (6.0-ft) layer of compacted clayey materials borrowed from an area near the site and a 0.6-m (2.0-ft) layer of sandy soil material over the tailings area.[8] Staff calculations show the proposed cover should be sufficient to reduce the radon flux from the reclaimed area to less than twice background (see Appendix F) and the gamma radiation to background levels (see Appendix G). A 0.3-m (1.0-ft) layer of coarse gravel and rock will be placed over the cap for protection against erosion. The cap will be designed to resist damage by differential settlement of the tailings.

The reclaimed impoundment is designed to mitigate the effects of erosion. The coarse rock and boulders covering the surfaces of the tailings area and the downstream face of the impoundment dam will resist gullying and water sheet erosion. Sediment-laden runoff from the 89-ha (220-acre) drainage basin above the dam will pond over the tailings cap. Ponded water would be dispersed by the evaporation because the underlying cap would have a low permeability and the remaining sediments carried into the impoundment would add to the thickness of the cap. This process would lead to conditions conductive to natural establishment of a vegetative cover.

Because the cap would be thick [2.75 m (9 ft)] and topped with riprap and because of the aridity of the region, the staff has concluded that root penetration into the tailings is not likely, reducing the possibility of adverse impacts associated with the upward migration of radionuclides and toxic elements through plant root systems. The periodic collection of runoff over the impoundment will prevent dessication of the clay cap and therefore limit the development of shrinkage cracks. The rapid evaporation of collected runoff and the small hydraulic head over the cap should eliminate the infiltration of water through the tailings.

With the materials and thicknesses of the liner and cover proposed by the applicant, the total estimated capital cost of Alternative 1 is about $11.1 million. This figure does not include capital and operating costs of the drainage and neutralization systems, but these costs are minor with respect to the cost of the basic alternative. (They have similarly been excluded from the costs of Alternatives 2 and 3.)

The major benefits that would accrue with implementation of this tailings disposal alternative are the following:

1. The tailings would be stored in a basin below the normal surface contours of the area. The tailings and cover would be below grade, and the cover would be topped with a layer of riprap that should provide a high degree of protection from erosion.
2. The impoundment liner in combination with the tailings drainage and neutralization systems should ensure that potential for problems with seepage are minimized. Also minimized should be project water requirements and the length of time between the cessation of operations and the start of tailings impoundment reclamation.

Alternative 2: Below-grade disposal of neutralized tailings in a specially excavated pit

This alternative involves the excavation of a pit immediately north of the proposed mill site of sufficient size and depth to place below grade a volume of tailings equivalent to that considered in Alternative 1 and the tailings cover (Fig. 10.3). The applicant proposed and evaluated a 14.5-ha (35.3-acre), 427-m-diam (1400-ft-diam), circular pit with a maximum depth of 61 m (200 ft) (see Figs. 10.4 and 10.6). The sides of the pit would have a slope of 3:1, horizontal to vertical, the maximum slope amenable to the placement of a liner. To minimize seepage from the disposal area, the impoundment would be lined with compacted silty clay having the same permeability as the material proposed for Alternative 1. The liner would have a minimum thickness of 0.9 m (3 ft) near the upper edge of the pit, increasing to 10% of the final hydraulic head in the deeper portions of the pit. The tailings drainage and neutralization concepts proposed for Alternative 1 would also be utilized. After completion of fill operations and as the tailings reach sufficient dryness to allow the movement of equipment over the pile, the tailings would be covered with layers of compacted soil, gravel, and coarse rock in the same configuration as proposed for Alternative 1 [1.8 m (6 ft) of compacted silty clay, 0.6 m (2 ft) of sand and local soils, and 0.3 m (1 ft) of gravel and coarse rock]. Therefore, the radon gas and gamma attenuation estimates would be the same as for Alternative 1.

Because (1) the drainage area above the pit would be small [less than 40 ha (100 acres)] and (2) a large water storage volume would be available until the final years of the project, flood protection requirements from this alternative would be minimized.

The floor of a pit 61 m (200 ft) deep at the proposed location would be either below or slightly above the elevation of the natural groundwater table [estimated to be approximately 1311 m (4300 ft)]. If the groundwater table were to be penetrated during pit construction, dewatering would be necessary to allow for placement of the compacted soil liner, drainage system, and mine waste rock. By increasing the diameter, a shallower pit could be constructed with sufficient storage capacity; however, such expansion at the proposed site would require excavation in Lost Spring Wash to the north and in the unnamed wash to the south of the proposed pit site. The estimated capital cost for this alternative is $31.4 million.

Alternative 3: Combination excavated pit and containment dike

This alternative is similar to Alternative 2, except that the pit would be shallower and the materials excavated from the pit would be used to construct an above-grade engineered embankment around the pit to enclose a partially above-grade impoundment (A portion of the tailings and the tailings cap would protrude above the natural surface contours.) (see Figs. 10.4 and 10.7). The pit would be constructed at the same location as proposed for Alternative 2 (north of the mill site, see Fig. 10.3). The excavated area would be about 42.7 m (140 ft) deep. The pit bottom elevation would be at about 1338 m (4390 ft), and the containment dike height would vary from approximately 611 m (20 ft) to 27.4 m (90 ft). [The average embankment height would be 18.3 m (60 ft), and the dike crest would be at elevation 1400 m (4590 ft).] The external face of the embankment would be covered with gravel and coarse rock to control water and wind erosion. The slope of the walls and the liner thicknesses and materials would be the same as for Alternative 2, and the capping materials and thicknesses and neutralization and drainage systems proposed for Alternatives 1 and 2 would be utilized. Flood protection would be provided by the embankment, which limits the "drainage" area to the area enclosed by the dike [approximately 14 ha (35 acres)]. However, flooding of the unnamed wash to the southeast of the impoundment could erode the toe of the embankment at that location. The capital cost of this alternative is estimated to be $27.9 million.

Alternative 4: Burial of tailings in depleted mines

In this alternative the tailings slurry would be transported by a 6.4-km (4-mile) pipeline from the mill site to the mines. The pipeline would follow the general course of the ore haul roads. The slurry would be deposited in worked-out areas in the mines, and specially constructed barriers or bulkheads would isolate the disposal areas from active portions of the mines. The excess tailings fluids would seep into the sandstone walls and floors of the disposal areas. The potential for groundwater contamination by infiltration of tailings liquid would be minimal because of the presence of the relatively impermeable Summerville Formation between the sandstone member containing the mines and the Entrada sandstone aquifer and because of the distance

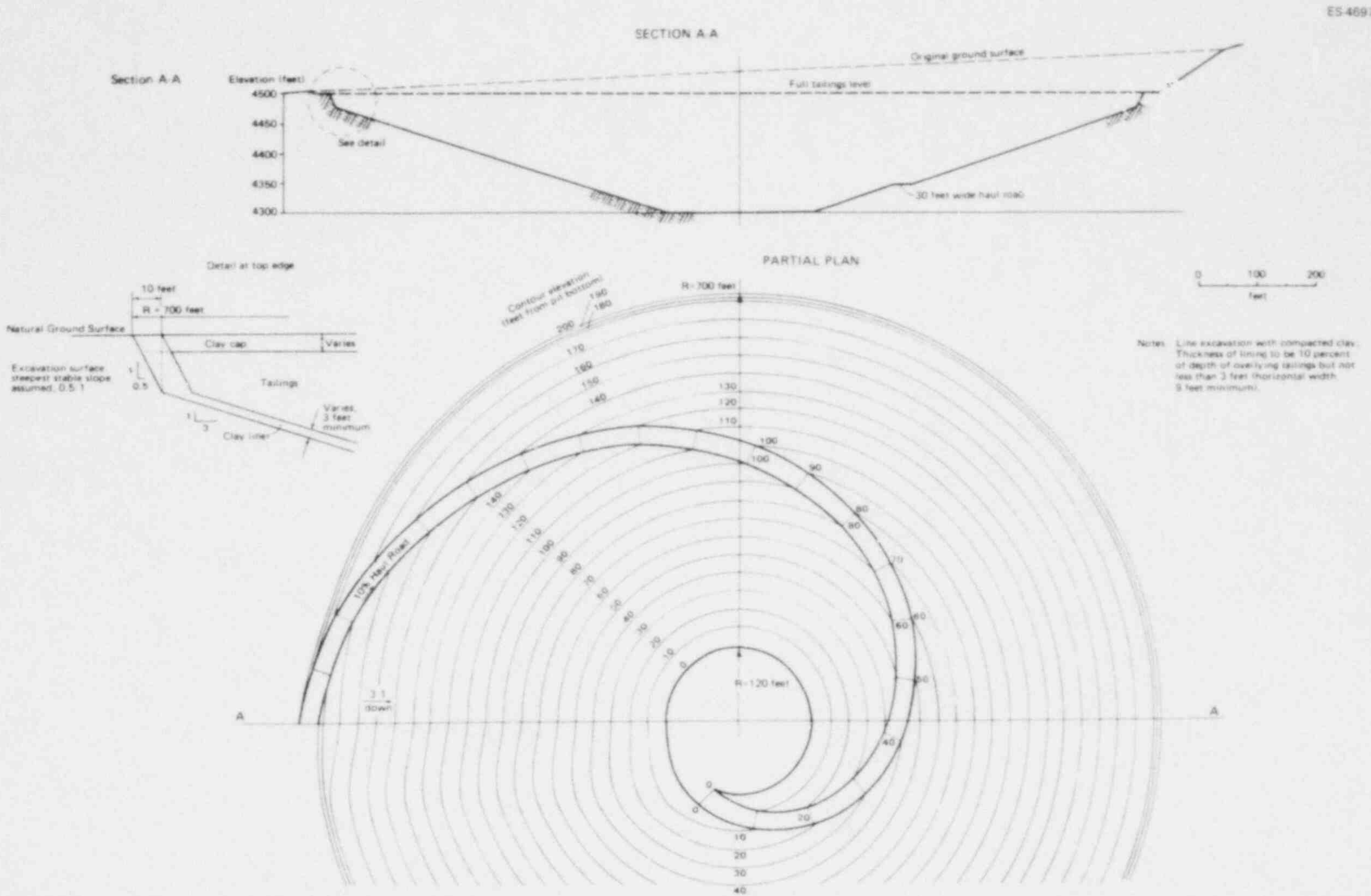


Fig. 10.6. Shootering Canyon Uranium Project tailings disposal study; disposal in excavated pit. Source: Plateau Resources, Ltd., *Tailings Management Plan, Proposed Ore Processing Facility, Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., Rev. June 1978, Fig. 3.

ES-4698

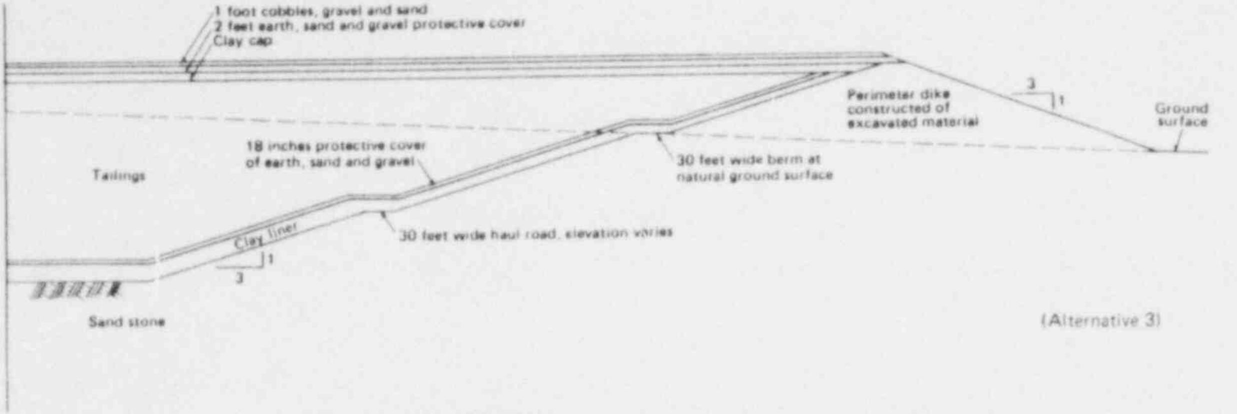


Fig. 10.7. Tailings containment structure for the Shootering Canyon Uranium Project: combined excavated pit and dike. Source: Plateau Resources, Ltd., *Tailings Management Plan, Proposed Ore Processing Facility, Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., Rev. June 1978, Fig. 4.

between the mines and the water table [72 m (250 ft)]. The carbonate constituents of the surrounding sandstone would neutralize the acidic effluent within a few feet of the disposal areas, causing the precipitation of most of the radionuclides and toxic materials from the solution.

The placement of tailings within the worked-out portions of the mines would minimize losses of tailings solids to wind and water erosion. The erosion resistance of mine areas would equal that of the natural formations in the area. Radon from the disposal area could represent a hazard to mine personnel if not adequately controlled but would not significantly increase the operational radon releases to the environment. If the mine openings and exploration drill holes are properly sealed at the close of operations, the long-term radon and gamma radiation releases should be of the same magnitude as the natural background levels prior to mining.

Operational difficulty could be encountered in the implementation of this alternative. The decision to stop mining a stope is basically an economic one, made when the ore grade drops below the point where the uranium values recovered do not cover the cost of extraction. However, as market conditions change, the extraction of such lower-grade deposits could become economically viable, particularly because there would be no additional access development costs. Historically, mines in Shootering Canyon have experienced intermittent operation due to such market conditions. The applicant has identified large areas of low-grade reserves contiguous to the planned mining areas that could not, at present, be extracted economically. Commitment of mined-out areas to tailings disposal would restrict or eliminate the potential for future recovery of these neighboring lower-grade deposits.

The costs of implementing this alternative were not estimated by the applicant.

Alternative 5: Solidification of tailings utilizing cement, asphalt, or other chemical fixants

For this option, mill tailings would be fixed with cement, asphalt, or other chemicals to form a solid, less-leachable product for disposal. The solidified tailings could then be stored in an impoundment. The disposal area, which would be reclaimed by covering the material with layers of overburden and topsoil, would be revegetated to minimize water and wind erosion.

Portland cement could be utilized to fix either the entire tailings solids (slimes, sands, and precipitates) or the slimes only. In either case, the tailings would be neutralized (probably by the addition of lime), and the waste slurry would be dewatered to a minimum of 60% solids before being mixed with the cement. A minimum of 1 part cement to 20 parts tailings would be required for solidification; strength, leaching resistance, and cost will increase as the ratio of cement to tailings increases (ref. 14, p. 43). The 1:20 cement to tailings mixture could be pumped, if necessary, by slurry pipeline to a disposal site.

Neutralized, dewatered (dried) slimes and waste solutions could be fixed with asphalt, and the final product would contain approximately 60% slime solids (ref. 14, p. 42). When first mixed, the product would be fluid and could be transported by pipeline to a disposal site. The major advantages of solidifying tailings in asphalt are (1) leaching resistance is high and (2) because asphalt is an effective radon diffusion barrier, radon exhalation is substantially reduced.

Commercially available chemical fixants could also be used to solidify the tailings. If this waste stabilization method were to be implemented, the chemicals would be blended into the tailings slurry and the resulting mixture pumped to an impoundment where solidification would occur within a few days to a few weeks. Either the waste material would be entirely entrapped or the pollutants (primarily heavy metals) would be chemically bound as insoluble complexes.

Although technologically feasible and environmentally desirable, solidification of tailings is expensive. Assuming a nominal cost of $10.00 per ton of tailings (commonly quoted costs range from $7.00 to $36.00 per ton of treated wastes), the staff estimates that chemically fixing the tailings produced by the mill operation would cost approximately $55 million; the costs of asphalt or cement fixation would range from about $45 million to $60 million.

10.3.3 Evaluation of alternatives

Alternative 1 is the preferred alternative of the applicant and the staff. The tailings and cover would be stored in a natural basin and reclaimed within the natural contours of the surrounding area. The riprap covering and depositional environment in which the impoundment would be located give additional assurance that wind and water erosion will be minimized. In addition, the small drainage area above the reclaimed tailings area obviates concerns over dispersion of cover from flooding, which in other cases could be a severe problem over the long term. The proposed cover meets the performance objectives for reduction of radon exhalation and gamma radiation and should eliminate the need for an ongoing monitoring and maintenance program. The liner and tailings drainage and neutralization systems should essentially eliminate potential problems with seepage.

Storing the tailings below grade (Alternative 2) in a specially dug pit would provide greater protection against long-term wind and water erosion of the reclaimed tailings than Alternative 1. In addition, the proposed cover (same as for Alternative 1) would meet the radon exhalation and gamma radiation criteria. However, the floor of the required pit would be at or below the water table level at this location, and failure of the liner could result in liquid wastes reaching the water table. The topography of the site is not amenable to the construction of a wider and shallower pit, which would provide better groundwater protection. Additionally, because significant amounts of bedrock would have to be excavated by blasting, the permeability of the sandstone material underlying the pit would probably be substantially increased. The benefits that this alternative might have over Alternative 1 do not justify the additional costs.

Alternative 3 involves the storage of dewatered, neutralized tailings in a specially dug pit enclosed by an engineered embankment constructed of the excavated materials. The major drawbacks associated with this alternative are the length of the embankment required to surround the impoundment [approximately 1341 m (4400 ft)] and, because a portion of the dike would lie in an unnamed wash southeast of the proposed site, the dam stability could be compromised over the long term. Although this alternative offers an advantage over Alternative 2 (decreased potential for groundwater contamination), the increased potential for adverse, long-term environmental impacts overshadow this advantage. Compared to Alternative 1, no significant environmental benefits would accrue, and the costs of tailings disposal would be significantly increased.

Alternative 4 (disposal in depleted mine areas) has the apparent advantage that as long as the sandstone formations containing the mines remain intact, the possibility of significant dispersal of toxic effluents into the atmosphere and/or into the groundwater system would be remote. The major disadvantage of this alternative is that the commitment of mined-out areas to tailings disposal would limit future access to contiguous, lower-grade ore deposits.

Although solidification (Alternative 5) offers some environmental advantages (elimination of windblown dusts and high resistivity to leaching and to the diffusion of radon), the technology is not well established, and at present, the costs far outweigh the benefits that might accrue.

For all of the alternatives considered, the applicant would be required to implement an interim stabilization program to minimize the blowing of tailings to the maximum extent reasonably achievable.

Based on the above discussion and evaluation of alternatives, the staff believes that the tailings management plan described under Alternative 1 is the best plan for the Shootering Canyon site when considered in terms of both the staff's performance objectives (Sect. 10.3.1) and economic factors. This alternative represents the most environmentally sound, reliable, and reasonable method of tailings management for the proposed Shootering Canyon site using existing commercial technology. It should be noted that the choice of the preferred alternative is based on present standards and existing technologies. However, if the Generic Environmental Impact Statement on Uranium Milling currently being prepared by the NRC shows that modification of the chosen alternative is necessary, the plan will be changed accordingly.

10.3.4 Alternatives considered and rejected

Table 10.3 lists some of the additional alternatives considered and rejected.

Table 10.3. Alternatives considered and rejected

Alternative	Reason for rejection
Install drains below pond to collect and discharge tailings liquid to a local waterway	Technology is not available to allow seepage water treatment sufficient to attain water that is environmentally and legally acceptable for release
Covering of the tailings with a synthetic or PVC plastic to reduce radon emanation	Additional overburden and topsoil would be required to reduce gamma radiation to the natural background level, to prevent plant root penetration into the tailings, and to minimize erosion problems. The cost of the cap would be excessive, compared to cost of the soil the liner would replace. The integrity of the liner could not be guaranteed over the long term due to the effects of freezing and thawing cycles, settlement of the tailings, and possible chemical attack by the tailings
Transport of tailings to currently active tailings impoundment	The environmental hazards and the costs of mitigating the adverse impacts associated with tailings disposal would only be shifted from the Shootering Canyon area to another location. The closest active disposal areas are located in Moab and LaSal. Neither impoundment is capable of holding the design output of the proposed mill. Additionally, transport of tailings would incur risks of accidents, dispersal of tailings, and exposure to workers and others along the transport route
Segregate (chemically) the toxic components of the tailings and dispose of these small quantities as low-level waste. Treat "clean" tailings as overburden	Technology is not sufficiently developed to implement this alternative

10.4 ALTERNATIVE OF USING AN EXISTING MILL

The option of utilizing existing ore processing mills requires the evaluation of numerous factors, including (1) the method and distance of mine-to-mill transport, (2) variations in ore grade, (3) quality of haul roads, (4) total tonnage to be transported, (5) haulage schedules, (6) traffic and weather conditions, (7) possible interim transfer and storage costs, (8) handling and milling costs, and (9) environmental costs and benefits.

The closest currently operating uranium ore processing facilities (in relationship to the Shootering Canyon ore bodies) are located in Moab, Utah (Atlas Minerals' Moab Mill) and LaSal, Utah (Rio Algom's Humeca Mill). The Moab mill is approximately 262 highway kilometers (164 miles) from the Shootering Canyon ore bodies and approximately 131 km (82 miles) from the applicant's Blanding ore buying station. The Humeca mill is, in highway distance, about 317 km (198 miles) from Shootering Canyon and 106 km (66 miles) from the Blanding ore buying station. A third mill, the Energy Fuels Nuclear, Inc. White Mesa facility which is in the planning stage and is currently being considered for a source material license, has been proposed for a site about 2.5 km (1.5 miles) from the applicant's Blanding ore buying station. The proposed White Mesa mill would be approximately 240 highway kilometers (150 miles) from the Shootering Canyon mines.

The staff has concluded that processing the applicant's ores at any of these mills is not feasible for the following reasons:

1. The Humeca mill utilizes an alkaline leach process. Although the Shootering Canyon ores can be successfully treated by alkaline leaching (Hydrojet Services, Inc., processed ores from the Shootering Canyon area utilizing an alkaline leach facility in the early 1970s), tests conducted by the applicant indicated that higher recovery rates could be obtained with an acid leaching process (ER, p. 10-1). Because most of the ores that would be processed at the proposed mill are low grade (approximately 0.10%), any significant lowering of recovery rates (which would occur if carbonate leaching were utilized) would adversely affect the economic feasibility of the proposed milling project, as well as waste a valuable natural resource. Also, because only ore from a company-owned and operating mine is currently being processed at the Humeca mill, it is unlikely that the mill has the capacity, processing capability, or willingness to accept additional ore from another source.
2. The Moab uranium mill has both alkaline and acid leach circuits. The acid leach circuit is designed to process 545 MT (600 tons) per day of vanadium-bearing ores (average ore grade - 0.25% U_3O_8 and 1.5% V_2O_5); therefore, with process adjustments, the Shootering Canyon ores could be successfully processed at this facility. However, the acid leach circuit was constructed to process recently discovered and acquired (by Atlas Minerals) ore deposits that are within economic shipping distance of the mill; therefore, additional ore could not be processed unless the facilities were expanded.
3. The costs of transporting the applicant's ores to either of the three mills would be excessive, considering the low grade of ore to be shipped, except for the small amount of ore from the Blanding OBS which could be transported cheaply to the White Mesa mill (see Sect. 3.1.1). Assuming an average ore grade of 0.10% and transportation costs of 10¢ per ton-mile, the staff estimates that, if the ore is shipped to these mills, costs of producing each pound of U_3O_8 would increase by the following amounts for additional transportation costs alone (i.e., does not include additional costs incurred for toll milling):

   a. Moab mill - $5.30 per pound,
   b. Humeca mill - $6.35 per pound,
   c. White Mesa mill - $4.40 per pound.

Transporting the ores to existing mills could reduce the total land requirements for processing the ores. However, the environmental costs associated with uranium ore processing and tailings disposal would not be decreased and would only be shifted away from the Shootering Canyon area to the area of the mill receiving the ore. If the proposed mill is not constructed, there is a high probability that other mills (or expansions in capacity of existing mills) will be proposed in the area to process the ore now programmed for the applicant's mill.

10.5 ALTERNATIVE ENERGY SOURCES

10.5.1 Fossil and nuclear fuels

10.5.1.1 Introduction

The use of uranium to fuel reactors for generating electric power is relatively new historically. Coal was the first fuel used in quantity for electrical power generation. Coal use was reduced because of the ready availability and low price of oil and natural gas, which are cleaner burning than coal and easier to use. Uranium fuel is even cleaner (chemically) than oil or gas and at present is less expensive, on a thermal basis, than any other fuel used to generate electric power. The following discussion concerns the relative availability of fuels for power generation over the next 10 to 15 years and a comparison of the health effects of utilizing coal and/or nuclear fuels as energy sources.

10.5.1.2 Overview of U.S. energy usage and availability

According to the *National Energy Plan*, published by the Carter Administration in April 1977, the United States uses more energy to produce goods and services than any other nation and consumes twice as much energy per capita as does West Germany, which has a similar standard of living.[15] In 1975, the United States consumed approximately 71 quadrillion Btu's (71×10^{15}), or 71 quads (q), of energy, with about 93% of this energy being supplied by three fossil fuels: oil, natural gas, and coal.[16] Approximately 75% of our energy needs are supplied by natural gas and oil; however, because domestic supplies of these valuable resources are limited (about 7% of proved reserves are oil and gas), the amount of oil imported from foreign sources has increased, undermining our military and economic security.[16] Table 10.4 illustrates the disparity between availability and usage of energy sources in the United States.

Table 10.4. Reserves and current consumption of energy sources

	Percentage of proven U.S. energy reserves economically recoverable with existing (1975) technology	Percentage of total U.S. energy consumption contributed by each energy resource
Coal	90	18
Oil	3	46
Gas	4	28
Nuclear	3	3
Other	0	5

Source: Tetra Tech, Inc., *Energy Fact Book – 1977*, prepared under the direction of the Director, Navy Energy and National Resources Research and Development Office, April 1977.

Despite concentrated efforts to slow down our consumption of oil and natural gas, increase the usage of coal-burning facilities, and further the utilization of nonconventional energy sources, energy demand forecasts indicate that by the year 2000, approximately 43% of our energy will still be supplied by oil and gas, 21% by coal, and only a small percentage (7%) by solar, geothermal, and oil shale (Table 10.5).[17]

Table 10.5. Forecast of gross energy consumption for 1980, 1985, and 2000

Fuel	1980		1985		2000	
	10^{12} Btu	Percentage of gross	10^{12} Btu	Percentage of gross	10^{12} Btu	Percentage of gross
Coal	17,150	19.7	21,250	20.6	34,750	21.3
Petroleum	41,040	47.1	45,630	44.1	51,200	31.3
Natural gas	20,600	23.6	20,100	19.4	19,600	12.0
Oil shale			870	0.8	5,730	3.5
Nuclear power	4,550	5.2	11,840	11.4	46,080	28.2
Hydropower and geothermal	3,800	4.4	3,850	3.7	6,070	3.7
Totals	87,140	100.0	103,540	100.0	163,430	100.0

Source: U.S. Bureau of Mines, *United States Energy through the Year 2000*, December 1975.

Of the 71 q of energy consumed in the United States in 1975, 20 q consisted of electric energy. An estimated 8.6% of this electric energy was generated using nuclear fuels, but within ten years this percentage is expected to increase to 26%. Coal was used for producing 59% of the electric energy generated by combustion of fossil fuels in 1975; oil and gas produced 20 and

21% respectively. Use of oil and gas to generate electric power has decreased about 10% over the last three years, a reflection of high oil prices and gas unavailability.[18]

Current and projected requirements for electric energy (1970-1985) and relative changes in resources used for generation, as estimated in the *Project Independence* report,[19] are shown in Table 10.6. The evidence available at this time indicates that, of the resources currently used in electric-power generation (coal, uranium, oil, gas, and hydro), coal and uranium must be used to generate an increasing share of U.S. energy needs. The supplies of oil and gas available for electric power generation are decreasing, and the United States does not have sufficient oil and gas reserves to ensure a long-run supply.

Table 10.6. Estimated relative changes in resources to be used for generation of projected electric energy requirements

Fuel resource used	Thermal energy required by years, %			
	1970[a]	1974[b]	1980[b]	1985[c]
Coal	45	45	45	46[c]
Oil and gas	38	34	25	16
Nuclear	2	4[d]	17	26
Hydro, waste, etc.	15	17	13	12
Total quads of energy required	15.6	20	25.5	34

[a] Actual.

[b] Estimated from Federal Energy Administration, *National Energy Outlook*, U.S. Government Printing Office, Washington, D.C., February 1976.

[c] Coal usage must increase 77% by 1985 to attain this level.

[d] Uranium-fueled reactors furnished 9.9% of the total U.S. production in January 1976.

Source: Federal Energy Administration, *Project Independence*, U.S. Government Printing Office, Washington, D.C., November 1974.

With increasing energy demands, both foreign and domestic, expectations are that in the next few decades the prices of oil and and gas will increase rapidly as reserves of these two resources become severely depleted. Because of the time lag between initial extraction and consumption of the resource for energy production (three to five years from mine to generation plant for uranium and coal, five to seven years for construction of a coal generating plant, and seven to ten years for construction of a nuclear generating plant), the exploitation of both coal and uranium resources must be integrated with contemporary energy needs. Although coal and uranium resources are adequate for foreseeable energy needs, major expansion of both uranium- and coal-producing industries will be required, as neither of these industries is considered capable of singly supplying future energy requirements.

The determination of availability of uranium in large enough quantities to fuel the projected nuclear generating capacity (for 1985 and beyond) is currently a matter of study.[20] Results of those studies are given in Appendix B, which includes an estimate of reactor installation through the year 2000 and the relative percentage of total electricity-generating capacity these new installations would represent.

10.5.1.3 Coal production

Congress and the Carter administration have stressed, via passed and proposed legislation, the necessity of future decreases in oil and gas demand to alleviate our dependence on foreign energy sources and to reorient our energy consumption patterns. The *Project Independence* report of November 1974 and the *National Energy Outlook* of February 1976 both proposed that coal production be increased from present levels (approximately 650 million tons per year) to approximately 1.2 billion tons by 1985.[18,19] The major expansion of coal production will likely be in the west (from approximately 92 million tons in 1974 to about 380 million tons in 1985), because of the low sulfur (low air pollutant) content of most western coals. The potential for environmental damage (due to disturbance of generally fragile ecosystems) in the western United States will be increased. Because the major markets for the coal produced will be located hundreds of miles from the western mines, transportation costs will be high, as will the environmental impacts associated with transportation systems. Currently, transportation costs for bringing western coal to the eastern United States account for the major portion of the market price. Also, for a given thermal content, transport facilities for U_3O_8 per year are minimal compared to those for coal because of the much higher energy content of uranium fuel. Approximately 250 tons of U_3O_8 per year are required for a 1000-MW nuclear plant operating at a plant factor of 0.8. Annual western coal requirements for an equivalent 1000-MW coal plant would be more than 3×10^6 tons, or the load capacity of at least one unit-train (100 cars of 100 tons each), per day of plant operation.

10.5.1.4 Uranium fuel production

Estimates presented in the *National Energy Outlook*[18] indicate that 140,000 to 150,000 MWe of nuclear generating capacity will be needed to supply 26% of the total electrical energy used in 1985. The first *Project Independence* report[19] indicated that nuclear capacity could increase to more than 200,000 MWe by 1985. A more recent and lower estimate resulted from lower projections of electricity demand, financial problems experienced by utilities, uncertainty about government policy, and continued siting and licensing problems. The more recent projections of uranium requirements are given in Table 10.7.

Table 10.7. Uranium requirements

MWe operating by 1985	Lifetime U_3O_8 requirements (tons) for specified plant factor	
	0.8	0.6
142,000	960,000	704,000

Source: Federal Energy Administration, *National Energy Outlook*, U.S. Government Printing Office, Washington, D.C., February 1976.

Table 10.8 presents estimates of quantities of uranium available at different recovery cost levels. Assuming reserves recoverable at a forward cost of production up to \$30/lb of U_3O_8, the Department of Energy (DOE) estimated that in January 1978 the total of all variously known categories of uranium resources was approximately 3.48×10^6 tons.[21] An estimated 6.9×10^5 tons of these resources consisted of known reserves; that is, drilling and sampling have established the existence of these deposits beyond reasonable doubt.[21] Approximately 5.2×10^5 tons of U_3O_8 could be recovered from very low grade ore and Chattanooga shale for about \$100/lb and approximately 4×10^9 tons of U_3O_8 from seawater for an estimated cost of between \$300/lb and \$750/lb.[22,23]

Historically, resources of uncertain potential have become established at an average rate of 7% per year since 1955.[19] If this rate were to persist over the next decade, total reserves would exceed requirements (1,340,000 tons of reserves vs a maximum 960,000 tons required for lifetime nuclear generating capacity rated at 142,000 MWe) by about 380,000 tons. Assuming no transfer of possible resources into the "probable" category, probable resources would still contain 430,000 tons.

Mill capacity in the United States as of January 1978 was 39,210 tons of ore per day. These mills operated at 79% of capacity in 1977. Uranium oxide output was approximately 14,946 tons, equivalent to about 2.5 lb of U_3O_8 per ton of ore.

Table 10.8. U.S. uranium (U_3O_8) resources

Forward cost	Reserves[a] (tons)	Potential resources (tons)		
		Probable[b]	Possible[c]	Speculative[c]
$30/lb	690,000	1,015,000	1,135,000	415,000

[a] Reserves are in known deposits.

[b] Probable resources have not been drilled and sampled as extensively as reserves.

[c] Possible and speculative resources have been estimated by inference from geologic evidence and limited sampling.

Source: Department of Energy, *Statistical Data of the Uranium Industry*, Report GJO-100(78), Jan. 1, 1978.

A survey of U.S. uranium marketing activity completed by ERDA in May 1977[24] indicated that annual contracted deliveries of U_3O_8 for nuclear-powered electric generation plants (assuming no recycle of plutonium and uranium and 0.20% uranium-235 enrichment plant tails assay until October 1, 1980, 0.25% thereafter) will exceed annual requirements until 1979 (see Fig. 10.8). Contracted imports of U_3O_8 will exceed contracted exports by a considerable margin over the next few years. Through 1990, cumulative contracted imports of U_3O_8 are 47,200 tons (approximately 50% of future contracted imports will come from Canadian sources), compared to 13,500 tons to be exported. Figure 10.8 illustrates total U_3O_8 requirements, domestic deliveries, imports, and exports through 1990.

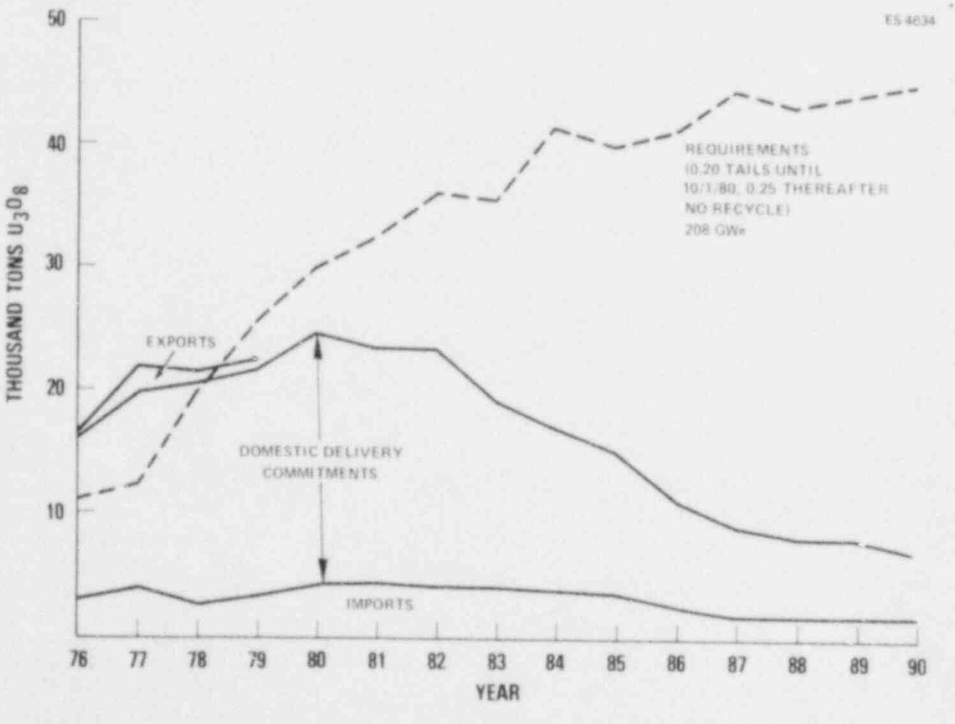


Fig. 10.8. Summary of uranium requirements and delivery commitments as of January 1, 1977. Source: Energy Research and Development Administration, *Survey of United States Uranium Marketing Activity*, Division of Uranium Resources and Enrichment, Office of Assistant Director of Raw Materials, May 1977.

Cumulative U.S. supplies of U_3O_8 (including domestic and foreign inventories and contract commitments) will exceed DOE enrichment feed requirements until 1983. The gap between cumulative supply and cumulative requirements is expected to be approximately 58,000 tons by 1985 and widen to approximately 233,000 tons by 1990 (see Fig. 10.9).

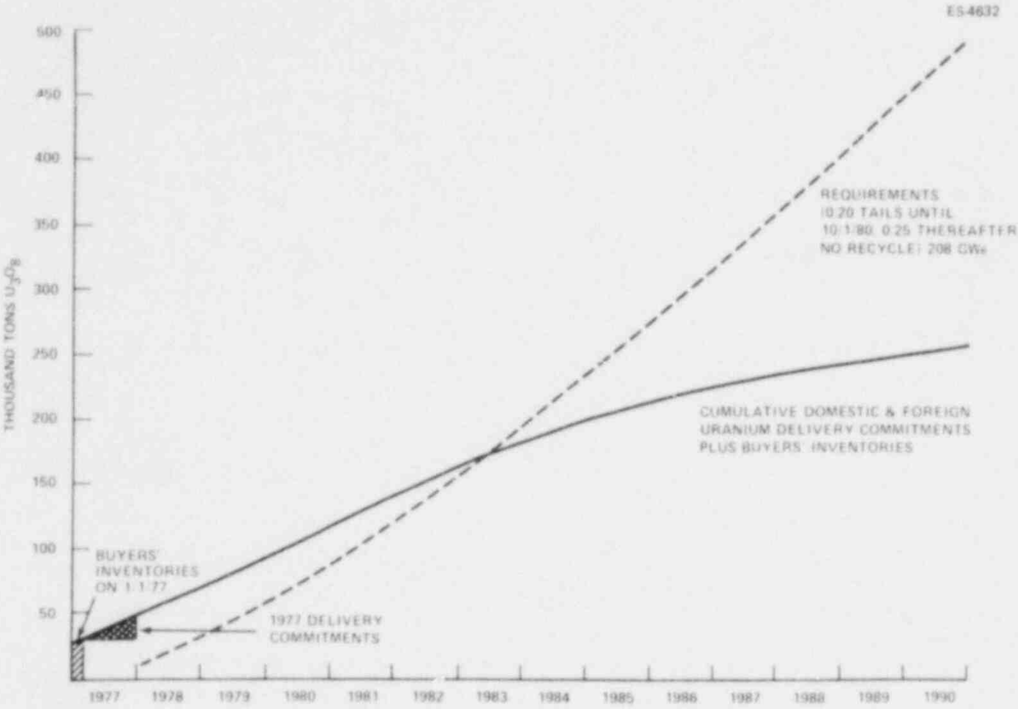


Fig. 10.9. Comparison of U_3O_8 requirements and contracted deliveries plus inventories. Source: Energy Research and Development Administration, *Survey of United States Uranium Marketing Activity*, Division of Uranium Resources and Enrichment, Office of Assistant Director of Raw Materials, May 1977.

10.5.1.5 Comparison of health effects of the uranium fuel cycle and the coal fuel cycle

Research conducted by the U.S. Nuclear Regulatory Commission[25] comparing the health effects associated with the coal fuel cycle (mining, processing, fuel transportation, power generation, and waste disposal) and the uranium fuel cycle (mining, milling, uranium enrichment, fuel preparation, fuel transportation, power generation, irradiated fuel transportation, and waste disposal) indicated that increases in the use of coal for power generation may cause the adverse health impacts related to electric energy production to increase. As defined by the study, health effects are stated in terms of "excess" mortality, morbidity (disease and illness), and injury among occupational workers and the general public, where "excess" implies illness and injury rates higher than normal and premature deaths. The estimated excess deaths per 0.8 gigawatt-year electric [GWyr(e)] (i.e., per 1000 MWe power plant operating at 80% of capacity for one year) were 0.47 for an all-nuclear economy (assumes that all of the electricity used within the nuclear fuel cycle is generated by nuclear power) and 1.1 to 5.4 if all the electricity used in the uranium fuel cycle (primarily for uranium enrichment and reactor operation) came from coal-fired plants. Excess deaths for the entire coal cycle varied from 15 to 120 per 0.8 GWyr(e). Mortality estimates are shown in Table 10.9.

Excess morbidity and injury rates for workers and the general public resulting from normal operations and accidents in an all-nuclear cycle were estimated to be about 14 per 0.8 GWyr(e), with injuries to miners from accidents (falls, cave-ins, and explosions) accounting for ten of these occurrences. If all the electrical power used in the uranium fuel cycle originated from

Table 10.9. Current energy source excess [illegible]ty summary per year per 0.8-GWyr(e) power plant

	[illegible]tional		General public		Totals
	Accident	Disease	Accident	Disease	
	Nuclear fuel cycle				
All nuclear	0.22[a]	0.14[b]	0.05[c]	0.06[b]	0.47
With 100% of the electricity used in the fuel cycle produced by coal power[d]	0.24–0.25[a,e]	0.14–0.46[b,f]	0.10[c,g]	0.64–4.6[h]	1.1–5.4
(U.S. population for nuclear effects; regional population for coal effects)					
	Coal fuel cycle				
Regional population	0.35–0.65[e]	0–7[f]	1.2[g]	13–110[h]	15–120
Ratio of coal to nuclear:				(all nucle[illegible])	32-260
				(with coal power)	14-22

[a]Primarily fatal nonradiological accidents, such as falls, explosions, etc.

[b]Primarily fatal radiogenic cancers and leukemias from normal operations at mines, mills, power plants and reprocessing plants.

[c]Primarily fatal transportation accidents (Table S-4, 10 CFR Part 51) and serious nuclear accidents.

[d]U.S. population for nuclear effects; regional population for coal effects.

[e]Primarily fatal mining accidents, such as cave-ins, fires, explosions, etc.

[f]Primarily coal workers pneumoconiosis and related respiratory diseases leading to respiratory failure.

[g]Primarily members of the general public killed at rail crossings by coal trains.

[h]Primarily respiratory failure among the sick and elderly from combustion products from power plants but includes deaths from waste coal bank fires.

[i]100% of all electricity consumed by the nuclear fuel cycle produced by coal power; amounts to 45 MWe per 0.8 GWyr(e).

Source: R. L. Gotchy, *Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives*, Report NUREG-0332, Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, September 1977.

coal-fired plants, these rates would increase to approximately 17-24 per 0.8 GWyr(e). The estimated excess disease and injury rate for the coal cycle was 57-210 per 0.8 GWyr(e). Coal-related illnesses among coal miners and the general public and injuries to miners account for the majority of nonfatal cases. Table 10.10 illustrates these comparative illness and injury rates.

Although the adverse health effects related to either the uranium fuel cycle or the coal fuel cycle represent small additional risks to the general public, the study concluded that ". . . the coal fuel cycle may be more harmful to man by factors of 4 to 260 depending on the effect being considered, for an all-nuclear economy, or factors of 3 to 22 with the assumption that all of the electricity used by the uranium fuel cycle comes from coal-powered plants . . ." (ref. 25, p. 13). Additionally, ". . . the impact of transportation of coal is based on firm statistics; this impact alone is greater than the conservative estimates of health effects for the entire uranium fuel cycle (all nuclear economy) and can reasonably be expected to worsen as more coal is shipped over greater distance . . ." (ref. 25, p. 13).

10.5.2 Solar, geothermal, and synthetic fuels

Estimates reported in the *National Energy Outlook*[18] indicate that solar and geothermal sources will each supply about 1% of U.S. energy requirements by 1985 and about 2% by 1990. Supplies of synthetic gas and oil derived from coal will probably not exceed 1% of U.S. energy requirements as of the year 1990. These projections are based on many considerations. The technology exists in all cases but not in a proven, commercially viable manner. The potential for proving these technologies on a commercial scale is great, but timely development will require a favorable market as well as governmental incentives. A maximum of 6% of projected 1990 energy requirements is expected to be derived from solar, geothermal, and synthetic fuel resources combined.

Table 10.10. Current energy source summary of excess morbidity and injury per 0.8 GWyr(e) power plant

	Occupational		General public		Totals
	Morbidity	Injury	Morbidity	Injury	
Nuclear fuel cycle					
All nuclear	0.84[a]	12[b]	0.78[c]	0.1[d]	14
With 100% of electricity used by the fuel cycle produced by coal power[e] (U.S. population for nuclear effects; regional population for coal effects)	1.7–4.1[f]	13–14[b]	1.3–5.3[g]	0.55[h]	17–24
Coal fuel cycle					
Regional population	20–70[f]	17–34[i]	10–100[g]	10[h]	57–210
Ratio of coal to nuclear:				(all nuclear)	4.1-15
				(with coal power)	3.4-8.8

[a]Primarily nonfatal cancers and thyroid nodules.

[b]Primarily nonfatal injuries associated with accidents in uranium mines, such as rock falls, explosions, etc.

[c]Primarily nonfatal cancers, thyroid nodules, genetically related diseases, and nonfatal illnesses following high radiation doses, such as radiation thyroiditis, prodromal vomiting, and temporary sterility.

[d]Transportation-related injuries from Table S-4, 10 CFR Part 51.

[e]U.S. population for nuclear effects; regional population for coal effects.

[f]Primarily nonfatal diseases associated with coal mining, such as coal workers pneumoconiosis, bronchitis, emphysema, etc.

[g]Primarily respiratory diseases among adults and children from sulfur emissions from coal-fired power plants but includes waste coal bank fires.

[h]Primarily injuries to coal miners from cave-ins, fires, explosions, etc.

[i]Primarily nonfatal injuries among members of the general public from collisions with coal trains at railroad crossings.

[j]100% of all electricity consumed by the nuclear fuel cycle produced by coal power; amounts to 45 MWe per 0.8 GWyr(e).

Source: R. L. Gotchy, *Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives*, Report NUREG-0332, Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, September 1977.

The *National Energy Plan*[15] does not set specific goals for increased use of synthetic fuels or geothermal energy, but does state that, as a possible goal, solar energy will be used in 2.5 million homes by 1985.

10.5.3 By-product uranium

Uranium recoverable as a by-product of phosphate fertilizer and copper production is estimated to be 140,000 tons through the year 2000.[21] These reserves are in addition to the 690,000 tons of $30 uranium available from conventional mining and milling sources.

The following is noted in a report by the National Academy of Sciences:[26]

> Like all by-product commodities, by-product uranium is entirely dependent upon production of the primary commodity, is limited in amount by the level of production of the primary commodity, and is unresponsive to the demand for uranium. By-product uranium could be obtained from the mining of phosphate, copper, and lignite.
>
> Much phosphate is treated with sulfuric acid to produce fertilizer and goes through a phosphoric acid step. Uranium in the phosphate can be recovered from the phosphoric acid. . . . It has been estimated that about 2500 ST U_3O_8 per year could be recovered from Florida phosphate mined for fertilizer.
>
> The Bureau of Mines studied the sulfuric acid leaching of low-grade dumps at 14 porphyry copper mines and concluded that about 750 ST U_3O_8 per year could be recovered. This would be recovered from rocks whose uranium content ranges from 1 to 12 ppm.

The Bureau of Mines thought that other porphyry copper deposits might also be possible sources of by-product uranium.

The staff has studied available data on the potential of uranium production from phosphate fertilizer production[27] and from copper dump leaching, and estimates that production could reach 3000 to 5000 MT (4000-6000 tons) per year from phosphoric acid extraction and 400 to 900 MT (500-1000 tons) per year from copper dump leaching.[27,28] Much effort has been expended to determine the amounts of uranium that might be recovered from coal and lignite. Some uranium was recovered from lignite ash in the early 1960s, but the lignite itself was not a suitable fuel for the process; supplementary fuel was needed for the necessary conversion to ash. No uranium has been recovered as a by-product from the ash of coal- or lignite-fired power plants. Ash samples continue to be analyzed for uranium, but to date no ash containing more than 20 ppm U_3O_8 has been found, and most ash samples contain from 1 to 10 ppm U_3O_8.[28]

10.5.4 Energy conservation

The cornerstone of the *National Energy Plan* is conservation, the cleanest and cheapest source of new energy supply.

> If vigorous conservation measures are not undertaken and present trends continue, energy demand is projected to increase by more than 30% between now [1977] and 1985.[15]

The *National Energy Plan* lists the following consuming segments as being prime targets for energy conservation:

1. transportation,
2. buildings, including residences,
3. appliances,
4. industrial fuel use, and
5. industries and utilities using cogeneration of electricity and low-grade heat.

Part of the *National Energy Plan* will be the utilization of all possible governmental means (tax reduction, incentives, direct subsidy, and legislation and regulation) to change the past relationship between energy production and use of energy requirements in the United States where energy usage is two times higher per capita than in other industrial countries for energy consumption and production and energy use.

The *National Energy Plan* clearly states that both coal and nuclear electrical generation facilities will be needed to meet estimates of U.S. energy requirements through the year 2000, even if the conservation goals of the *Plan* are met. The relative amounts of each energy source used will depend on economic and regional environmental considerations.

10.6 ALTERNATIVE OF NO LICENSING ACTION

Among the alternative actions available to the NRC is the denial of a Source Material License to the applicant. Classifications of source materials are discussed in 10 CFR Part 40.13(b); these classifications are based on Section 62 of the Atomic Energy Act of 1954, which specifically exempts "unbeneficiated ore" from control. Under these regulations Plateau Resources Ltd. could mine the ore but could not process it, should the NRC deny the Source Material License.

Exercise by the NRC of this option would leave the applicant with three possible courses of action: (a) mine the ore and have it processed at an existing mill possessing a Source Material License; (b) postpone the project while attempting to remove the objections that led to the denial of the license; or (c) abandon the project. Alternative (a) has been discussed in Sect. 10.4. Alternative (b) is essentially the applicant's proposal (merely shifted in time), which is the subject of this Statement. Alternative (c), therefore, is the only alternative discussed herein.

If the applicant were not awarded a Source Material License, the uranium concentrate it intends to produce would not become available for use as fuel in nuclear reactors in as timely a manner. The relationship of electrical energy produced by nuclear reactors to the total U.S. energy requirements has been discussed in Sect. 10.5.

The yellow cake produced by the Shootering Canyon mill will be used as fuel in nuclear reactors that are either operating or under construction. These reactors will produce electric power for sale to U.S. consumers. Lack of fuel would require those reactors short of fuel to reduce their output and could conceivably result in the shutdown of some of them.

The applicant has indicated the effects of losses of local and regional economic benefits that would occur if the Shootering Canyon mill where not licensed, and has also pointed out the environmental costs that would not be incurred should no license be issued. Overall, the benefits accruing from the mill outweigh the costs.

REFERENCES FOR SECTION 10

1. Plateau Resources, Ltd., *Preliminary Site Selection Study, Proposed Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., June 1977.

2. D. A. Clark, *State-of-the-Art: Ur[illegible]um Mining, Milling, and Refining Industry*, Report EPA-660/2-74038, National Environmental Center, Office of Research and Development, U.S. Environmental Protection Agency, June 1974.

3. R. C. Merritt, *The Extractive Metallurgy of Uranium*, Colorado School of Mines Research Institute, Golden, Colo., 1971.

4. Plateau Resources, Ltd., *Tailings Management Plan, Proposed Ore Processing Facility, Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., May 1978.

5. Plateau Resources, Ltd., *Evaluation of Tailings Disposal Alternatives, Shootering Canyon Uranium Project, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., December 1978.

6. Plateau Resources, Ltd., *Tailings Management Plan and Geotechnical Engineering Studies, Shootering Canyon Uranium Project, Garfield County, Utah*, prepared by Woodward-Clyde Consultants, San Francisco, Calif., September 1978.

7. "Responses to Questions from NRC Dated August 25, 1979, Shootering Canyon Uranium Project," prepared by Woodward-Clyde Consultants, San Francisco, Calif., Sept. 15, 1978.

8. "Responses to Questions from NRC Dated July 27, 1978, and August 26, 1978," prepared by Woodward-Clyde Consultants, San Francisco, Calif., Aug. 29, 1978.

9. U.S. Nuclear Regulatory Commission, *Draft Environmental Statement Related to the White Mesa Uranium Project, San Juan County, Utah*, Docket No. 40-8681, December 1978.

10. U.S. Nuclear Regulatory Commission, *Final Environmental Statement Related to the Rocky Mountain Energy Company's Bear Creek Project, Converse County, Wyoming*, Docket No. 40-8451, June 1977.

11. U.S. Department of Agriculture, Forest Service, *Draft Environmental Statement for the Homestake Mining Company's Pitch Project, Saguache County, Colorado*, Report USDA-FS-R2-DES (ADM), July 14, 1978.

12. U.S. Nuclear Regulatory Commission, *Final Environmental Statement Related to the Minerals Exploration Company's Sweetwater Uranium Project, Sweetwater County, Wyoming*, Docket No. 40-8584, December 1978.

13. U.S. Nuclear Regulatory Commission, *Draft Environmental Statement Related to the Operation of Morton Ranch Uranium Mill, Converse County, Wyoming*, Docket No. 40-8602, April 1978.

14. M. B. Sears et al., *Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing "As Low As Practicable" Guides – Milling of Uranium Ores*, Report ORNL/TM-4903, vol. 1, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1975.

15. Executive Office of the President, *The National Energy Plan*, Energy Policy and Planning, April 1977.

16. Tetra Tech., Inc[illegible] *[illegible]nergy Fact Book – 1977*, prepared under the direction of the Director, Navy Energy a[illegible]ional Resources Research and Development Office, April 1977.

17. U.S. Bu[illegible], *United States Energy through the Year 2000*, December 1975.

18. Federal [illegible]istration, *National Energy Outlook*, U.S. Government Printing Office, Washington, D.C., February 1976.

19. Federal Energy Administration, *Project Independence*, U.S. Government Printing Office, Washington, D.C., November 1974.

20. Department of Energy, *Latest Estimate of U.S. Uranium Resources*, April 1978.

21. Department of Energy, *Statistical Data of the Uranium Industry*, Report GJO-100(78), January 1, 1978.

22. *Nuclear News*, July 1975, p. 37 [reprinted in *Energy Factbook - 1977*].

23. U.S. Bureau of Mines, *Recovery of Uranium from Low-Grade Resources*, December 7, 1977 (unpublished).

24. Energy Research and Development Administration, *Survey of United States Uranium Marketing Activity*, Division of Uranium Resources and Enrichment, Office of Assistant Director of Raw Materials, May 1977.

25. R. L. Gotchy, *Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives*, Report NUREG-0332, Division of Site Safety and Environmental Analysis, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, September 1977.

26. National Academy of Sciences, *Mineral Resources and the Environment. Supplementary Report: Reserves and Resources of Uranium in the U.S.*, Washington, D.C., 1975, p. 106.

27. J. Klemenic and D. Blanchfield, "Production Capability and Supply (of Uranium)," paper presented at Grand Junction, Colo., ERDA Uranium Conference, October 1977.

28. J. F. Pacer, Jr., "Production Statistics," paper presented at Grand Junction, Colo., ERDA Uranium Conference, October 1977.

11. NRC BENEFIT-COST SUMMARY FOR THE SHOOTERING CANYON URANIUM PROJECT

11.1 GENERAL

Implicit in the decision of a utility to construct a nuclear power plant is that the uranium needed to fuel the reactor is available (Appendix B). For each application to the NRC for a permit to construct a nuclear power plant, an Environmental Statement is prepared that includes a review of the availability of uranium resources. The uranium to be produced by the Shootering Canyon mill is among the total U.S. resources considered to be available to the commercial market for reactor fuel; thus, the uranium from this mill is needed to meet the demands of the nuclear power industry. In the Environmental Statement, the benefits (the electrical energy produced) of the nuclear plant are weighed against the economic and environmental costs, including a prorated share of the environmental costs of the uranium fuel cycle. These incremental impacts in the fuel cycle are justified in terms of the benefits of energy generation. However, because these costs and benefits are not localized, it is appropriate to review the specific site-related benefits and costs for an individual fuel cycle facility such as the Shootering Canyon mill.

11.2 QUANTIFIABLE ECONOMIC IMPACTS

Section 4 of this Environmental Statement treats the quantifiable economic impacts for the Shootering Canyon Uranium Project. On the one hand, many monetary benefits accrue to the community from the presence of the mill — for example, local expenditures of construction and operating funds and payments of State and local taxes. Against these monetary benefits are the monetary costs to the different communities involved — for example, costs for new or expanded schools and other community services. It is not possible to arrive at an exact numerical balance between the benefits and costs for any one community unit or for the mill because the distribution of revenues to support services may not be timely or completely consistent with those geographical locations where impacts occur.

11.3 THE BENEFIT-COST SUMMARY

As stated in Sect. 11.1, the benefit-cost summary for a fuel cycle facility such as the Shootering Canyon Uranium Project rests on a comparison between the societal benefit of an assured U_3O_8 supply (ultimately providing electrical energy) and local environmental costs for which there are no directly related compensations. For the Shootering Canyon mill, these uncompensated environmental costs are basically two: radiological impact and disturbance of the land. As shown in Sect. 4.7, the radiological impact of the Shootering Canyon mill is acceptable by current standards. The disturbance of the land, as shown in Sect. 4.2, is a long-term impact that is judged to be small in comparison to alternative uses the land may support in the future.

11.4 STAFF ASSESSMENT

The staff has concluded that the adverse environmental impacts and costs are such that use of the mitigative measures suggested by the applicant and the regulatory agencies involved will reduce to acceptable levels the short- and long-term adverse environmental impacts and costs associated with the project.

In considering the energy value of the U_3O_8 produced, minimal radiological impacts, minimal long-term disturbance of land, and mitigable nature of the impacts of growth on the local communities, the staff has concluded that the overall benefit-cost balance for the Shootering Canyon Uranium Project is favorable, and the indicated action is that of licensing the facility.

Appendix A

RESERVED FOR COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

Appendix B

BASIS FOR NRC EVALUATION OF THE SHOOTERING CANYON URANIUM PROJECT

Appendix B

BASIS FOR NRC EVALUATION OF THE SHOOTERING CANYON URANIUM PROJECT

B.1 THE NUCLEAR FUEL CYCLE

The nuclear fuel cycle comprises all the processes involved in the utilization of uranium as a source of energy for the generation of electrical power.

The nuclear fuel cycle consists of several steps:

1. extraction — removing uranium ore from the ground, separating the uranium content from the waste, and converting the uranium to a chemically stable oxide (nominally U_3O_8);

2. conversion or fluorination — changing the U_3O_8 to a fluoride (UF_6), which is a solid at room temperature but becomes a gas at slightly elevated temperatures, prior to enrichment;

3. enrichment — concentrating the fissionable isotope (uranium-235) content of the uranium from the 0.7% occurring in nature to the 2 to 4% required for use in reactors for power generation;

4. fabrication — converting the enriched uranium fluoride to uranium dioxide (UO_2), forming it into pellets, and encasing the pellets in tubes (rods) that are assembled into fuel bundles for use in power generating reactors;

5. nuclear power generation — using the heat resulting from uranium and plutonium fission to generate steam for use in the reactor turbines;

6. spent fuel reprocessing — chemical separation of fissionable and fertile values (uranium-235, uranium-238, plutonium) from fission products (waste), with concurrent separation of uranium from plutonium; and

7. waste management — storage of fission products, spent fuel, and low-level wastes in a manner that is safe and of no threat to human health or the environment.

Step 6 (reprocessing, involving the recycling of plutonium), which had traditionally been considered as an essential part of the nuclear fuel cycle, was recently deferred by the National Energy Plan (NEP)[1] as a necessary part of the cycle. The U.S. commitment to advanced nuclear technologies based on the use of plutonium recovered by the reprocessing of spent light-water-reactor (LWR) fuel has also been deferred. These policy statements enter into the staff's evaluation of the need for licensing the Shootering Canyon mill, because without reprocessing, all LWR fuel must be derived from the mining and milling of new U_3O_8 from projects such as the Shootering Canyon mill and the related uranium mines.

This cycle, as defined by current policy, is portrayed in Fig. B.1.

Nuclear reactor operation converts about 75% of the fissionable isotope (uranium-235) into fission products, thereby liberating thermal energy and creating plutonium, another fissionable element, in the process. Some plutonium is retained in the spent fuel.

The spent fuel removed from the reactor is stored at the reactor site (and later at the reprocessing plant, if policy changes) to "cool." The radioactivity of the fuel is reduced by a factor of about 10 after 150 days storage. Without reprocessing, this spent fuel is considered waste. Policies and methods regarding its storage and/or disposal are currently under study by the DOE and NRC.

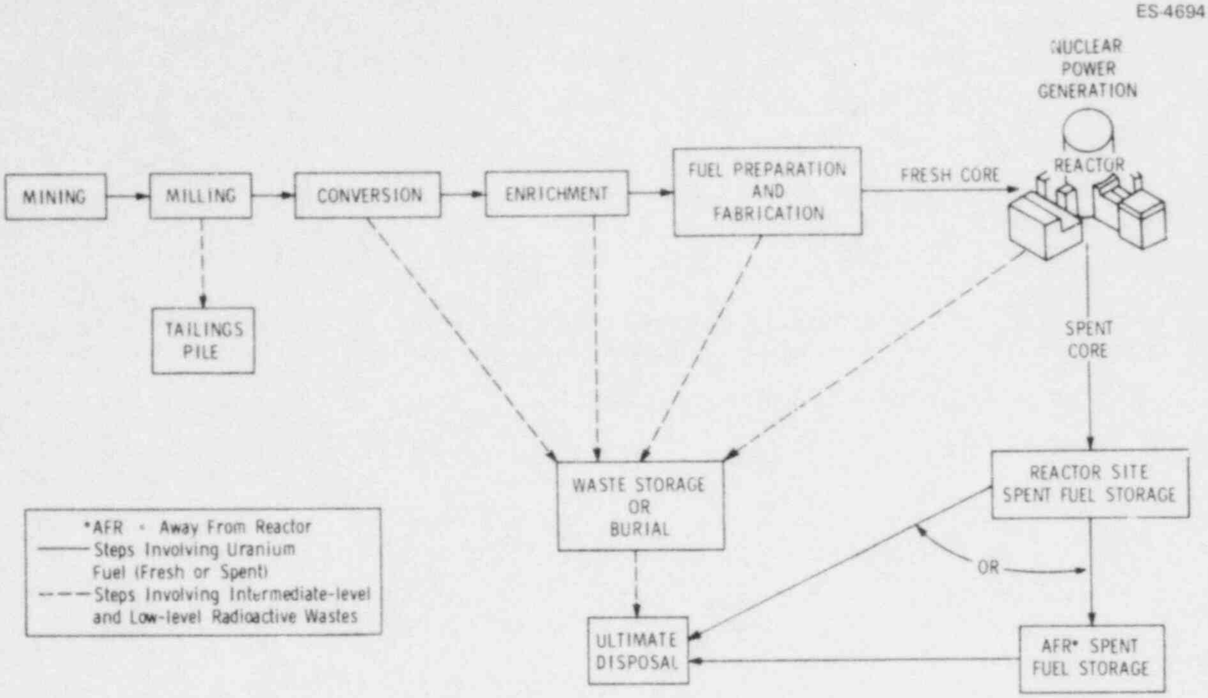


Fig. B.1. The LWR fuel cycle.

B.2 USE OF NUCLEAR FUEL IN REACTORS

Two types of reactors are currently used to generate essentially all of the nuclear energy sold in the United States: the boiling-water reactor (BWR) and the pressurized-water reactor (PWR). Each reactor type is operated with a fuel-management scheme designed to meet the requirements of the utility operator. Different fuel-management schemes result in different fuel burnup rates which, along with other design parameters, affect the quantity of residual fissionable materials, the type and amount of radioactive wastes in the spent fuel, and the quantities of nuclear fuel consumed.

The need for uranium fuel, as dictated by the installation of 380 GWe of nuclear capacity anticipated by the year 2000, is shown in Table B.1. A 1000-MWe reactor will require ≈30 MT of uranium fuel per year at a plant factor of 0.6 and ≈30 MT of uranium fuel for a plant factor of 0.8. The term "plant factor" indicates the ratio of the average power load of an electric power plant to its rated capacity. For a 3% enriched fuel and 0.25% enrichment tails assay, 7.9 times the metric tons of fuel replaced equals the standard tons of U_3O_8 required for a 1000-MWe power plant. The percentage of total electrical generating capacity over the same time period that this schedule represents is shown in Table B.2. On the basis of recent statements by the industry and the DOE, the staff believes that this schedule represents a maximum for nuclear reactor installations between 1990 and 2000 but is reasonably accurate through 1990.[2]

Cumulative requirements through the year 2000 would be 883,000 MT of uranium as U_3O_8 (Table B.1). Table B.3 compares this requirement with available uranium (reserves and probable resources) for the year 2000 and the 30-year plant lifetimes of the 380 GWe projected for installation by the year 2000. Requirements and resources are in reasonable balance;[3] that is, the sum of reserves and probable resources is approximately equal to the lifetime requirements of the 380 GWe installed by 2000.

Table B.1. Projected U.S. requirements for U_3O_8, 1976–2000[a,b]

Year	Generating capacity (GWe)	Annual U_3O_8 requirements (MT)	Cumulative U_3O_8 requirements (MT)
1976	43	9,500	9,350
1977	49	10,000	19,100
1978	53	10,000	29,100
1979	57	11,000	40,200
1980	61	11,000	52,000
1981	74	17,500	69,400
1982	87	18,000	87,600
1983	100	20,500	108,000
1984	112	22,500	130,000
1985	127	26,500	157,000
1986	141	28,000	185,000
1987	154	30,000	215,000
1988	167	32,500	248,000
1989	181	35,500	283,000
1990	195	38,000	321,000
1991	210	41,000	362,000
1992	225	43,500	406,000
1993	240	46,500	452,000
1994	260	51,500	504,000
1995	280	54,500	558,000
1996	300	58,000	616,000
1997	320	61,500	678,000
1998	340	65,500	743,000
1999	360	68,500	811,000
2000	380	71,500	883,000

[a] The annual U_3O_8 requirements were calculated on the basis of annual discharges of 28 MT/GWe (0.7 plant factor) of spent fuel and replacement of that spent fuel with a 3% enriched fuel with tails assay of 0.25% in enrichment.

[b] To convert to short tons, multiply by 1.1.

Table B.2. Comparison of total and nuclear generating capacity, operating in years 1977–2000

Year	Total generating capacity (GWe)[a]		Nuclear generating capacity (GWe)				
	Minimum	Maximum	Actual	Planned or under construction	Estimated	Nuclear, minimum case (%)	Nuclear, maximum case (%)
1978	507	507	49			12	12
1980	544	627		84		16	14
1985	624	840		127		20	15
1990	734	1131		195		26	17
1995	869	1525			280	32	18
2000	1039	2092			380	36	18

[a] From "Electric Utilities Study" by TRW for ERDA, Contract E(49-1)-3885, pp. 1–19, et seq. Maximum case is 7.0% compounded annual growth through 1985, then 6.4% to 2000. Minimum case is 3.9% through 1985, then 3.5% to 2000.

Table B.3. Comparison of U.S. reactor requirements and domestic resource availability (in metric tons of U_3O_8 as of January 1978)[a,b]

Time period	Reactor demand	Resource availability	
		At \$30/lb[c]	At \$50/lb[c]
Through year 2000	883,000		
For 30-year lifetime of 380 GWe	2,051,000		
Reserves[d]		626,000	808,000
Probable resources		921,000	1,180,000
Sum of reserves and probable resources		1,550,000	2,000,000

[a]To convert to short tons multiply by 1.1.

[b]Based on information presented by U.S. Energy Research and Development Administration (now U.S. Department of Energy) at the Uranium Industry Seminar, Grand Junction, Colorado, October 1977, and in "ERDA Makes Estimate of Higher Cost Uranium Resources," U.S. Energy Research and Development Administration, June 1978.

[c]Costs include all those incurred in property exploitation and production except costs of money and taxes.

[d]Does not include 126,000 MT of U_3O_8 which could be produced as a by-product of phosphate fertilizer and copper production.

In 1977, 23 mills produced about 12,000 MT of U_3O_8 while handling 32,000 MT of ore per day. These mills operated at 80 to 85% of capacity. The U_3O_8 content of the ore was less than 1.5 kg/MT (3 lb/ton; <0.15%).[4] Ores processed by the Shootering Canyon mill will have a U_3O_8 content approximating this national average.

As can be seen in Table B.1, the annual requirement for U_3O_8 in 1981 (17,500 MT) exceeds the output of existing uranium mills (12,000 MT). In 1980, the Shootering Canyon Uranium Project will produce 6% of the national capacity for tons of ore per day, and its total production of U_3O_8 through the next 15 years of operation would be about 3% of the national requirements. The project will contribute to meeting the demand forecast for the nuclear power industry.

REFERENCES FOR APPENDIX B

1. Office of the President, *National Energy Plan*, Washington, D.C., April 1977.

2. Brown and Williamson, U.S. Department of Energy, "Domestic Uranium Requirements, Policy and Evaluation," paper presented at the Urarium Seminar, Grand Junction, Colo., October 1977.

3. "ERDA Makes Preliminary Estimate of Higher Cost Uranium Resources," U.S. Energy Research and Development Administration Notice, June 1977.

4. J. F. Pacer, Jr., "Seminar on Uranium Resources," paper presented at the Uranium Seminar, Grand Junction, Colo., October 1977.

APPENDIX C

TICABOO FEASIBILITY ANALYSIS

TICABOO FEASIBILITY ANALYSIS

Introduction

The Ticaboo subdivision should provide a quality of life considerably higher that what the employees of the Shootering Canyon project would experience in an unplanned trailer camp. For example, the site plan calls for clustered housing, which minimizes disruption of the land and maximizes the preservation of open space. The site plan also visually separates portions of the development from each other (e.g., commercial from residential), which helps to preserve the resident's sense of privacy. The modular and conventional houses are proposed to be built with adobe, which will further help the development to blend with its setting. In addition to the visual aspects of Ticaboo, the applicant's consultants have also been trying to establish a high-quality school system for Ticaboo with the assistance of Brigham Young University (representative of Quality Development, Inc., private communication, August 17, 1978).

It is important to study the feasibility of Ticaboo to see whether the applicant's goals can be achieved under the development currently proposed. A standard feasibility analysis for a proposed housing development estimates the initial and monthly costs of housing and services and compares them with the estimated incomes of potential residents. Ordinarily these costs include marginal costs of utility extension. There is usually an existing housing market with which the costs can be compared.

In the case of the Ticaboo Subdivision, there are several factors that prevent a standard feasibility analysis:

1. Because the development is isolated, there is no housing market available for comparison and no costs are marginal.
2. The development is very small, which makes it impossible to evaluate the proposed services in terms of typical service area populations (e.g., the development really needs only part of a policeman).
3. A lack of information exists on key financial issues, such as costs of housing and services, financing mechanisms, available income, and assets of proposed residents.

Given the above problems, a definitive cost-revenue-oriented feasibility study is not possible at this time. Instead, the following evaluation is based on (1) the history of other comparable developments and (2) qualitative evaluation of the plans provided by the applicant. The evaluation examines the following issues:

- housing costs related to income of purchasers,
- effect of large proportion of mobile homes on development feasibility,
- market for development without the Shootering Canyon Uranium Project,
- financial feasibility of infrastructure development, and
- overall project feasibility.

Housing Costs Related to Income of Potential Purchasers

Ticaboo is expected to contain about 300 housing units. About 40% will be single-family houses of modular or conventional construction; another 40% will be mobile homes; the remaining 20% will be in multifamily housing.

Early estimates from the applicant and Ticaboo developer indicate a possible problem of meshing housing costs and available income from expected purchasers of those houses. Monthly housing costs are estimated to be between $376 and $426 for the modular houses and about $481 for the conventional houses. Some mobile homes will be provided by the development; monthly costs for these will be $268.[1] It is assumed that multifamily units would rent at close to the same rate as mobile homes.

In contrast to these housing costs, the developer's consultant projected those portions of employees' monthly incomes[1] that would be available for housing expenses. These dollar amounts represent 25% of the disposable income. (Disposable income is 80% of gross income.) Although this figure (actually 20% of the gross income) is somewhat higher than the 15% spent on housing by the typical U.S. household, it is still acceptable. In fact many government programs allow participants to pay 25% of their gross income on housing.

Skill level	Monthly income available for housing
Supervisors	$347
Miners	300
Miner assistants	250
Mechanics, electricians, equipment operators (A)	280
Mechanics, electricians, equipment operators, carpenters (B)	260
Laborers and trainees	190
Kitchen, office, and warehouse workers	150

As the cost and income figures reveal, only families with more than one wage earner could be expected to afford either conventional or modular units. Most employees could afford mobile homes. The applicant's consultant contends that many of the families will consist of two wage earners. The question remains whether the secondary wage earner would be employed at the time of moving to Ticaboo. Most banks would include all family income in estimating the family's capacity to pay the monthly housing costs; it is unlikely, however, that bankers would include the potential income of a family member. Therefore, at the least, there is a timing problem related to the affordability of housing.

The consultant reports that efforts to reduce housing costs are continuing. In addition, wages are expected to rise soon, when new mining contracts are negotiated. Even if housing costs are reduced and wages rise, the workers may still have a problem with down payments. The applicant is considering alternative plans for assisting employees who have difficulty meeting down payment requirements or who cannot qualify for permanent home financing. Possibilities would include mortgage guarantees or lease/purchase arrangements involving properties owned by the applicant.[2] If incomes and housing costs cannot be made to correlate, it is likely that the lower-cost housing (mobile homes and multifamily units) will predominate at Ticaboo.

Other similar developments have faced the problem of mismatched housing costs and worker income, or reluctance to buy housing, in a variety of ways, all of which involve some combination of a lease/purchase option. Three examples of such options follow:

> . . . once enough money had been paid to equal a 5 percent down payment on a bank home mortgage all the rent money was returned to the renter for the home purchase . . .
>
> A renter when buying, gets credit for all improvements as well as a year's rent deducted from his house cost . . .
>
> At any time during the initial three years a renting employee may purchase his house, receiving one-half of his base rent as an interest-free loan, which is forgiven at the rate of 1/30th of the original amount for 36 months.[3]

It is recommended that the applicant further consider these options for the Ticaboo development.

Effect of a Large Proportion of Mobile Homes on Development Feasibility

The goal of the developers of Ticaboo is to provide a high-quality community for the workers and their families who will be associated with the Shootering Canyon Uranium Project. This development is intended to be superior to the traditional trailer camp found at similar facilities. The developer recognizes a need to allow some room for mobile homes — partly for the construction workers and partly for single- or low-income permanent employees. Employees will be allowed to bring their own trailers.

This raises the question of whether the anticipated 40% mobile homes will have any effect on the success of Ticaboo. There is no conclusive answer to this question from available research. Although mobile homes do not preclude the development of a desirable community, they do add some risk.

The risk at Ticaboo is lessened somewhat because people in remote western areas are accustomed to living in or near mobile homes. Moreover, Ticaboo attempts to minimize the visual impact of these homes by grouping them separately from other areas of the development in a location not readily visible from the road. There may be some aesthetic problem within the mobile home area (since various sizes and styles are likely to be present), but this can be remedied with landscaping or some unifying architectural treatment (such as porches).

People are less likely to buy higher-priced homes if mobile homes are available. This situation is especially likely if services (particularly schools) are not available when the plant begins full operation. Finally, the development might operate successfully as an all-mobile-home community if appropriate site planning and infrastructure were provided, but it would not be the same community as proposed by the developer.

Market for the Development Without the Shootering Canyon Project

The applicant reported that "Ticaboo will be developed regardless of NRC's action on Plateau's proposed processing facility." The implication is that demand from the neighboring Bullfrog Marina, Glen Canyon National Recreation Area, is sufficient to provide a market for all the proposed units. Sufficient evidence has not been provided to support this claim. If it is true that Ticaboo would have a market other than the employees of the Shootering Canyon project and their families, the meshing of supply and demand factors related to those workers would have a less central position in the analysis.

Although it is true that visitations to Bullfrog Marina and surrounding recreation areas are rising at an annual rate of 20% and that currently about 150,000 visitations are made to the facility annually, Bullfrog Marina appears to have satisfied much of the demand for overnight visitors and is expanding its recreational vehicle sites to accommodate additional visitors. One park official reported that there would probably be some demand for motel spaces at Ticaboo from Bullfrog Marina visitors. However, he did not feel that Ticaboo would develop without the Shootering Canyon facility. His judgment was based on the seasonal quality of the recreational demand. In his opinion there would be virtually no demand for accommodations during the winter months. The official believes that visitation at Bullfrog Marina is dependent on external factors, particularly the economy and availability of fuel for automobiles. Because Bullfrog is 480 km (300 miles) from its prime market areas in Utah and Colorado, he feels it would be extremely risky for a development to plan on a primary market from Bullfrog Marina visitors.

The available evidence does not deny the possibility of a recreational market for Ticaboo housing; it only challenges the viability of the development without the mill. If there is such a market, it creates an additional problem: the need to safeguard sufficient housing for the workers and their families. The applicant indicated awareness of this potential area of competing demand for housing and is considering a way to mitigate.

Financial Feasibility of Infrastructure Development

A broad range of urban-level services is proposed for Ticaboo, including water, sanitary sewers, electricity, schools, and police and fire protection. The only health service to be provided initially is emergency transportation.

As described earlier in the report, the applicant intends to extend primary responsibility for Ticaboo to a private developer. This responsibility allots many of the initial capital costs to that developer. The developer has had the county form a special service district, so that tax-exempt bonds may be issued to finance water and sewer system development. The developer also hopes to transfer some costs, such as a garbage truck to the district.

A variety of financing plans have been considered, including county bonds, nonprofit corporation-issued bonds, leases, and prepayment of sales and use taxes. As stated earlier, it is not possible to conduct a quantitative evaluation of the feasibility of the financing methods being considered. The proposals can be compared, however, with the procedures used to finance other remote developments. The numerous cases of western mining towns reviewed in *Residential Aspects of Coal Development* by Dr. William C. Metz[3] have a common element of company investment in the provision of services (as well as in housing). There are two major reasons for this investment. First, in small, remote developments, it is highly unlikely that needed services could be paid for from current personal and property taxes received from the residential development. Even in suburban developments, where the costs of providing services are cheaper than in remote areas, residential development typically costs the local government more than it provides in revenues.* Second, although the eventual taxes from the industrial development will provide a net gain to the area, the payment of this revenue occurs after the major capital investments have to be made. Therefore, the government and taxpayers are being asked to take the risks that are being incurred by the development.

The likelihood that Ticaboo would, for a short time, be an economic liability, might cause difficulty in floating general bond issues or gaining support for revenue bonds for the needed services. Although bond issues are certainly an acceptable financing method, dependence on them might cause project delays that could jeopardize the success of Ticaboo. For example, if school construction cannot be financed in time to provide schools for the children of employees, employees will not bring their families, or a larger percentage of unmarried workers may become affiliated with the facility. If the work force composition is not as projected, it may be very difficult for the development to sell the housing. To ensure project success, the applicant may decide to consider additional front-end investment in Ticaboo.

Overall Project Feasibility

Evidence from similar industry-related communities leads to the following conclusion: such developments can be socially and financially feasible. The element needed to make this true is initial financial investment from the industry. The company is very likely to recoup

---

*The conclusion relative to residential costs vs revenues is reached based upon historical precedent, as shown in the following three studies, rather than upon evaluation of the specifics of Ticaboo.

1. A single family suburban development proposed in New Jersey would produce neither a gain nor loss to its local government; nearly all costs in the case were marginal increases in utilization of existing capacity, rather than new capital costs. (George Sternlieb et al., *Housing Development and Municipal Costs*, Center for Urban Policy Research, Rutgers University, New Brunswick, N.J., n.d., p. 49).
2. A major survey, *The Use of Land*, found that three recent cost-revenue studies show that "more families with school-age children mean higher property taxes for everyone." (William K. Reilly, Ed., *The Use of Land: A Citizens Policy Guide to Urban Growth*, Thomas Crowell, New York, 1973, p. 227.)
3. A study on remote recreational developments supports national findings that as these areas become full-time residences and service users, they impose net costs on local governments. (Judith Stoloff, *Critical Environmental Areas in Tennessee vs. Second Home Development*, State Planning Office, Nashville, Tenn., 1978, pp. 26-43.)

The indication from these sources is that from a local government, cost-revenue viewpoint — based on the residential development alone — Ticaboo would be a costly development.

the bulk of this investment either directly, through the sale of houses and community facilities, or indirectly, through savings produced by lower turnover and greater worker productivity.*

The company needs to make a substantial front-end investment. The local community may not want to take the risks of incurring large bonded indebtedness when the future of the uranium mine and mill cannot be guaranteed (see Sect. 4.8). Although the size of this investment cannot be specified, there is relevant experience from coal and nuclear generating plants. In one study, the utilities contributed between 0.01 and 1.38% of total project costs to community support and development activities.[4] The only known investment by the applicant to date is an $80,000 loan for planning to the developer of Ticaboo. This loan represents a very small — 0.0002% of all total capital and operating costs for the Shootering Canyon project.

The feasibility of Ticaboo is likely to be an issue which will be an investment decision for the applicant, who has already recognized the need to assist the residential development in addition to building the mine and mill. There is likely to be a need for additional front-end investment or guarantees. It is not clear how much of the investment will be regained directly from sale or lease of housing. The company will have to decide what value to place on the potential for lower turnover, higher productivity, and a superior quality of life for its workforce.

---

*Br'ef descriptions of other western coal and uranium company towns support this view (W. C. Metz, *Residential Aspects of Coal Development*, American Institute of Planners Annual Conference, Kansas City, Mo., Oct. 10-12, 1977, pp. 8-17.)

1. A mobile home community owned and operated by Amax Coal has cost the company $1.2 million and more investment is anticipated. The company expects to recoup this investment within 20 years.
2. A larger development is expected to cost ARCO $10 million. The company expects to recoup part of this investment and "meanwhile ARCO will be known for having built a first-class community because it cares about its workers."
3. Energy Development Corporation invested $1.5 million in a small development in Hanna, Wyoming. While the company lost $0.5 million, the loss was acceptable ". . . because the attraction of experienced workers was easier and work force turnover was less than 2 percent."
4. A United States Fuel Company town ". . . is an annual financial burden to the coal company, costing slightly over $50 thousand a year. The company considers the town an asset well worth the cost."

REFERENCES FOR APPENDIX C

1. Woodward-Clyde Consultants, "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," San Francisco, Calif., Aug. 29, 1978.

2. "Responses to NRC Questions on the Environmental Report for the Shootering Canyon Uranium Project," Oct. 9, 1978.

3. W. C. Metz, *Residential Aspects of Coal Development*, American Institute of Planners Annual Conference, Kansas City, Mo., Oct. 10-12, 1977.

4. Elizabeth Peelle, "Mitigating Community Impacts of Energy Development: Some Examples for Coal and Nuclear Generating Plants in the United States," presented at International Meeting of the American Nuclear Society, Nov. 17, 1976, Washington, D.C. [original title "Internalizing Social Costs in Power Plant Siting"], rev. December 1978 [to be published in a special issue of *Environment and Behavior* and *Nuclear Technology*].

Appendix D

DETAILED RADIOLOGICAL ASSESSMENT

Appendix D

DETAILED RADIOLOGICAL ASSESSMENT

Supplemental information is provided below that describes the models, data, and assumptions utilized by the staff in performing its radiological impact assessment of the Shootering Canyon Uranium Project. The primary calculational tool employed by the staff in performing this assessment is an NRC-modified version of the UDAD (Uranium Dispersion and Dosimetry) computer code, originated at Argonne National Laboratory.[1]

D.1 ANNUAL RADIOACTIVE MATERIAL RELEASES

Estimated annual activity releases for the Shootering Canyon site are provided in Table 3.5. Except for the annual average dusting rate for exposed tailings, these releases are based on the data and assumptions given in Table 3.4 and described elsewhere in Sect. 3 and in Appendix F. The dusting rate is calculated in accordance with the following equation:

$$M = \frac{3.156 \times 10^7}{0.5} \sum_s R_s F_s \ , \qquad (D.1)$$

where

F_s is the annual average frequency of occurrence of wind speed group s, dimensionless;

R_s is the dusting rate for tailings sands at the average wind speed for wind speed group s, for particles ≤ 20 μm in diameter, g/m^2·sec;

M is the annual dust loss per unit area, g/m^2·year;

3.156×10^7 is the number of seconds per year;

0.5 is the fraction of the total dust loss constituted by particles ≤ 20 μm in diameter, dimensionless.[1]

The values of R_s and F_s utilized by the staff are as given in Table D.1. The calculated value of the annual dusting rate, M, is 192 g/m^2·year. Annual curie releases from the tailings piles are then given by the following relationship:

$$S = MA(1 - f_c)f_t(283)(2.5)(1 \times 10^{-12}) \ , \qquad (D.2)$$

where

A is the assumed beach area of the pile, m^2;

f_c is the fraction of the dusting rate controlled by mitigating actions, dimensionless;

f_t is the fraction of the ore content of the particular nuclide present in the tails;

S is the annual release for the particular beach area, Ci/year;

283 is the assumed raw ore activity, pCi/g;

2.5 is the dust-to-tails activity ratio;

1×10^{-12} is Ci/pCi.

Table D.1. Parameter values for calculation of annual dusting rate for exposed tailings sands

Wind speed group (knots)	Average wind speed (mph)	Dusting rate, R_s (g/m^2·sec)[a]	Frequency of occurrence, F_s[b]
0–3	1.5	0	
4–6	5.5	0	
7–10	10.0	3.92E-7	0.1832
11–16	15.5	9.68E-6	0.0906
17–21	21.5	5.71E-5	0.0161
>21	28.0	2.08E-4	0.0057

[a]Dusting rate as a function of wind speed is computed by the UDAD Code. See M. Momeni et al., *Uranium Dispersion and Dosimetry (UDAD) Code*, Argonne National Laboratory, in preparation.

[b]Wind speed frequencies obtained from annual joint frequency presented in Table D.2.

Tailings emission calculations are based on the last year of operation. At that time the tailings impoundment will cover approximately 27.7 ha.[2] It is assumed that 100% of this area will be beach and subject to dust emission. Mitigating action to reduce dusting is assumed to reduce dust losses by 80%.

D.2 ATMOSPHERIC TRANSPORT

The staff analysis of offsite air concentrations of radioactive materials released at the Shootering Canyon mill site has been based on a full year of meteorological data collected onsite during the period 8/1/77 through 7/31/78.[2] The collected meteorological data are entered into the UDAD code as input, after assemblage and reduction, in the form of a joint frequency distribution by stability class, wind speed group, and direction. The joint frequency data employed by the staff for this analysis are presented in Table D.2.

The dispersion model employed by the UDAD code is the basic straight-line Gaussian plume model.[1] Ground level, sector-averaged concentrations are computed using this model and are corrected for decay and ingrowth in transit (for radon-222 and daughters) and for depletion due to deposition losses (for particulate material). Area sources are treated using a virtual point-source technique. Resuspension into the air of particulate material initially deposited on ground surfaces is treated using a resuspension factor that depends on the age of the deposited material and its particle size.[1] For the isotopes of concern here, the total air concentration including resuspension is about 1.6 times the ordinary air concentration.

The assumed particle size distribution, particle density, and deposition velocities for each source are presented in Table D.3.

D.3 CONCENTRATIONS IN ENVIRONMENTAL MEDIA

Information provided below describes the methods and data used by the staff to determine the concentrations of radioactive materials in the environmental media of concern in the vicinity of the Shootering Canyon site. These include concentrations in the air (for inhalation and direct external exposure), on the ground (for direct external exposure), and in meat and vegetables (for ingestion exposure). Concentration values are computed explicitly by the UDAD code for uranium-238, thorium-230, radium-226, radon-222 (air only), and lead-210. Concentrations of thorium-234, protactinium-234, and uranium-234 are assumed to be equal to that of uranium-238. Concentrations of bismuth-210 and polonium-210 are assumed to be equal to that of lead-210.

Table D.2. Joint frequency meteorological data in percent for the Shootering Canyon Uranium Project

MPH	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
STABILITY CLASS 1																	
1.5	.0492	.0123	.0123	0.0000	.0492	.0123	0.0000	.0738	.1353	.2705	.1476	.2091	.3812	.1107	.0615	.1230	1.6480
5.5	.0738	.0123	0.0000	0.0000	.0123	.0123	0.0000	.0123	.0369	.1353	.0984	.1599	.0861	.0984	.0369	.0861	.8610
10.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0492	0.0000	0.0000	0.0000	0.0000	0.0000	.0123	.0615
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.1230	.0246	.0123	0.0000	.0615	.0246	0.0000	.0861	.1722	.4550	.2460	.3690	.4673	.2091	.0984	.2214	2.5705
STABILITY CLASS 2																	
1.5	.1230	.0246	0.0000	0.0000	0.0000	.0123	.0123	.0369	.3935	.4796	.5534	.4550	.3320	.0984	.0369	.1230	2.6809
5.5	.1230	.0615	.0123	0.0000	.0123	.0369	.0123	.0861	.5534	.9069	.2705	.2705	.1353	.0861	0.0000	.1476	2.7547
10.0	.0492	.0369	.0123	.0123	0.0000	0.0000	0.0000	0.0000	.2951	.3689	.1722	.1230	.2091	.0984	.0861	.0369	1.5004
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0123	.0246	.0123	.0123	0.0000	0.0000	0.0000	.0615
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.2952	.1230	.0246	.0123	.0123	.0492	.0246	.1230	1.2420	1.8077	1.0207	.8608	.6887	.2829	.1230	.3075	6.9975
STABILITY CLASS 3																	
1.5	.0984	.0492	0.0000	.0123	.0123	.0246	.0123	.0984	.5288	.5657	.4796	.4304	.3689	.0738	.0738	.1230	2.9515
5.5	.0861	.0615	.0123	0.0000	.0123	.0123	.0123	.0492	.8116	.8116	.4550	.2828	.0984	.0615	.0246	.0738	2.8653
10.0	.0369	.0123	.0492	.0246	.0123	0.0000	.0123	.0492	.2582	.7624	.4304	.1599	.1722	.1353	.1107	.0984	2.3243
15.5	.0123	.0246	.0369	0.0000	.0123	0.0000	0.0000	0.0000	.0738	.3443	.1968	.1107	.0861	.0492	.0492	.0246	1.0208
21.5	.0123	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0123	.0246
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	.2460	.1476	.0984	.0369	.0492	.0369	.0369	.1968	1.6724	2.4840	1.5618	.9838	.7256	.3198	.2583	.3321	9.1865
STABILITY CLASS 4																	
1.5	1.8815	1.6478	.7870	.9100	1.1190	.5903	.4919	1.0944	1.9060	1.2174	.7747	.6608	1.4388	.4427	.1968	.7501	16.1092
5.5	1.2247	.6517	.1230	.0861	.1353	.0738	.0984	.6763	2.3656	1.2294	.4058	.2705	.2828	.1845	.1107	.3689	8.3125
10.0	.5534	.3812	.2828	.1107	.0492	.0246	.0369	.1722	1.5002	1.6478	.7378	.3074	.3689	.0984	.0984	.2459	6.6158
15.5	.2459	.3320	1.1559	.2705	.0123	0.0000	.0123	.0615	.4181	1.5002	1.1559	.5534	.3689	.0984	.0861	.1968	6.4682
21.5	.0615	.0615	.5903	.0369	0.0000	.0246	0.0000	0.0000	.1230	.1599	.2336	.1476	.0123	.0492	.0123	.0738	1.5865
28.0	0.0000	.0369	.1845	0.0000	.0123	0.0000	0.0000	0.0000	.0123	.1107	.0123	.0492	.0492	.0246	.0246	.0492	.5658
ALL	3.9720	3.1111	3.1235	1.4142	1.3281	.7133	.6395	2.0044	6.3452	5.8654	3.3201	2.1889	2.5209	.8978	.5289	1.6847	39.6580
STABILITY CLASS 5																	
1.5	1.7846	2.7692	1.1446	.9846	1.0708	.8000	.5538	.7015	1.3415	.8246	.2708	.5169	.8246	.3815	.0369	.5415	14.5474
5.5	.9838	.5534	.1599	.0615	.0492	.0738	.3689	.9715	1.2297	.5165	.2213	.2705	.3566	.0369	.0246	.2091	6.0872
10.0	.4304	.5042	.7993	.1353	.0984	.0123	.1599	.5534	1.5986	.7501	.5288	.5534	.5657	.1230	.0246	.3320	7.1694
15.5	.0246	.0738	.3074	.1107	.0246	0.0000	.0246	.0123	.2951	.2336	.1353	.1599	.0615	0.0000	0.0000	.0492	1.5126
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	3.2234	3.9006	2.4112	1.2921	1.2430	.8861	1.1072	2.2387	4.4649	2.3248	1.1562	1.5007	1.8084	.5414	.0861	1.1318	29.3166
STABILITY CLASS 6																	
1.5	1.4703	1.5301	.3979	.4487	.5113	.1618	.3104	.3831	.5833	.4718	.1377	.4369	.4987	.2882	.0746	.3992	8.1046
5.5	.7378	.7132	.2583	.0492	.0492	.0984	.2214	.4550	.4304	.1599	.0615	.0492	.0861	.0615	.0123	.0738	3.5172
10.0	.0615	.0861	.0738	.0246	.0123	0.0000	.0246	.0615	.1599	.0492	.0369	.0369	.0123	0.0000	0.0000	.0123	.6519
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ALL	2.2696	2.3294	.7300	.5225	.5728	.2602	.5564	.8996	1.1736	.6809	.2361	.5230	.5971	.3497	.0869	.4853	12.2731
ALL	10.1292	9.6363	6.4000	3.2780	3.2669	1.9703	2.3606	5.5486	15.0703	13.6178	7.5409	6.4262	6.6080	2.6007	1.1816	4.1628	100.0022

Table D.3. Physical characteristics assumed for particulate material releases

Activity source	Diameter (μm)	Density (g/cm³)	Deposition velocity (cm/sec)	AMAD[a] (μm)
Crusher dusts	1.0	2.4	1.0	1.55
Yellow cake dusts	1.0	8.9	1.0	2.98
Tailings, ore pile dusts	5.0 (30%)	2.4	1.0	7.75
	35.0 (70%)	2.4	8.8	54.2
Ingrown Rn daughters		1.0	0.3	0.3

[a]Aerodynamic equivalent diameter, used in calculating inhalation doses. See M. Momeni et al., *Uranium Dispersion and Dosimetry (UDAD) Code*, Argonne National Laboratory, in preparation.

D.3.1 Air concentration

Ordinary, direct air concentrations are computed by the UDAD code for each receptor location, from each activity source, by particle size (for particulates). Direct air concentrations computed by UDAD include depletion by deposition (particulates) or the effects of ingrowth and decay in transit (radon and daughters). To compute inhalation doses, the total air concentration of each isotope at each location, as a function of particle size, is computed as the sum of the direct air concentration and the resuspended air concentration:

$$C_{aip}(t) = C_{aipd} + C_{aipr}(t) , \tag{D.3}$$

where

$C_{aip}(t)$ is the total air concentration of isotope i, particle size p, at time t, pCi/m³;

C_{aipd} is the direct air concentration of isotope i, particle size p (constant), pCi/m³;

$C_{aipr}(t)$ is the resuspended air concentration of isotope i, particle size p, at time t, pCi/m³.

The resuspended air concentration is computed using a time-dependent resuspension factor, $R(t)$, defined by

$$R_p(t) = (1/V_p)10^{-5} \exp(-\lambda_R t) \text{ (for } t \leq 1.82 \text{ years)} , \tag{D.4a}$$

$$R_p(t) = (1/V_p)10^{-9} \qquad \text{(for } t > 1.82 \text{ years)} , \tag{D.4b}$$

where

$R_p(t)$ is the ratio of the resuspended air concentration to the ground concentration, for a ground concentration of age t years, of particle size p, m⁻¹;

V_p is the deposition velocity of particle size p, cm/sec;

λ_R is the assumed decay constant of the resuspension factor (equivalent to a 50-day half-life), 5.06 yr⁻¹;

10^{-5} is the initial value of the resuspension factor (for particles with a deposition velocity of 1 cm/sec), m⁻¹;

10^{-9} is the terminal value of the resuspension factor (for particles with a deposition velocity of 1 cm/sec), m⁻¹;

1.82 is the time required to reach the terminal resuspension factor, years.

The basic formulation of the above expression for the resuspension factor, the initial and final values, and the assigned decay constant derive from experimental observations.[3] The inverse relationship to deposition velocity eliminates mass balance problems involving resuspension of more than 100% of the initial ground deposition for the 35-μm particle size (see Table D.3). Based on this formulation, the resuspended air concentration is given by

$$C_{aipr}(t) = 0.01C_{aipd}\left[10^{-5}\left\{\frac{1 - \exp[-(\lambda_i^* + \lambda_R)1.82]}{(\lambda_i^* + \lambda_R)}\right\} + 10^{-9}\left\{\frac{\exp(-1.82\lambda_i^*) - \exp(-\lambda_i^* t)}{\lambda_i^*}\right\}\right](3.156 \times 10^7) \quad , \quad \text{(D.5)}$$

where λ_i^* is the effective decay constant for isotope i on soil (see Eq. D.7) per year; 0.01 is the deposition velocity of particles for which the initial and final values of the resuspension factor are defined in m/sec; and 3.156×10^7 is sec/year.

Total air concentrations are computed using Eqs. D.5 and D.3 for all particulate effluents. Radon daughters that grow in from released radon are not depleted due to deposition losses and are therefore not assumed to resuspend.

D.3.2 Ground concentrations

Concentrations of particulate materials in and on soil are computed from direct air concentrations. Resuspension of deposited activity is not treated as a loss mechanism and redeposition is ignored. Ground concentrations are given by

$$C_{gip}(t) = 0.01C_{aipd}V_p\left[\frac{1 - \exp(-\lambda_i^* t)}{\lambda_i^*}\right] \quad , \quad \text{(D.6)}$$

where

$C_{gip}(t)$ is the ground concentration of isotope i, particle size p, at time t, pCi/m^2;

λ_i^* is the effective decay constant for isotope i on or in soil, per year;

$$\lambda_i^* = \lambda_i + \lambda^* \; ; \quad \text{(D.7)}$$

where λ_i is the radiological decay constant, per year; λ^* is the assumed environmental loss constant for activity in soil (equivalent to a 50-year half-life), 1.39×10^{-2} per year; and 0.01 is m/cm.

In general, the half-lives of the pertinent isotopes are such that it is appropriate to assume either complete ingrowth or no ingrowth. However, ingrowth of lead-210 from radium-226 is treated explicitly using the standard Bateman formulation.

D.3.3 Vegetation concentrations

Concentrations of released particulate materials can be environmentally transferred to the edible portions of vegetables, or to hay or pasture grass consumed by animals, by two mechanisms — direct foliar retention and root intake. Five categories of vegetation are treated by the staff-modified version of the UDAD code. They are edible above-ground vegetables, potatoes, other edible below-ground vegetables, pasture grass, and hay. Vegetation concentrations are computed using the following equation

$$C_{vip} = 0.01V_pC_{aip}F_rE_v\left[\frac{1 - \exp(-\lambda_w t_v)}{Y_v\lambda_w}\right] + C_{gip}(B_{vi}/P) \quad , \quad \text{(D.8)}$$

where

B_{vi} is the soil-to-plant transfer factor for isotope i, vegetation type v, dimensionless;

C_{vip} is the resulting concentration of isotope i, particle size p, in vegetation v, pCi/kg;

E_v is the fraction of the foliar deposition reaching edible portions of vegetation v, dimensionless;

F_r is the fraction of the total deposition retained on plant surfaces, 0.2, dimensionless;

P is the assumed areal soil density for surface mixing, 240 kg/m^2;

t_v is the assumed duration of exposure while growing for vegetation v, sec;

Y_v is the assumed yield density of vegetation v, kg/m^2;

λ_w is the decay constant accounting for weathering losses (equivalent to a 14-day half-life), 6.73×10^{-7} per sec;

0.01 is m/cm.

The value of E_v is assumed to be 1.0 for all above-ground vegetation, and 0.1 for all below-ground vegetables.[4] The value of t_v is taken to be 60 days, except for pasture grass where a value of 30 days is assumed. The yield density, Y_v, is taken to be 2.0 kg/m^2 except for pasture grass, where a value of 0.75 kg/m^2 is applied. Values of the soil-to-plant transfer coefficients, B_{vi}, are provided in Table D.4.

Table D.4. Environmental transfer coefficients

	U	Th	Ra	Pb
Plant/soil (B_{vi})				
Edible above ground	2.5E-3	4.2E-3	2.0E-2	4.2E-3
Potatoes	2.5E-3	4.2E-3	3.2E-3	4.2E-3
Other below ground	2.5E-3	4.2E-3	2.0E-2	4.2E-3
Pasture grass	2.5E-3	4.2E-3	6.6E-2	7.8E-2
Stored feed (hay)	2.5E-3	4.2E-3	6.6E-2	7.8E-2
Beef/feed (F_{bi}), pCi/kg per pCi/day	3.4E-4	2.0E-4	3.0E-3	2.9E-4

D.3.4 Meat concentrations

Radioactive materials can be deposited on grasses, hay, or silage that are eaten by meat animals, which are in turn eaten by man. For the Shootering Canyon site, it has been assumed that meat animals obtain their entire feed requirement by grazing (ER, p. F-9). The equation used to estimate meat concentrations is

$$C_{mi} = QF_{bi}C_{pgi} , \qquad (D.9)$$

where

C_{pgi} is the concentration of isotope i in pasture grass, pCi/kg;

C_{mi} is the resulting concentration of isotope i in meat, pCi/kg;

F_{bi} is the feed-to-meat transfer factor for isotope i, pCi/kg per pCi/day (see Table D.4);

Q is the assumed feed ingestion rate, 50 kg/day.

D.4 DOSES TO INDIVIDUALS

Doses to individuals have been calculated for inhalation, external exposure to air and ground concentrations, and ingestion of vegetables and meat. Internal doses are calculated by the staff using dose conversion factors that yield the 50-year dose commitment, that is, the entire dose insult received over a period of 50 years following either inhalation or ingestion. Annual doses given are the 50-year dose commitments resulting from a one-year exposure period. The one-year exposure period was taken to be the final year of mill operation when environmental concentrations resulting from plant operations are expected to be at their highest level.

D.4.1 Inhalation doses

Inhalation doses have been computed using air concentrations obtained by Eq. D.3 (resuspended air concentrations are included) for particulate materials, and the dose conversion factors presented in Table D.5. These dose conversion factors have been computed[1] in accordance with the Task Group Lung Model of the International Commission on Radiological Protection.[5] Doses to the bronchial epithelium from radon-222 and short-lived daughters were computed based on the assumption of indoor exposure at 100% occupancy. The dose conversion factor for bronchial epithelium exposure from radon-222 is derived as follows:

1 pCi/m^3 of radon-222 = 5×10^{-6} working level (WL);*

continuous exposure to 1 WL = 25 cumulative working level months (WLM) per year;

1 WLM = 5000 millirems .[7]

Therefore,

$$(1\ pCi/m^3 \text{ of radon-222})\left(5 \times 10^{-6}\ \frac{WL}{pCi/m^3}\right)\left(25\ \frac{WLM}{WL}\right)\left(5000\ \frac{\text{millirems}}{WLM}\right) = 0.625 \text{ millirem} ;$$

thus the radon-222 bronchial epithelium dose conversion factor is taken to be 0.625 millirem $year^{-1}\ pCi^{-1}\ m^{-3}$.

D.4.2 External doses

External doses from air and ground concentrations are computed using the dose conversion factors provided in Table D.6.[1] Doses were computed based on 100% occupancy at the particular location. Indoor exposure was assumed to occur 14 hr/day at a dose rate of 70% of the outdoor dose rate.

D.4.3 Ingestion doses

Ingestion doses have been computed for fresh vegetables and meat (beef, processed pork, and lamb). Ingestion doses reported are based on concentrations obtained using Eqs. D.8 and D.9, ingestion rates given in Table D.7, and dose conversion factors given in Table D.8.[1,8] Vegetable ingestion doses were computed assuming an average 50% activity reduction due to food preparation.[4] Ingestion doses to children and teenagers were computed and found to be less than adult doses.

---

*One WL concentration is defined as any combination of short-lived radioactive decay products of radon-222 in 1 liter of air that will release 1.3×10^5 MeV of alpha-particle energy during their radioactive decay of lead-210. The conversion factor given is from ref. 6.

Table D.5. Inhalation dose conversion factors, millirems year^{-1} pCi^{-1} m^{-3}

Particle size = 0.3 μm

	Pb-210	Po-210
Whole body	7.46	1.29
Bone	2.32E2	5.24
Kidney	1.93E2	3.87E1
Liver	5.91E1	1.15E1
Mass average lung	6.27E1	2.66E2

Particle size = 1.0 μm; density = 8.9 g/cm^3

	U-238	U-234	Th-230	Ra-226	Pb-210	Po-210
Whole body	1.44	1.64	1.37E2	3.97E1	9.42	1.77
Bone	2.42E1	2.64E1	4.90E3	3.97E2	2.87E2	7.22
Kidney	5.53	6.30	1.37E3	1.40	2.39E2	5.33E1
Liver	0	0	2.82E2	4.94E-2	7.32E1	1.59E1
Mass average lung	2.13E3	2.42E3	2.37E3	3.04E2	2.49E1	1.12E2

Particle size = 1.0 μm; density = 2.4 g/cm^3

	U-238	U-234	Th-230	Ra-226	Pb-210	Po-210
Whole body	1.65	1.87	1.66E2	3.40E1	8.24	1.54
Bone	2.78E1	3.03E1	5.95E3	3.40E2	2.56E2	6.29
Kidney	6.33	7.22	1.67E3	1.20	2.13E2	4.64E1
Liver	0	0	3.43E2	4.22E-2	6.53E1	1.38E1
Mass average lung	2.88E3	3.28E3	3.22E3	4.04E2	3.38E1	1.48E2

Particle size = 5.0 μm

	U-238	U-234	Th-230	Ra-226	Pb-210	Po-210
Whole body	1.16	1.32	1.01E2	4.47E1	1.00E1	1.96E
Bone	1.96E1	2.14E1	3.60E3	4.47E2	3.11E2	7.99
Kidney	4.47	5.10	1.00E3	1.57	2.59E2	5.89E1
Liver	0	0	2.07E2	5.55E-2	7.93E1	1.76E1
Mass average lung	1.24E3	1.42E3	1.38E3	1.87E2	1.45E1	7.01E1

Particle size = 35.0 μm

	U-238	U-234	Th-230	Ra-226	Pb-210	Po-210
Whole body	7.92E-1	9.02E-1	5.77E1	4.40E1	9.66	[illegible]
Bone	1.34E1	1.46E1	2.07E3	4.40E2	3.00E2	7.84
Kidney	3.05	3.47	5.73E2	1.55	2.50E2	5.79E1
Liver	0	0	1.19E2	5.47E-2	7.65E-1	1.73E1
Mass average lung	3.33E2	3.80E2	3.71E2	6.38E1	3.91	2.58E1

Table D.6. Dose conversion factors for external exposure

Isotope	Skin	Whole body
Dose factors for doses from air concentrations, millirems $year^{-1}$ pCi^{-1} m^{-3}		
U-238	1.05E-5	1.57E-6
Th-234	6.63E-5	5.24E-5
Pa-234	8.57E-5	6.64E-5
U-234	1.36E-5	2.49E-6
Th-230	1.29E-9	3.59E-6
Ra-226	6.00E-5	4.90E-5
Rn-222	3.46E-10	2.83E-6
Po-218	8.18E-7	6.34E-7
Pb-214	2.06E-3	1.67E-3
Bi-214	1.36E-2	1.16E-2
Po-214	9.89E-7	7.66E-7
Pb-210	4.17E-5	1.43E-5
Dose factors for doses from gound concentrations, millirems $year^{-1}$ pCi^{-1} m^{-2}		
U-238	2.13E-6	3.17E-7
Th-234	2.10E-6	1.66E-6
Pa-234	1.60E-6	1.24E-6
U-234	2.60E-6	4.78E-7
Th-230	2.20E-6	6.12E-7
Ra-226	1.16E-6	9.47E-7
Rn-222	6.15E-8	5.03E-8
Po-218	1.42E-8	1.10E-8
Pb-214	3.89E-5	3.16E-5
Bi-214	2.18E-4	1.85E-4
Po-214	1.72E-8	1.33E-8
Pb-210	6.65E-6	2.27E-6

Table D.7. Assumed food ingestion rates,[a] kg/year

	Child	Teen	Adult
Fresh vegetables (total)	48	76	105
Edible above ground	17	29	40
Potatoes	27	42	60
Other below ground	3.4	5	5
Meat (beef, processed pork, and lamb)	28	45	78

[a]Ingestion rates are averages for typical rural farm households. No allowance is credited for portions of year when locally grown food may not be available.

Source: J. F. Fletcher and W. L. Dotson, compilers, *HERMES — A Digital Computer Code for Estimating Regional Radiological Effects from the Nuclear Power Industry*, Hanford Engineering Development Laboratory, Report HEDL-TME-71-168, December 1971.

Table D.8. Ingestion dose conversion factors, millirems/pCi

Age group	Organ	U-238	U-234	Th-234	Th-230	Ra-226	Pb-210	Bi-210	Po-210
Infant	Whole body	3.33E-4	3.80E-4	2.00E-8	1.06E-4	1.07E-2	2.38E-3	3.58E-7	7.41E-4
	Bone	4.47E-3	4.88E-3	6.92E-7	3.80E-3	9.44E-2	5.28E-2	4.16E-6	3.10E-3
	Liver	0	0	3.77E-8	1.90E-4	4.76E-5	1.42E-2	2.68E-5	5.93E-3
	Kidney	9.28E-4	1.06E-3	1.39E-7	9.12E-4	8.71E-4	4.33E-2	2.08E-4	1.26E-2
Child	Whole body	1.94E-4	2.21E-4	9.88E-9	9.9[illegible]-5	9.87E-3	2.09E-3	1.69E-7	3.67E-4
	Bone	3.27E-3	3.57E-3	3.42E-7	3.5[illegible]E-3	8.76E-2	4.75E-2	1.97E-6	1.52E-3
	Liver	0	0	1.51E-8	1.78E-4	1.84E-5	1.22E-2	1.02E-5	2.43E-3
	Kidney	5.24E-4	5.98E-4	8.01E-8	8.67E-4	4.88E-4	3.67E-2	1.15E-4	7.56E-3
Teenager	Whole body	6.49E-5	7.39E-5	3.31E-9	6.00E-5	5.00E-3	7.01E-4	5.66E-8	1.23E-4
	Bone	1.09E-3	1.19E-3	1.14E-7	2.16E-3	4.90E-2	1.81E-2	6.59E-7	5.09E-4
	Liver	0	0	6.68E-9	1.23E-4	8.13E-6	5.44E-3	4.51E-6	1.07E-3
	Kidney	2.50E-4	2.85E-4	3.81E-8	5.99E-4	2.32E-4	1.72E-2	5.48E-5	3.60E-3
Adult	Whole body	4.54E-5	5.17E-5	2.13E-9	5.70E-5	4.60E-3	5.44E-4	3.96E-8	8.59E-5
	Bone	7.67E-4	8.36E-4	8.01E-8	2.06E-3	4.60E-2	1.53E-2	4.61E-7	3.56E-4
	Liver	0	0	4.71E-9	1.17E-4	5.74E-6	4.37E-3	3.18E-6	7.56E-4
	Kidney	1.75E-4	1.99E-4	2.67E-8	5.65E-4	1.63E-4	1.23E-2	3.83E-5	2.52E-3

REFERENCES FOR APPENDIX D

1. M. Momeni et al., *Uranium Dispersion and Dosimetry (UDAD) Code*, Argonne National Laboratory Report, in preparation.

2. M. B. Bennedsen, "Responses to NRC questions on 'Input Data Requirement — Radiological Impact Analysis' for the Shootering Canyon Uranium Project," Nov. 28, 1978.

3. U.S. Nuclear Regulatory Commission, *Generic Environmental Impact Statement on Uranium Milling*, Report NUREG-0511, in preparation.

4. J. F. Fletcher and W. L. Dotson, compilers, *HERMES — A Digital Computer Code for Estimating Regional Radiological Effects from the Nuclear Power Industry*, Report HEDL-TME-71-168, Hanford Engineering Development Laboratory, Hanford, Wash., December 1971.

5. ICRP Task Group on Lung Dynamics, "Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract," *Health Phys.* 12: 181 (1966).

6. U.S. Environmental Protection Agency, *Environmental Analysis of the Uranium Fuel Cycle. Part I — Fuel Supply*, Report EPA-520/9-73-003-B, October 1973.

7. National Academy of Sciences — National Research Council, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, Report of the Advisory Committee on the Biological Effects of Ionizing Radiation* (BEIR Report), NAS-NRC, Washington, D.C., 1972.

8. G. R. Hoenes and J. K. Soldat, *Age — Specific Radiation Dose Conversion Factors for a One-Year Chronic Intake*, Report NUREG-0172, Battelle Pacific Northwest Laboratories, Richland, Wash., November 1977.

Appendix E

ATMOSPHERIC DISPERSION COEFFICIENTS

Appendix E

ATMOSPHERIC DISPERSION COEFFICIENTS

Tables E.1 through E.3 list χ/Q (sec/m^3) values calculated by the staff using AIRDOS-II, a FORTRAN computer code,[1] and onsite meteorological data supplied by the applicant (ER, Supplement S2, Sect. 2.7). Joint frequency distributions of wind velocities and directions summarized by stability class are given in Table D.2 of Appendix D.

Table E.1. Annual average χ/Q (sec/m^3) at various distances from the facility site for the 16 compass directions, release height 1 m.

Wind	Distance from center of facility (m)						
Toward	200	400	800	1200	2400	4200	9700
N	8.84E-5	2.16E-5	5.17E-6	2.32E-6	6.25E-7	2.25E-7	4.79E-8
NNW	4.23E-5	1.01E-5	2.37E-6	1.05E-6	2.74E-7	9.58E-8	1.89E-8
NW	2.46E-5	5.48E-6	1.18E-6	4.98E-7	1.22E-7	4.09E-8	7.34E-9
WNW	1.99E-5	4.42E-6	9.60E-7	4.08E-7	9.87E-8	3.20E-8	5.30E-9
W	3.75E-5	7.89E-6	1.59E-6	6.54E-7	1.53E-7	4.90E-8	8.26E-9
WSW	3.45E-5	7.44E-6	1.55E-6	6.48E-7	1.57E-7	5.21E-8	9.42E-9
SW	4.43E-5	1.05E-5	2.40E-6	1.06E-6	2.78E-7	9.96E-8	2.10E-8
SSW	1.05E-4	2.27E-5	4.64E-6	1.92E-6	4.54E-7	1.48E-7	2.62E-8
S	1.04E-4	2.27E-5	4.64E-6	1.91E-6	4.55E-7	1.51E-7	2.83E-8
SSE	3.21E-5	7.09E-6	1.55E-6	6.68E-7	1.71E-7	5.97E-8	1.21E-8
SE	6.52E-6	1.51E-6	3.42E-7	1.58E-7	3.90E-8	1.37E-8	2.92E-9
ESE	2.14E-5	4.48E-6	9.08E-7	3.79E-7	9.25E-8	3.13E-8	6.09E-9
E	4.90E-5	1.11E-5	2.48E-6	1.08E-6	2.75E-7	9.52E-8	1.90E-8
ENE	4.01E-5	9.06E-6	2.03E-6	8.88E-7	2.32E-7	8.23E-8	1.74E-8
NE	3.20E-5	7.90E-6	1.94E-6	8.82E-7	2.43E-7	8.91E-8	2.00E-8
NNE	6.29E-5	1.52E-5	3.66E-6	1.65E-6	4.47E-7	1.62E-7	3.55E-8

Table E.2. Annual average χ/Q (sec/m³) at various distances from the facility site for the 16 compass directions, release height 11 m.

Wind Toward	Distance from center of facility (m)						
	200	400	800	1200	2400	4200	9700
N	3.36E-5	1.69E-5	5.88E-6	3.00E-6	9.21E-7	3.32E-7	6.61E-8
NNW	1.32E-5	7.61E-6	2.88E-6	1.47E-6	4.39E-7	1.55E-7	2.91E-8
NW	5.98E-6	3.81E-6	1.48E-6	7.84E-7	2.46E-7	8.23E-8	1.29E-8
WNW	7.03E-6	4.12E-6	1.40E-6	6.95E-7	1.98E-7	6.36E-8	9.64E-9
W	1.13E-5	6.36E-6	2.20E-6	1.16E-6	3.66E-7	1.14E-7	1.52E-8
WSW	9.85E-6	5.76E-6	2.03E-6	1.08E-6	3.43E-7	1.10E-7	1.61E-8
SW	1.15[illegible]	7.36E-6	2.73E-6	1.44E-6	4.61E-7	1.64E-7	3.06E-8
SSW	2.35E-5	1.51E-5	5.79E-6	3.16E-6	1.03E-6	3.37E-7	4.79E-8
S	2.40E-5	1.39E-5	5.21E-6	2.92E-6	1.02E-6	3.39E-7	4.92E-8
SSE	1.03E-5	5.23E-6	1.84E-6	9.90E-7	3.23E-7	1.07E-7	1.78E-8
SE	2.83E-6	1.18E-6	3.93E-7	2.04E-7	6.45E-8	2.20E-8	3.92E-9
ESE	6.40E-6	3.08E-6	1.04E-6	5.90E-7	2.07E-7	6.60E-8	9.49E-9
E	1.88E-5	8.90E-6	2.99E-6	1.55E-6	4.88E-7	1.64E-7	2.80E-8
ENE	1.52E-5	6.84E-6	2.30E-6	1.22E-6	3.98E-7	1.34E-7	2.39E-8
NE	1.62E-5	6.62E-6	2.08E-6	1.05E-6	3.26E-7	1.18E-7	2.49E-8
NNE	2.73E-5	1.23E-5	4.15E-6	2.11E-6	6.44E-7	2.29E-7	4.61E-8

Table E.3. Annual average χ/Q (sec/m³) at various distances from the facility site for the 16 compass directions, release height 24 m.

Wind Toward	Distance from center of facility (m)						
	200	400	800	1200	2400	4200	9700
N	3.10E-6	4.40E-6	3.36E-6	2.14E-6	8.04E-7	3.32E-7	8.03E-8
NNW	4.89E-7	1.21E-6	1.32E-6	9.28E-7	3.83E-7	1.62E-7	3.79E-8
NW	6.91E-8	3.62E-7	5.86E-7	4.43E-7	1.91E-7	8.07E-8	1.87E-8
WNW	1.23E-7	3.63E-7	5.36E-7	4.25E-7	1.81E-7	7.31E-8	1.48E-8
W	1.62E-7	5.88E-7	9.19E-7	6.85E-7	2.76E-7	1.12E-7	2.48E-8
WNW	1.38E-7	8.36E-7	9.80E-7	6.80E-7	2.63E-7	1.06E-7	2.41E-8
SW	5.52E-7	1.34E-6	1.39E-6	9.44E-7	3.73E-7	1.57E-7	3.90E-8
SSW	4.60E-7	1.80E-6	2.32E-6	1.73E-6	7.35E-7	3.10E-7	7.34E-8
S	9.08E-7	2.24E-6	2.35E-6	1.54E-6	6.63E-7	2.82E-7	7.27E-8
SSE	1.06E-6	1.33E-6	1.02E-6	6.50E-7	2.42E-7	9.83E-8	2.33E-8
SE	4.87E-7	4.66E-7	2.54E-7	1.45E-7	5.00E-8	2.03E-8	5.02E-9
ESE	8.72E-7	8.37E-7	5.87E-7	3.73E-7	1.35E-7	5.34E-8	1.31E-8
E	2.41E-6	2.52E-6	1.77E-6	1.10E-6	3.94E-7	1.57E-7	3.67E-8
ENE	2.58E-6	2.41E-6	1.44E-6	8.61E-7	3.04E-7	1.22E-7	2.96E-8
NE	3.01E-6	2.80E-6	1.43E-6	8.53E-7	2.87E-7	1.14E-7	2.81E-8
NNE	4.45E-6	4.37E-6	2.60E-6	1.56E-6	5.61E-7	2.28E-7	5.48E-8

REFERENCE FOR APPENDIX E

1. R. E. Moore, *The AIRDOS-II Computer Code for Estimating Radiation Dose to Man from Airborne Radionuclides in Areas Surrounding Nuclear Facilities*, Report ORNL-5425, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1977.

Appendix F

RADON RELEASES FROM AREA SOURCES

Appendix F

RADON RELEASES FROM AREA SOURCES

This appendix describes the assumptions, data, and equations used to estimate annual radon-222 releases from the ore storage facility and the tailings impoundment system. For the tailings area, radon-222 releases are estimated for both prereclamation and postreclamation conditions.

F.1 AVERAGE SPECIFIC FLUX

Radon release rates from area sources are based on an assumed average specific flux of 1 $pCi/m^2 \cdot sec$ of radon-222 per picocurie per gram of the parent radium-226. This value has been used to obtain radon-222 releases from the ore storage pile and the unreclaimed tailings area. Radon releases from the reclaimed tailings impoundment have been estimated by using this specific flux to estimate the upward flux at the surface of the tailings, which is then attenuated by the specified cover materials and depths.

Actual radon fluxes are dependent on a wide range of highly variable site- and time-specific conditions. These include, for example, topography, wind conditions, humidity, temperatures, and rainfall as well as characteristics of the host ore or tailings materials such as particle sizes and distribution, porosity, and most importantly, moisture content. At present there is no generalized calculational model by which all of these parameters can be accounted for in the estimation of radon-222 releases. Thus, the staff has elected to use the average specific flux identified above. The particular numerical value chosen is based on estimates presented in refs. 1 and 2 for radon releases from uranium mill tailings. Haywood et al. have calculated the average specific flux from tailings materials, based on diffusion coefficients from ref. 3, to be 0.35, 0.65, and 1.2 $pCi/m^2 \cdot sec$ per picocurie per gram of radium-226 for wet, moist, and dry tailings respectively.[1] Also, Schiager has estimated a specific flux for dry, packed tailings of 1.6 $pCi/m^2 \cdot sec$ per picocurie per gram of radium-226.[2]

In view of the above, the staff considers the assumed average specific flux to be a reasonable estimate for tailings materials, which are subject to large spatial and temporal variations in moisture content. In light of the proposed plan to maintain moist tailings surfaces, it is likely to be somewhat conservative. The assumed average specific flux is also applied to obtain radon-222 releases from the ore storage pile. Although the raw ore is generally composed of rock-like fragments, as opposed to sand grains, and may thus have a reduced fraction of escaped radon, the ore pile is also subject to continuing physical disturbance as raw ore is added or removed. In any event, the estimated ore pile radon release is only a small fraction of that calculated for the tailings area, and offsite exposures are relatively unaffected by radon from the ore pile.

F.2 RADON FROM ORE STORAGE

For the Shootering Canyon Uranium Project, the average raw ore concentration of radium-226 is estimated to be 283 pCi/g. The ore storage facility area is 0.25 ha (0.63 acres), and the estimated annual radon-222 release is given by the product

$$\left(\frac{1.0\ pCi/m^2 \cdot sec}{pCi/g}\right)(283\ pCi/g)(2500\ m^2)(3.156 \times 10^7\ sec/year)(10^{-12}\ Ci/pCi)\ .$$

The estimated radon-222 release is 22.3 Ci/year.

F.3 RADON FROM UNRECLAIMED TAILINGS

The radon release from the tailings area is estimated based on the ultimate tailings pile area, 27.7 ha (68.5 acres), and the average radium-226 concentration in the tailings, 282.4 pCi/g. The average tailings radium-226 concentration is the average raw ore concentration times the fraction passing through the mill and remaining in the tails, 0.998. The estimated radon-222 release rate from the fully developed tailings area is calculated to be 2470 Ci/year.

F.4 RADON FROM RECLAIMED TAILINGS

The radon-222 flux at the surface of the tailings material is estimated to be 282.4 pCi/m^2·sec. This is also the rate of radon release for the uncovered tailings material. After mill operation ceases, the tailings area will be reclaimed by the application of cover material. The proposed tailings pile cover consists of a 6-ft (183-cm) layer of compacted clayey material and a 2-ft (61-cm) layer of sandy-soil material.

A 1-ft (30.5-cm) cover of coarse gravel and rock is also proposed for purposes of erosion control. The proposed cover materials will attenuate the radon flux at the surface of the tailings so that the total radon flux released to the atmosphere is less than twice the estimated background flux. The attenuated radon flux is estimated by the following relationship:[4]

$$J = J_0 \exp\left\{-\sum_{i=1}^{n} x_i[\lambda/(D_e/v)_i]^{0.5}\right\} ,$$

where

$(D_e/v)_i$ is the effective diffusion coefficient for cover layer i, cm^2/sec;

J is the attenuated radon-222 release flux, pCi/m^2·sec;

J_0 is the radon-222 flux at the surface of the tailings material, pCi/m^2·sec;

n is the number of cover layers, dimensionless;

x_i is the thickness of cover layer i, cm;

λ is the radon-222 radiological decay constant, 2.1×10^{-6} sec^{-1}.

Because the clayey cover will actually be a mixture of clay and soil, the effective diffusion coefficient for that layer is assumed to be equal to that for Mancos Shale, 1.2×10^{-3} cm^2/sec (ref. 5). The effective diffusion coefficient for the sandy-soil material is assumed to be 3.6×10^{-2} cm^2/sec (ref. 6). Using these effective diffusion coefficients and the cover thicknesses specified above, the value of J, the attenuated flux of radon-222 released to the atmosphere from the reclaimed tailings area, is calculated to be 0.084 pCi/m^2·sec, above background.

Because the background concentration of radium-226 in soil in the area is about 0.9 pCi/g (ref. 7), the background radon-222 flux from natural soil is estimated to be 0.9 pCi/m^2·sec. Thus the estimated flux of radon-222 from tailings materials, after reclamation, is estimated to be less than 10% of the natural background flux. Based on the 27.7-ha (68.5-acre) tailings pile area, postreclamation radon-222 releases from tailings materials are estimated to amount to only about 0.73 Ci/year.

REFERENCES FOR APPENDIX F

1. F. F. Haywood et al., *Assessment of Radiological Impact of Inactive Uranium Mill Tailings Pile at Salt Lake City, Utah*, Report ORNL/TM-5251, Oak Ridge National Laboratory, Oak Ridge, Tenn., November 1977.

2. K. J. Schiager, "Analysis of Radiation Exposures on or near Uranium Mill Tailings Piles," *Radiat. Data Rep.* 15: 415 (July 1974).

3. A. B. Tanner, "Radon Migration in the Ground: A Review," in *The Natural Radiation Environment*, J. A. S. Adams and W. M. Lowder, Eds., University of Chicago Press, Chicago, 1965.

4. M. B. Sears et al., *Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing "as Low as Practicable" Guides — Milling of Uranium Ores*, Report ORNL/TM-4903, vol. 1, Oak Ridge National Laboratory, Oak Ridge, Tenn., May 1975.

5. U.S. Nuclear Regulatory Commission, *Draft Environmental Statement Related to Operation of White Mesa Uranium Project*, Docket No. 40-8681, December 1978. (NUREG-0494)

6. H. W. Kraner et al., "Measurements of the Effects of Atmospheric Variables on Radon-222 Flux and Soil-Gas Concentrations," in *The Natural Radiation Environment*, J. A. S. Adams and W. M. Lowder, Eds., University of Chicago Press, Chicago, 1965.

7. Woodward-Clyde Consultants, letter to the U.S. Nuclear Regulatory Commission, Nov. 28, 1978.

Appendix G

CALCULATIONS OF TAILINGS PILE GAMMA RADIATION ATTENUATION

Appendix G

CALCULATIONS OF TAILINGS PILE GAMMA RADIATION ATTENUATION

Assuming soil to be composed mainly of SiO_2, the mass attenuation coefficient for a 1- to 2-MeV gamma ray is 0.0518 cm^2/g (ref. 1). (Most of the dose rate from a typical natural emitter is in this range.[2]) Based on the radium concentration of 283 pCi/g and the conversion factor[3] of 2.5(μR/hr)/(pCi/g), the gamma radiation from the uncovered tailings pile is approximately 6.2 R/year. Assuming that the gamma radiation level is 6.2 R/year and that the bulk density of the soil is 1.6 g/cm^3, the effect of the 2.45 m (8 ft) of soil materials proposed (excluding the cobble layer) would reduce the gamma radiation to approximately 9.424×10^{-9} R/year.

$$I/I_0 = \exp[-(\mu_{en}/\rho)\rho x] = \exp[-(0.0518 \text{ cm}^2/\text{g})(1.6 \text{ g/cm}^3)(245 \text{ cm})] = 1.52 \times 10^{-9} \ ;$$

$$I = (1.52 \times 10^{-9})(6.2 \text{ R/year}) = 9.424 \times 10^{-9} \text{ R/year} \ .$$

The background radiation dose as measured by the applicant is 72.8 mR/year (ER, p. 2-171). The gamma radiation from the deposited tailings would be insignificant compared to the natural gamma background.

REFERENCES FOR APPENDIX G

1. U.S. Department of Health, Education, and Welfare, *Radiological Health Handbook*, U.S. Government Printing Office, Washington, D.C., January 1970, p. 139.

2. H. May and L. D. Marinelli, "Cosmic Ray Contribution to the Background of Low-Level Scintillation Spectrometry," in *The Natural Radiation Environment*, J. A. S. Adams and W. M. Lowder, Eds., University of Chicago Press, Chicago, 1964.

3. K. J. Schiager, "Analysis of Radiation Exposure on or near Uranium Mill Tailings Piles," *Radiat. Data Rep.*, 15: 415 (July 1974).

Appendix H

CORRESPONDENCE WITH THE UTAH STATE HISTORIC PRESERVATION OFFICER

STATE OF UTAH
Scott M. Matheson, Governor

DEPARTMENT OF
DEVELOPMENT SERVICES

J. Phillip Keene III
Executive Director
104 State Capitol
Salt Lake City, Utah 84114
Telephone: (801) 533-5961

December 12, 1978

R. A. Scarano
Section Leader
Uranium Mill Licensing Section
Division of Fuel Cycle and Material Safety
Nuclear Regulatory Commission
Washington, D.C. 20555

RE: Shootering Canyon Uranium Project, Garfield County

Dear Chairperson:

On the basis of staff review and recommendation, the State Historic Preservation Officer has determined that although a known site (42GA1534, Lost Spring Dune Site, Garfield County, Utah) exists in the project area, a determination was made that the site was not significant. The basis for this determination is a report on the test excavation of the site by the Antiquities Section of the Division of State History in May of 1978 (Dykman:1978). The proposed project will have no known effect on any recognized or potential National Register historical, archeological, or cultural site(s). Please be advised, however, that should artifacts or cultural objects be discovered during the construction stage, it is the responsibility of the Federal agency or a community receiving block grant funds to notify this office immediately as provided for in the Utah State Antiquities Act of 1973 and Public Law 93-291.

Should you need assistance or clarification, please call Wilson G. Martin, Preservation Development Coordinator, State Historical Society, 307 West 200 South, Salt Lake City, Utah 84101, 533-6017.

Sincerely,

J. Philip Keene, III
Executive Director and
State Historic Preservation Officer

WGM:br:B599.GA

cc: Plateau Resources, Ltd., 141 East First South, Salt Lake City, UT 84111

(2) clearance

Enclosure