draft

NUREG-0494

environmental statement

related to operation of

WHITE MESA URANIUM PROJECT

ENERGY FUELS NUCLEAR, INC.

DECEMBER 1978

Docket No. 40-8681

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

DRAFT ENVIRONMENTAL STATEMENT

related to the
Energy Fuels Nuclear, Inc.,

WHITE MESA URANIUM PROJECT

(San Juan County, Utah)

Docket No. 40-8681

December 1978

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 Energy Fuels Nuclear, Inc., for the construction and operation of the proposed White Mesa Uranium Project with a product (U_3O_8) production limited to 7.3×10^5 kg (1.6×10^6 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 White Mesa Uranium Project will include the following:

      - Alterations of up to 358 ha (885 acres) that will be occupied by the mill, mill facilities, tailings area, 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 towns of Blanding and Monticello, Utah, where the majority of mill workers will be housed during mill construction and operation.

      - Production of waste material (tailings) from the mill, which will be produced at a rate of about 1.8×10^6 kg (2000 tons) per day for 15 years and will be deposited onsite in subsurface pits.

   b. S rface 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 1.18 m^3 (310 gal) per minute. Some 5.9×10^5 m^3 (480 acre-ft) of water per year will be utilized by the mill.

   c. There will be no 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 within 50 miles of the proposed mill site are presented below. Natural background doses are also presented for comparison. These dose estimates were based on the projected population in the year 2000. The dose commitments from normal operations of the proposed White Mesa mill will represent only very small increases from those due to current background radiation sources.

Annual population dose commitments to the population within an 80-km (50-mile) radius of the plant site in the year 2000

	Dose (man-rems/yr)	
Receptor organ	Plant effluents	Natural background
Total body	3.4	7,500
Lung	7.1	7,500
Bone	6.4	7,500
Bronchial epithelium	13.2	23,000

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

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

f. The area devoted to the milling operations will be reclaimed after operations cease, but the approximately 183 ha (450 acres) tailings area 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 grazing land.

g. Surface and subsurface archaeological surveys have identified numerous archaeological sites within the proposed project area. Because the NRC, in consultation with the State Historic Preservation Officer for the State of Utah, has made the preliminary determination that these sites are likely to yield information important in the prehistory of the region, the Secretary of Interior will be requested to render an opinion concerning the eligibility of these sites for National Register nomination. Each register eligible site would then be evaluated against the criteria for "adverse effect" and "no adverse effect" set down in 36 CFR 800, "Procedures for the Protection of Historic and Cultural Properties." All measures pertaining to the mitigation of adverse effects to archaeological sites will be addressed in the Final Environmental Statement.

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 for 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 Board of Health
   Utah State Planning Coordinator
   Utah Division of Oil, Gas, and Mining

6. This Draft Environmental Statement was made available to the public and to the specified agencies in December 1978.

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

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

   b. The applicant shall implement an interim stabilization program that minimizes to the maximum extent reasonably achievable disposal of blowing tailings. The effectiveness of the control methods used shall be evaluated weekly by means of a documented tailings area inspection.

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 (grazing, residences, etc.) 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 comply with the requirements specified in Section 4.2.2 of this document regarding protection and preservation of cultural resources.

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 conduct a meteorological monitoring program as specified in Section 6.1 of this document. The data obtained from this program shall be tabulated and made available for NRC inspection.

h. 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.

i. 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 the White Mesa 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 7i, 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 will be subject to express conditions that approved waste-generating processes and uranium mill tailings management practices may be subject to revision in accordance with the conclusions of the final generic environmental impact statement and any related rule making.

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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 Energy Fuels Nuclear, Inc., for the issuance of an NRC Source Material License, authorizing operation of the proposed White Mesa 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 Energy Fuels Nuclear, Inc. (the applicant).

The NEPA states, among other things, that it is the continuing resposibility 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-0494, 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, Energy Fuels Nuclear, Inc. (the applicant), on February 6, 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 White Mesa Uranium Project, will process ores from independent and company-owned mines. There will be no uranium mining at the project site.

The project will consist of construction and operation of a mill with a nominal processing capacity of 1800 metric tons (MT; 2000 tons) per day with provision for recovery of vanadium as well as uranium.

The applicant presently controls by ownership, lease, or contract, ore reserves of approximately 8600 MT (9500 tons) of U_3O_8 with an average ore grade of 0.125%. The proposed operating schedule is 24 hr/day, 340 days per year. At this schedule, there are about 11 years of ore supply. The applicant has designed for a 15-year project lifetime with the expectation that other ore sources will be discovered later. Based on these figures and a 94% recovery, the mill will produce approximately 730 MT (800 tons) of U_3O_8 per year.

Waste materials (tailings) from the mill will be produced at about 1800 MT (2000 tons) of solids per day and stored onsite. Sequential preparation, filling, and reclamation of tailings impoundment cells are planned (Sect. 3.2.4.7). This will decrease the amount of tailings exposed (and radon exhaled) during operation of the mill.

In accordance with NRC Guides 3.5 and 3.8, the applicant has submitted a Source Material License Application (Form AEC-2),[1] an Environmental Report (ER),[2] and supplements to the ER in response to questions by the NRC staff.

1.2 BACKGROUND INFORMATION

The proposed Energy Fuels Nuclear, Inc., mill will be located in San Juan County, Utah, about 8 km (5 miles) south of Blanding, Utah (Fig. 1.1). Ore for the mill feed will be provided through two existing ore buying stations, one near Hanksville in Wayne County, Utah, and the other adjacent to the planned mill on the same site (Fig. 2.1). These buying stations, owned by Energy Fuels, purchase ore from independent mines and will also receive ore from company-owned mines.

The surface area of the project site is owned by Energy Fuels Nuclear, Inc., or controlled by mill site claims. The mill will occupy about 20 ha (50 acres) of the site, including 6 ha (16 acres) presently occupied by the existing ore buying station. At the end of the proposed 15-year project lifetime, the tailings disposal cells will occupy approximately another 180 ha (450 acres).

The purpose of this Environmental Statement is to discuss in detail the environmental effects of project construction as well as monitoring and mitigating measures proposed to minimize the effects of the 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.,

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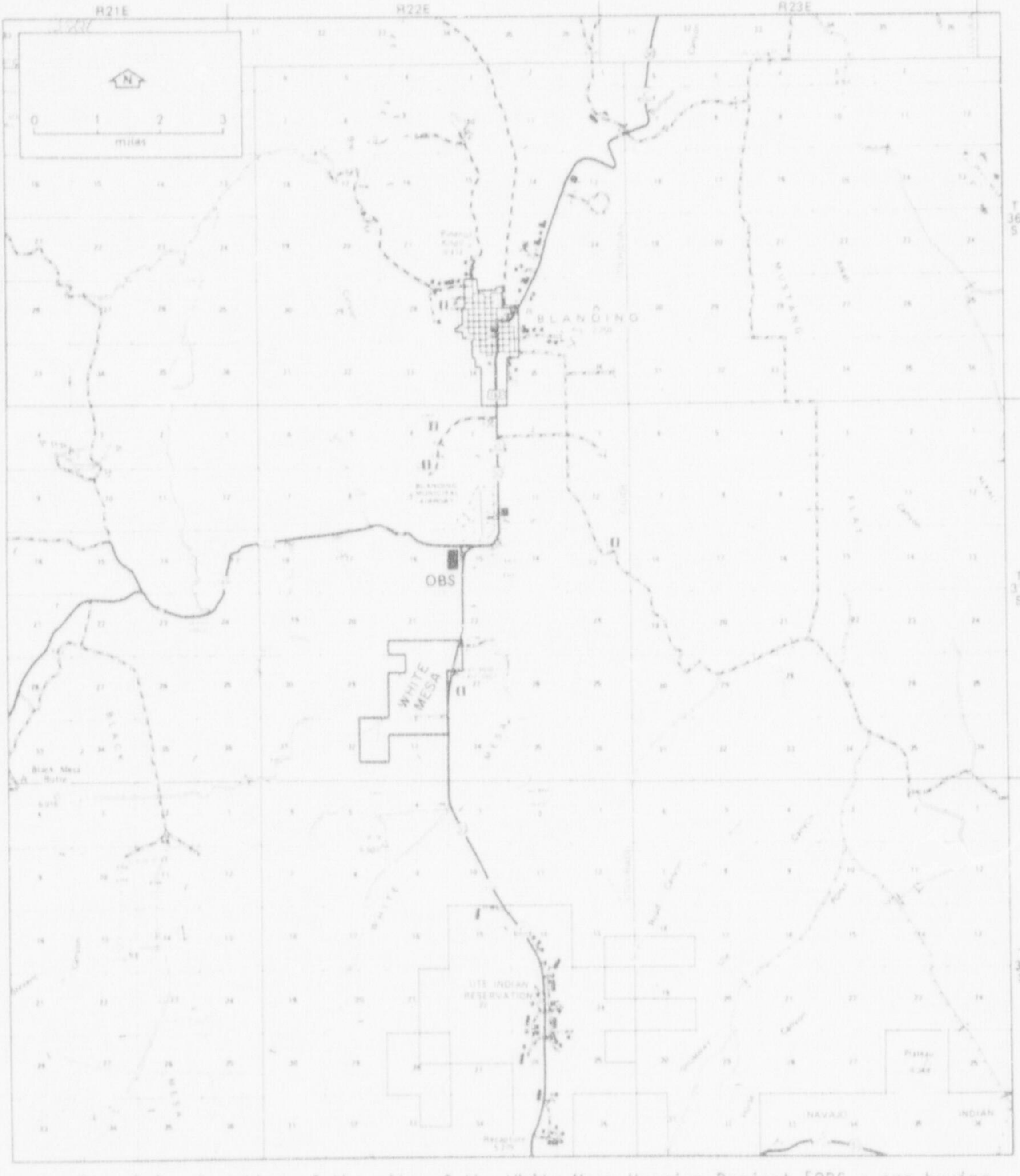

Fig. 1.1. Location of the site of the White Mesa Uranium Project [OBS = ore buying station]. <u>Source</u>: Plateau Resources, Ltd., *Application for a Source Material License for the Blanding Ore Buying Station*, Grand Junction, Colo., Apr. 3, 1978, Fig. 2.1-2.

uranium and/or thorium in any form or ores containing 0.05% or more of uranium, thorium, or combinations thereof). 10 CFR Part 51 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." Legislation presently awaiting congressional action may make tailings disposal and area reclamation specifically the responsibility of NRC. In any case bonding requirements will be established to provide assured funding for reclamation and stabilization as well as long-term maintenance costs for such disposal sites.

1.4 STATUS OF REVIEWS AND ACTIONS BY FEDERAL AND STATE AGENCIES

The only regulatory action required from the NRC is the issuance of a Source Material License. In addition, before construction and operation of the White Mesa 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.

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 White Mesa Uranium Project.

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 White Mesa mill in particular. This mill is located near multiple mining operations producing low-grade ore (≈0.13%). 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.

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

Permit or license	Granting authority	Status[a]
NPDES permit	UBWQ(a) - USEPA(b)	Not required
Water appropriation certificate	USEO(c)	
(1) 47943 - (09-689)		Granted 10/17/77
(4) 47331 - (09-672)		Granted 04/27/77
Water Quality Construction Permit	UBWQ(a) - UWPCC(d)	EDA(k) 12/01/78
Public Drinking Water System	UBWQ(a) - UWPCC(d)	EDA(k) 12/01/78
Air Quality Construction Permit	UBAQ(e) - UACC(f)	EDA(k) 12/01/78
Solid waste disposal permit (tailings)	UBSWM(g)	EDA(k) 12/01/78
Recording of mill site claims	BLM(h)	
Source Material License	USNRC(i)	Application under review
Sanitation Facilities	UBS(j)	EDA(k) 12/01/78
Prevention of Significant Deterioration	USEPA(b)	EDA(k) 12/01/78

a. Utah Bureau of Water Quality
b. U.S. Environmental Protection Agency
c. Utah State Engineers Office
d. Utah Water Pollution Control Committee
e. Utah Bureau of Air Quality
f. Utah Air Conservation Committee
g. Utah Bureau of Solid Waste Management
h. U.S. Bureau of Land Management
i. U.S. Nuclear Regulatory Commission
j. Utah Bureau of Sanitation
k. Expected Date of Application (Not applied for)

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 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 effect 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, 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 generation, 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 the existing mills will be required to support presently operating nuclear power reactors and those expected to begin operation in 1977." The White Mesa 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 could adversely affect the ability of reactors to deliver needed electrical power. Such a shortfall of electrical energy is generally construed to be harmful to the public interest. (See also App. B.)

REFERENCES FOR SECTION 1

1. Energy Fuels Nuclear, Inc., "Application for Source Material License (NRC-2)", February 6, 1978, revised September 26, 1978.

2. Energy Fuels Nuclear, Inc., "Environmental Report, White Mesa Uranium Project, San Juan County, Utah", January 30, 1978, revised May 15, 1978.

3. Energy Fuels Nuclear, Inc., letter to NRC, November 8, 1978.

4. "Uranium Milling, Intent to Prepare a Generic Environmental Impact Statement," Federal Register (41 FR 22430), June 3, 1976.

2. THE EXISTING ENVIRONMENT

2.1 CLIMATE

2.1.1 General influences

Although varying somewhat with elevation and terrain in the vicinity of the site, the climate can generally be described as semiarid. Skies are usually clear with abundant sunshine, precipitation is light, humidity is low, and evaporation is high. Daily ranges in temperature are relatively large, and winds are normally light to moderate. Influences that would result in synoptic meteorological conditions are relatively weak; as a result, topography and local micrometeorological effects play an important role in determining climate in the region.

Seasons are well defined in the region. Winters are cold but usually not severe, and summers are warm. The normal mean annual temperature reported for Blanding, Utah, is about 10°C (50°F), as shown in Table 2.1. January is usually the coldest month in the region, with a normal mean monthly temperature of about -3°C (27°F). Temperatures of -18°C (0°F) or below may occur in about two of every three years, but temperatures below -26°C (-15°F) are rare. July is generally the warmest month, having a normal mean monthly temperature of about 23°C (73°F). Temperatures above 32°C (90°F) are not uncommon in the summer and are reported to occur about 34 days a year; however, temperatures above 38°C (100°F) occur rarely.

2.1.2 Precipitation

Precipitation in the vicinity of the White Mesa Uranium Project is light (Table 2.2). Normal annual precipitation is about 30 cm (12 in.). Most precipitation in the area is rainfall, with about 25% of the annual total in the form of snowfall.

There are two separate rainfall seasons in the region. The first occurs in late summer and early autumn when moisture-laden air masses occasionally move in from the Gulf of Mexico, resulting in showers and thunderstorms. The second rainfall period occurs during the winter when Pacific storms frequent the region.

2.1.3 Winds

Wind speeds are generally light to moderate at the site during all seasons, with occasional strong winds during late winter and spring frontal activity and during thunderstorms in the summer. Southerly wind directions are reported to prevail throughout the year. Summaries of wind direction and wind speed distributions are given in Tables D.1 and D.2 of Appendix D.

2.1.4 Storms

Thunderstorms are frequent during the summer and early fall when moist air moves into the area from the Gulf of Mexico. Related precipitation is usually light, but a heavy local storm can produce over an inch of rain in one day. The maximum 24-hr precipitation reported to have fallen during a 30-year period at Blanding was 5.02 cm (1.98 in.). Hailstorms are uncommon in this area. Although winter storms may occasionally deposit comparable amounts of moisture, maximum short-term precipitation is usually associated with summer thunderstorms.

Tornadoes have been observed in the general region, but they occur infrequently (see Sect. 5.1.3.1 for estimate of probability). Strong winds can occur in the area along with thunderstorm activity in the spring and summer. The White Mesa site is susceptible to occasional duststorms, which vary greatly in intensity, duration, and time of occurrence. The basic conditions for blowing dust in the region are created by wide areas of exposed dry topsoil and strong, turbulent winds. Duststorms usually occur following frontal passages during the warmer months and are occasionally associated with thunderstorm activities.

Table 2.1. Temperature means and extremes at Blanding, Utah[a]

Month	Means						Extremes					
	Daily maximum		Daily minimum		Monthly		Record highest		Year	Record lowest		Year
	°C	°F	°C	°F	°C	°F	°C	°F		°C	°F	
January	3.9	39.1	–9.1	15.6	–2.6	27.4	16	60	1956	–27	–17	1937
February	6.5	43.7	–6.4	20.4	0.1	32.1	19	67	1932	–31	–23	1933
March	11.1	51.9	–3.3	26.1	3.9	39.0	22	72	1934	17	2	1948
April	17.0	62.6	0.9	33.7	8.9	48.1	28	82	1943	12	11	1936
May	22.2	71.9	5.2	41.3	13.7	56.6	33	92	1951	–5	23	1933
June	28.2	82.8	9.6	49.2	18.9	66.0	38	100	1954	–2	28	1947
July	31.7	89.1	13.8	56.9	27.8	73.0	39	103	1931	2	36	1934
August	30.3	86.5	13.1	55.5	21.7	71.0	37	98	1954	6	42	1950
September	26.2	79.3	8.7	47.7	17.6	63.6	35	95	1948	–2	29	1934
October	19.0	66.2	2.7	36.9	10.9	51.6	32	90	1937	–10	14	1935
November	10.4	50.8	–4.4	24.1	3.1	37.5	21	69	1934	–22	–7	1931
December	5.3	41.6	–7.4	18.6	1.1	30.1	16	61	1949	–24	–11	1935
Annual	17.7	63.8	1.9	35.5	9.8	49.7	39	103	July 1931	–31	–23	February 1933

[a]Period of record: 1931–1960 (30 years).

Source: Plateau Resources, Limited, *Application for Source Material License*, Table 2.2-1, p. 2-6, Apr. 3, 1978.

Table 2.2. Precipitation means and extremes at Blanding, Utah[a]

Month	Total						Year
	Mean monthly		Maximum monthly		Greatest daily		
	cm	in.	cm	in.	cm	in.	
January	3.04	1.20	10.31	4.06	2.64	1.04	1952
February	2.95	1.16	4.39	1.73	2.62	1.03	1937
March	2.38	0.94	5.00	1.97	2.54	1.00	1937
April	2.18	0.86	5.41	2.13	2.69	1.06	1957
May	1.63	0.64	5.11	2.01	2.39	0.94	1947
June	1.39	0.55	5.51	2.17	3.56	1.40	1938
July	2.13	0.84	7.79	3.07	3.35	1.32	1930
August	3.02	1.19	12.59	4.96	5.03	1.98	1951
September	3.02	1.19	9.60	3.78	3.07	1.21	1933
October	3.51	1.38	16.79	6.61	3.94	1.55	1940
November	1.88	0.74	5.21	2.05	2.41	0.95	1946
December	3.20	1.26	9.29	3.66	3.56	1.40	1931

[a]Period of record: 1931–1960 (30 years).

Source: Plateau Resources, Limited, *Application for Source Material License*, Table 2.2-2, p. 2-8, Apr. 3, 1978.

2.2 AIR QUALITY

The proposed mill site lies within the jurisdiction of the Four Corners Interstate Air Quality Control Region No. 14, which encompasses parts of Colorado, Arizona, New Mexico, and Utah. The air quality of the region is evaluated according to a classification system that was established in 1971 for all Air Quality Control Regions (AQCR) in the United States (ER, Sect. 2.7.4.2). The classification system rates the five major air pollutants (particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide, and photochemical oxidants) as having a priority of I, II, or III. A priority I rating means that a portion of the region is significantly violating Federal standards for a particular pollutant and special emission controls are needed. If the emissions are predominately from a single-point source, then it is further classified as IA. A priority rating of II indicates a better quality of air in the region; a priority III rating classifies the highest quality. The concentrations that define the classification are outlined in Table 2.3.

Table 2.3. Federal regional priority classifications based on ambient air quality

Pollutant	Average time	Air quality for each priority group[a]		
		I	II	III
Sulfur oxides	Annual	>100 μg/m³	60–100 μg/m³	<60 μg/m³
	24 hr	>455 μg/m³	260–455 μg/m³	<260 μg/m³
	3 hr		1300 μg/m³	<1300 μg/m³
Particulate matter	Annual	>95 μg/m³	60–95 μg/m³	<60 μg/m³
	24 hr	>325 μg/m³	150–325 μg/m³	<150 μg/m³
Carbon monoxide	8 hr	>14 mg/m³		<14 mg/m³
	1 hr	>55 mg/m³		<55 mg/m³
Nitrogen dioxide	Annual	>110 μg/m³		<110 μg/m³
Photochemical oxidants	1 hr	>195 μg/m³		<195 μg/m³

[a] In the absence of measured data to the contrary, any region containing an area whose 1970 "urban place" population exceeds 200,000 will be classified priority I. All others will be classified priority III. Hydrocarbon classifications will be same as for photochemical oxidants.

Source: ER, Table 2.7-20.

The priority classifications for the Four Corners Interstate AQCR, which includes the proposed mill site, are presented below:

	Sulfur dioxides	Particulate matter	Nitrogen oxides	Carbon monoxide	Photochemical oxidants (Hc)
Priority classification	IA	IA	III	III	III

The priority IA ratings for particulate matter and sulfur dioxide for the AQCR are due to emissions from fossil-fueled power plants located within the region (ER, Sect. 2.7.4.2). However, none of the power plants lie within 50 km (31 miles) of the mill site, which suggests that the air quality in the vicinity of the site may be better than the priority IA classification indicates.

The Utah Division of Health monitors total suspended particulates and sulfur dioxide at a station located 105 km (66 miles) west-southwest of the site at Bull Frog Marina. Except for the short-term (24-hr) particulate measurement, all reported values (ER, Table 2.7-21) were

well below the Federal and State of Utah air quality standards. The 24-hr particulate violations are believed to have been caused by dust blown by high winds.

Based on data collected from four sampling locations on the project site for one year, dustfall averaged 33 g/m^2 per month; the highest monthly average was 102 g/m^2 occurring in August.[1] Total suspended particulate monitoring from October 1977 through February 1978 revealed a geometric mean of 18 μg/m^3.[1] Dustfall for this same time period averaged 23 g/m^2 per month. If a linear relationship between total suspended particulate matter and dustfall is assumed, the annual geometric mean for total suspended particulates is expected to be 26 μg/m^3. This value is well below the Federal and State air quality standard of 60 μg/m^3. The maximum 24-hr concentration was 79 μg/m^3, or approximately one-half of the Federal and State standard of 150 μg/m^3. Sulfation-rate monitoring for one year at four locations on the site indicate that sulfur dioxide concentrations at the site vicinity are less than 0.005 ppm.[1] The Federal and State standard for the annual average of sulfur dioxide is 0.03 ppm.

2.3 TOPOGRAPHY

The site is located on a "peninsula" platform tilted slightly to the south-southeast and surrounded on almost all sides by deep canyons, washes, or river valleys. Only a narrow neck of land connects this platform with high country to the north, forming the foothills of the Abajo Mountains. Even along this neck relatively deepstream courses intercept overland flow from the higher country. Consequently, this platform (White Mesa) is well protected from runoff flooding, except for that caused by incidental rainfall directly on the mesa itself. The land on the mesa immediately surrounding the White Mesa site is relatively flat.

2.4 DEMOGRAPHY AND SOCIOECONOMIC PROFILE

The site of the proposed White Mesa Uranium Mill is in San Juan County in southeastern Utah (Fig. 2.1), approximately 8 km (5 miles) south of the city of Blanding. Energy Fuels Nuclear, Inc., currently operates an ore buying station on this property. Energy Fuels also operates an ore buying station near Hanksville, Utah. It is intended that ore will be transported from the Hanksville facility to the proposed mill on Utah Route 95, passing through portions of Wayne, Garfield, and San Juan counties (ER, pp. 2-4 to 2-7). It should be noted that Plateau Resources Limited currently operates a uranium ore-buying station in Blanding at a site located approximately 3 km (1.9 miles) north of the Energy Fuels' White Mesa site.

Because of its close proximity to the proposed mill site, the city of Blanding is likely to receive the largest share of this project's socioeconomic impacts. The communities of Monticello and Bluff also are likely to share the effects of mill-induced population increases and ensuing social impacts. These three communities and Hanksville have been studied for socioeconomic impacts. The counties of San Juan, Wayne, and Garfield have been examined where effects are likely to be generalized over a larger area.

2.4.1 <u>Demography of the area</u>

2.4.1.1 <u>Current population and distribution</u>

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 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.

San Juan County, where the proposed White Mesa mill would be constructed, has a population of 13,000 (an increase of 35.3% from 1970). Wayne County, the site of the Hanksville ore-buying station, has a population of 1800 (a 21.4% increase since 1970). Garfield County has a total population of 3600 (an increase of 14% from 1970). The data in Table 2.4 illustrate that while these three counties have experienced growth in recent years, their overall density has remained low.

The closest city to the proposed mill site is Blanding (Table 2.5), which had a 1977 population of 3075, up 37% from 1970. Monticello, the county seat, has 2208 residents, 54% more than in 1970. Between them, these two communities account for nearly 40% of San Juan County's population (ER, p. 2-18). Another 46% of the total is made up of Navajo Indians living on or near

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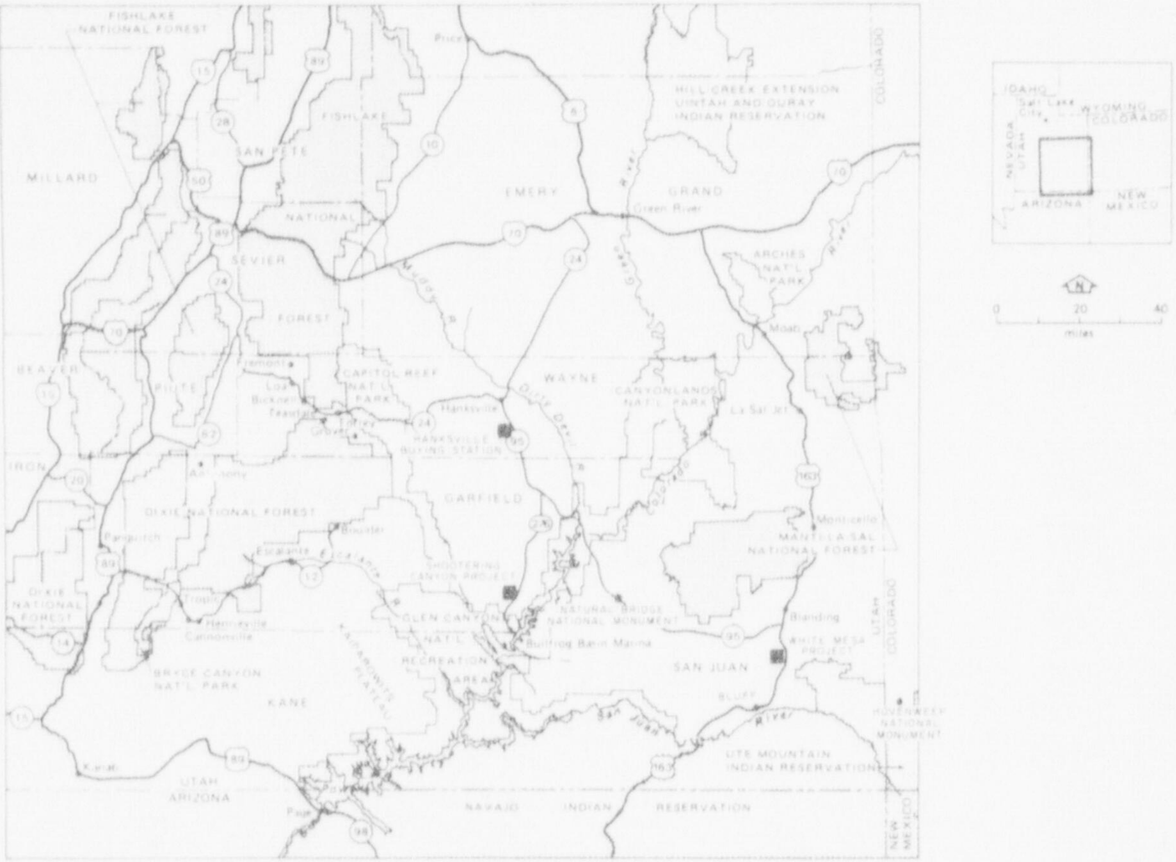

Fig. 2.1. Regional map of the White Mesa Uranium Project site. Source: Plateau Resources, Ltd., *Application for a Source Material License for the Blanding Ore Buying Station*, Grand Junction, Colo., Apr. 3, 1978.

Table 2.4. Area and population for Utah and Wayne, Garfield, and San Juan counties, 1970 and 1977

State or county	Land area		Total population			Population per square kilometer			
						1970		1977[a]	
	km²	sq miles	1970	1977[a]	Change (%)	km²	sq. mile	km²	sq. mile
Utah, total	213,180	82,340	1,059,273	1,271,300	20.0	33.4	12.9	40.0	15.4
Wayne	6,444	2,489	1,483	1,800	21.4	1.6	0.6	1.8	0.7
Garfield	13,507	5,217	3,157	3,600	14.0	1.6	0.6	1.8	0.7
San Juan	20,412	7,884	9,606	13,000	35.3	3.1	1.2	4.1	1.6

[a]Preliminary data.

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

Table 2.5. Population centers near the White Mesa Uranium Project

	Approximate distance from the project sites			
	Blanding site		Hanksville site	
	km	miles	km	miles
Colorado				
Grand Junction[a]	290	180	260	160
Cortez[a]	140	85	346	215
Durango[a]	210	130	420	260
Utah				
Blanding	8	5	209	130
Monticello	48	30	225	140
Bluff	32	20	225	140
Hanksville	225	140	16	10
Moab[a]	130	80	193	120
New Mexico				
Farmington[a]	260	160	750	290

[a]Population greater than 4500 according to 1975 Census records.

Source: Adapted from ER, Table 2.2-1.

the Navajo Reservation in southern San Juan County (ER, p. 2-15). The town of Bluff has a population of 280, more than double its population in 1970 (ER, p. 2-18).

Within a 290-km (180-mile) radius of the proposed mill there are several larger cities that are important regional centers (See Table 2.5 for distance relationships to the project sites). Moab, Utah, the closest and also the smallest, has a population of approximately 4500 according to 1976 census records (ER, Table 2.2-1). Cortez, Colorado, has a population slightly under 6800 and Durango, Colorado, has nearly 12,000 residents. Both Grand Junction, Colorado, and Farmington, New Mexico, have populations approaching 28,000.

Approximately 16 km (10 miles) from the Hanksville ore buying station is the town of Hanksville, which had a 1975 population of 160.

The area within an 8-km (5-mile) radius of the proposed mill is sparsely populated and primarily agricultural. It is estimated that about 70 to 80 people currently reside here. The closest currently inhabited dwelling unit is approximately 5 km (3 miles) north of the site (Applicant's responses to ER questions, Enclosure 2, p. 2), but most area residents live to the south in the Ute Mountain community of White Mesa. The Blanding airport also lies within this 8-km (5-mile) zone, and approximately 30 to 40 people use that facility daily.

2.4.1.2 Projected population and distribution

Between now and the year 2000, Utah's population is expected to rise steadily according to projections prepared by the Utah Agricultural Experiment Station (Table 2.6). Both high and low projections assume a gradual decline in mortality and constant fertility. The difference between them is that the high figures also assume a positive net migration while the low figures are based on no net migration at all. Projections for San Juan County indicate a much greater growth rate than for the State as a whole (Table 2.6).

According to the city manager of Blanding, a population increase of almost 1500 is expected within the next three years, bringing the number of city residents to 4540 by 1981 (City Manager of Blanding, Utah, personal communication, July 10, 1978). This estimate represents an increase of 47.6% over the 1977 population and is based on the assumption that the proposed White Mesa uranium mill will be built. Monticello's city manager is also predicting growth, but at a lesser rate than for Blanding. Between now and 1983, an increase of approximately 600 (or 27%) is expected (City Manager of Monticello, Utah, personal communication, July 30, 1978).

Table 2.6. Population projections,[a] San Juan, Wayne, and Garfield counties, compared to the State

	1975[b]	1980	1990	2000	Percent increase (1975–2000)
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
San Juan County					
High	12,816	17,373	26,002	33,300	160
Low	12,716	13,954	16,917	19,753	5[illegible]
Wayne County					
High	1,960	2,660	3,770	4,530	131.1
Low	1,950	2,060	2,310	2,510	28.7
Garfield County					
High	3,480	3,940	4,670	5,960	71.3
Low	3,470	3,760	4,460	5,120	47.6

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

[b] U.S. Census estimation for 1975 indicates that actual population for the State and all three counties was below the "low" projection presented in this table.

Source: ER, Table 2.2-22.

The Blanding airport, about 5.6 km (3.5 miles) north of the prospective mill site, has plans to expand its existing runway and storage areas by summer of 1979. An increase in flights to and from the facility may accompany these improvements (Manager of Blanding City Airport, personal communication, Aug. 2, 1978). The Ute Mountain Indian community of White Mesa is currently considering requesting the use of the idle Blanding Launch Site, part of the White Sands Missile Range, from the U.S. Army. This property, which is approximately 6 km (4 miles) south of the mill site, would be used for a community center and would not have permanent residents.

2.4.1.3 Transient population

Although the permanent population in southeastern Utah is relatively low, this area receives a substantial number of tourists each year (Table 2.7). Capital Reef National Park alone had nearly 0.5 million visitors in 1976. The exact numbers fluctuate from year to year, but the overall trend appears to be toward increasing visitation. Manti-La Sal Forest, which is six miles north of Blanding, is the nearest recreation area.

2.4.2 Socioeconomic profiles

2.4.2.1 Social profile

Housing

Blanding. From 1972 to 1975, approximately 12 new units were added each year, but in 1976 that figure rose to 37.[2,3] In 1977, 43 new dwelling units were added, and this accelerated rate of construction appears to be continuing (City Manager of Blanding, Utah, personal communication, July 10, 1978). Mobile homes in this area are often found on individual lots in single-family neighborhoods as well as in mobile home parks.

At present, the supply of new housing is keeping up with the number of residences, and the vacancy rate is very low. Approximately 200 lots are available for single-family houses in Blanding to accommodate future growth. There are also around 25 current vacancies in a local mobile home park (ER, p. 4-18). The supply of rental units in Blanding, as in many small cities, is low (ER, p. 2-50).

Table 2.7. Visitor statistics, recreation areas in southeastern Utah[a]

Area	Visitors (thousands)					
	1972	1973	1974	1975	1976	1977 (January–September)
Glen Canyon National Recreation Area	60.8					
Canyonlands National Park	60.8	62.6	59.0	71.8	80.0	67.3
Manti-La Sal National Forest (visitor days)[b]	105.3	100.9	88.7	76.4		NA[c]
Capital Reef National Park	272.0	311.2	234.0	292.1	469.6	364.2 (through August)
Hovenweep National Monument[d]	12.1	12.0	11.0	13.2	19.4	16.2
Natural Bridges National Monument	58.5	42.7	40.3	48.4	71.9	67.1

[a] Data refer to actual visitations for each area except Manti-La Sal National Forest. Here, data indicate recreation visitor days. A visitor day is the equivalent of one person entering an area for 12 hr.

[b] Data refer to the Monticello Ranger District only.

[c] Indicates data not available.

[d] Data refer to the Square Tower Ruin Unit, near Blanding.

Source: ER, Table 2.2-5.

Monticello. During the five years of 1972 through 1976, the supply of housing in Monticello was increasing at approximately six units per year.[4,5] In 1977 this figure jumped to around 60 units per year, and between 60 and 80 new units are expected to be constructed in 1978; however, the demand for housing has not yet exceeded the supply (City Manager of Monticello, Utah, private communication, July 20, 1978). An expected annexation will double the size of the city and provide room for at least 150 more single-family homes. Approximately 35 vacancies now exist in local mobile home parks (ER, p. 4-18). As in Blanding, rental housing is scarce. A 23-unit apartment is currently being constructed to accommodate some of the demand for this kind of housing (City Manager of Monticello, Utah, private communication, July 20, 1978).

Bluff. Over the last five years, the supply of new housing in Bluff has increased at a rate of five or six new housing units annually and the demand has not exceeded the supply. The existence of approximately 70 vacant lots with water connections and available spaces in two mobile parks within the city limits indicate that Bluff is capable of accommodating future growth (ER, p. 2-56).

Hanksville. Hanksville currently has no excess housing supply and, because of a lack of vacant land with connections to the local water system, Hanksville has little capacity for future expansion (ER, p. 2-74).

Public services

Blanding. Water is obtained from surface runoff and underground wells, and an 0.11-m^3/sec (1800-gpm) sewage treatment plant is operated by the city. Water consumption in 1976 averaged 0.023 m^3/sec (547,000 gpd). The current system is adequate to handle moderate population increases, and improvements are being planned to handle the influx of new residents expected by 1981 (City Manager of Blanding, Utah, personal communication, July 10, 1978). Sewage treatment is provided through a lagoon system, and improvements are planned for the near future. Electricity is provided through a city-owned distribution system; the city also provides solid waste collection and disposal. Propane gas is available through two private distributors, but there is no natural gas service (ER, p. 2-46). Local streets are maintained jointly by the city and county (Treasurer of San Juan County, Utah, personal communication, July 25, 1978).

Blanding has a full-time police force of three officers and an auxiliary force of eight, and a volunteer fire department provides fire protection. Health care is available through the 36-bed San Juan County Hospital in Monticello, a 31-bed nursing home in Blanding, and two local doctors, one public health nurse, and one dentist. There is a mental health clinic in town with one full-time therapist (ER, p. 2-47).

Two elementary schools and one high school serve Blanding. The combined capacity of the elementary schools is 750 students; 630 are currently enrolled. With 874 students, however, the high school has 174 students more than the planned capacity. The opening of two new high schools, scheduled for the near future (one in 1978 and one in 1979/1980), should ease the current overcrowding (ER, p. 2-48).

For recreation facilities, Blanding has four public parks and access to several national parks, forests, monuments, and recreation areas (Table 2.7). The San Juan County Library is located just north of Blanding (Treasurer of San Juan County, Utah, personal communication, July 25, 1978)

Monticello. Water is supplied by surface runoff and groundwater, and, as in Blanding, there is a city-operated water treatment plant. Improvements to the water supply system are being undertaken to raise its overall capacity (City Manager of Monticello, Utah, personal communication, July 20, 1978). Primary and secondary sewage treatment is provided by a local digestor plant, and future improvements are planned (ER, p. 2-51). The City of Monticello distributes electricity supplied by Utah Power and Light to city residents. The transmission system is now at capacity, but Monticello's city manager has said that the city is currently considering ways to expand its service area. Natural gas is available through the Utah Gas Service (ER, p. 2-54). Monticello currently operates a waste disposal service, and street maintenance is a joint responsibility of city and county.

Police and fire protection is p[illegible] by the three full-time police employees and one part-time police employee. They a[illegible] the County Sheriff's Department and a volunteer fire department with three trucks (E[illegible] and 2-54). The 36-bed San Juan County Hospital and a small mental health clinic wi[illegible]st and one outreach worker are in Monticello. There is also a public health nu[illegible]n.

There are an elementary school and [illegible] school in town, both of which are currently operating at about two-thirds of their p[illegible] capacity. The elementary school, which can handle 550 students, now has 365 enrolled. The high school, designed for 500, serves 370 students (ER, p. 2-54).

Recreational facilities consist of a city park, a public golf course, and the national areas listed in Table 2.7.

Bluff. The water system for Bluff consists of three artesian wells and a 760-m^3 (2×10^5-gal) storage tank capable of servicing a population almost double the present one. Sewage treatment is currently provided through individual septic tanks although construction of a community treatment facility has been proposed (ER, p. 2-56).

Two sheriff's deputies are responsible for local police protection, and fire protection is the responsibility of an eight-person volunteer fire department. Bluff residents have access to county health services in neighboring cities, and outreach workers from the Four Corners Mental Health Agency are available.

One elementary school, with a capacity of 200, provides education for the 104 students. Recreation facilities are shown in Table 2.7.

Hanksville. A single privately owned well supplies water to Hanksville residents and is operating at peak capacity although expansion is planned for the near future. No community sewage is provided. A county dump is available for city waste disposal (ER, p. 2-72). The Gar-Kane Power Company supplies electricity in this area (ER, p. 2-74).

Law enforcement is provided by one part-time sheriff and road maintenance is also provided by the county. Ambulance and emergency medical services are available in town; however, the nearest medical clinic is in Green River, 97 km (60 miles) to the north. The nearest hospital is over 160 km (100 miles) away in Moab (ER, p. 2-72).

Hanksville's 50 elementary students attend a local school with an enrollment capacity of 60. Middle and high schoolers are bused to Bicknell, 105 km (65 miles) away. The middle school has a current enrollment of 105 and a capacity of 120; the high school has 155 students and the ability to take 200 (ER, p. 2-74).

Culture

A large Navajo Indian population in this part of the state, largely concentrated in the Navajo Indian Reservation in southern San Juan County, has its own cultural heritage. As shown in Table 2.8, almost half of the county's residents are nonwhite (46.4%), and most of these are Navajos. Religion is another significant influence in southeastern Utah. The predominant Church of Jesus Christ of Latter Day Saints stresses within its beliefs the values of family life, education, and marriage and provides a focus for community life. Table 2.8 also compares the age and educational attainment of the three counties and the state as a whole.

Table 2.8. Selected demographic characteristics, San Juan County, compared to Utah (1970)

	San Juan County	Wayne County	Garfield County	Utah
Total population	9,606	1,638	3,157	1,059,273
Race				
White	5,153			1,033,880
Other (%)	46.4			2.4
Education				
Median school years completed (population 25 years and over)	10.7	12.1	12.2	12.5
Percent of population with less than 5 years	27.0	1.2	0.3	2.0
Percent of population with 4 years of college or more	8.8	8.9	8.7	14.0
Age				
Median age	18.0	27.3	26.4	23.0
Percent under 5 years	13.9	7.4	8.2	10.6
Percent 5–17	36.0	35.4	32.6	29.6
Percent 18–64	45.6	49.3	49.4	52.5
Percent 65+	4.5	7.9	9.8	7.3

Source: ER, Tables 2.2-4 and 2.2-21.

2.4.2.2 Economic profile

Between 1970 and April 1978, the number of nonagricultural payroll jobs in San Juan County increased by over 1000 – from 1786 to 2452. The relative importance of the various economic sectors also shifted in that period. Services stayed nearly the same; the relative importance of trade, transportation, construction, and manufacturing declined slightly; and the significance of finance, insurance, and real estate rose a little. The importance of mining and

government changed dramatically, however. Employment in government services declined from 31.6 to 24.5%, while mining climbed from 21.3 to 31.7% of the total.[6]

Because total employment increased so greatly, the absolute number of jobs rose in all categories. The largest increase by far, however, was in mining, which grew from 381 jobs in 1970 to 935 in April 1978. In the one-year period ending April 1978, the largest numerical increases were experienced in construction, mining, trade, and services (Table 2.9).

Table 2.9. Nonagricultural payroll jobs in San Juan, Wayne, and Garfield counties from April 1977 to April 1978

	April 1977	Percent of total	April 1978	Percent of total	Percent change
San Juan County					
Manufacturing	185	6.6	197	6.7	6.5
Mining	890	31.5	935	31.7	5.1
Construction	142	5.0	155	5.2	9.2
Transportation, commerce, utilities	157	5.6	168	5.7	7.0
Trade	400	14.2	424	14.4	6.0
Finance, insurance, real estate	25	0.9	27	0.9	8.0
Services	303	10.7	322	10.9	6.3
Government	718	25.5	724	24.5	0.8
Total	2820	100.0	2452	100.0	4.7
Wayne County					
Manufacturing	28	6.5	24	6.5	3.6
Mining	48	11.1	50	11.2	4.2
Construction	63	14.6	64	15.4	9.5
Transportation, commerce, utilities	2	0.5	2	0.4	—
Trade	44	11.4	52	11.6	6.1
Finance, insurance, real estate	7	1.6	7	1.6	—
Services	23	5.3	24	5.4	4.3
Government	211	49.0	214	47.9	1.4
Total	431	100.0	447	100.0	3.7
Garfield County					
Manufacturing	237	19.1	252	19.4	6.3
Mining	46	3.7	48	3.7	4.3
Construction	57	4.6	62	4.8	8.8
Transportation, commerce, utilities	66	5.3	71	5.4	7.6
Trade	184	14.9	195	15.0	6.0
Finance, insurance, real estate	14	1.1	15	1.2	7.1
Services	288	23.3	306	23.6	6.2
Government	347	28.0	350	26.9	0.9
Total	1234	100.0	1244	100.0	4.8

Source: Utah Department of Employment Security, Research and Analysis Section, adapted from *Quarterly Employment Newsletter of Southeastern District of Utah*, January–April 1978.

The mineral industry is extremely important to San Juan County, and uranium production is a substantial component of this sector. In fact, San Juan County is the largest producer of uranium in Utah, and this activity has increased dramatically since 1975 (Utah Geological and Mineral Survey, private communication, July 17, 1978). Natural gas and crude oil are the other important materials being produced here (ER, p. 2-32).

Tourism is also an important part of San Juan County's economy, a part that has been increasing steadily in recent years. Between 1975 and 1977, tourist room rentals increased by 32.5%.

Total nonagricultural payroll employment in Wayne County was 447 in April 1978 (Table 2.9). The government employed almost 50% of those workers, and construction, trade, and mining activities accounted for nearly 40%.

In Garfield County, nonagricultural employment for April 1978 totaled 1244 (Table 2.9). The government accounted for slightly over 25% of this employment, services for slightly under 25%, manufacturing for almost 20%, and trade for another 15%.

Between 1973 and 1977, per capita income for the State of Utah rose by 44%, from $4100 to $5900. Increases in per capita income for San Juan County did not keep pace with raises elsewhere. Income in 1973 was $2400, 58.5% of the State average, and 1977 income was $3400 or 57.6% of the State figure (Table 2.10).

Between 1970 and 1977, unemployment fell for the State as a whole and for Wayne, Garfield, and San Juan counties. The State figure went from 6.1 to 5.3%; Wayne County, from 8.5 to 7.2%; Garfield, from 19.2 to 7.9%; and San Juan, from 10.7 to 8.1% (Table 2.11).

The characteristics of job applicants in San Juan County, where the White Mesa mill is to be located, are listed in Table 2.12. Most jobs in mining are classified in the "miscellaneous" section.

The number of retail and wholesale establishments and their sales are shown in Table 2.13 for San Juan County and the cities of Blanding and Monticello. Since 1967, county wholesale and retail sales have both nearly tripled.[7] Retail sales are almost evenly divided between Blanding and Monticello, together accounting for 94.3% of the county's total retail activity.

In 1977, San Juan County levied an ad valorem tax of 16 mills on the assessed value of all property in the county for the general fund. An additional 40 mills was collected for the county school district and a final 2 mills for the countywide water conservation district. The communities of Monticello, Blanding, and Bluff also levied an extra 15, 21, and 10 mills, respectively, on the assessed value of all property within their corporate limits. Finally, the Monticello and Blanding Cemetery Districts each collected 2 mills on all property within those district boundaries. Mines and mills are subject to the above taxes as is all other real property. The total amount collected from all these funds combined was $5,126,748 (Treasurer of San Juan County, Utah, personal communication, July 25, 1978), two-thirds of which went to the County School District. In addition to the property tax, San Juan County also received $87,496 in sales taxes.

San Juan County handles its financial affairs through a number of separate funds, the largest of which is the general fund (Appendix C). Within this fund, the property tax comprises the largest single source of revenue, accounting for slightly over 33% of the 1977 total. Shared revenues from the State of Utah contributed another 20.1%, and Federal shared revenues and in-lieu-of-tax payments added another 15.3%.

The largest expenditure for San Juan County in 1977 was for road maintenance ($1,176,000) amounting to slightly over one-half of total county funds. Other large outlays were 11.2% for health services and 6.4% for the Sheriff's Department.

In the fiscal year ending in June 1977, the largest source of revenue for the city of Blanding's general fund (Appendix C) was the sale of a general obligation electric-, water-, and sewer-improvement bond issue, yielding $225,000. This was followed by slightly over $55,000 from sales and use taxes and a little more than $44,000 from property taxes. Federal revenue sharing and waste collection and disposal fees were the other major sources of funds, each contributing about $18,000 to the total. Utility operations were financed through a separate fund.

Blanding's major expenditures in the same year were for public utility capital improvements and police expenses, each of which cost less than $50,000. Street maintenance cost about half this amount, and waste collection and airport funds made up the last of the major expenditures.

Table 2.10. Per capita incomes for Utah and Wayne, Garfield, and San Juan counties, 1973–1977

State or county	1973	1974	1975	1976[a]	1977[b]
Utah	$4,100	$4,500	$4,800	$5,300	$5,900
Wayne	3,100	3,400	3,800	4,100	6,100
Garfield	3,400	3,300	3,500	4,200	5,000
San Juan	2,400	2,700	2,900	2,900	3,400

[a] Revised.

[b] Preliminary estimate.

Source: Utah Department of Employment Security, Research and Analysis Section, adapted from *Quarterly Employment Newsletter of Southeastern District of Utah*, January–March 1978.

Table 2.11. Total civilian labor and unemployment for Utah and Wayne, Garfield, and San Juan counties, 1970 and 1977

State or county	Labor force		Unemployment		Unemployment rate	
	1970	1977[a]	1970	1977[a]	1970	1977[a]
Utah	414,248	551,900	25,214	29,500	6.1	5.3
Wayne	664	880	57	63	8.5	7.2
Garfield	1,483	1,773	285	140	19.2	7.9
San Juan	3,015	4,198	322	341	10.7	8.1

[a] Preliminary.

Source: Utah Department of Employment Security, Research and Analysis Section, adapted from *Quarterly Employment Newsletter of Southeastern District of Utah*, January–March 1978.

Table 2.12. Occupational characteristics of job applicants in the Blanding area, January–March 1978

Includes persons actively seeking employment, some of whom were employed at the time

Professional, technical, managerial	44
Clerical, sales	59
Service	76
Farm, fisheries, forestry	39
Processing	5
Machine trades	27
Bench work	56
Structural	156
Miscellaneous	51
Total	513

Source: Utah Department of Employment Security, Research and Analysis Section, adapted from *Quarterly Employment Newsletter of Southeastern District of Utah*, January–March 1978.

Table 2.13. Retail and wholesale activity in San Juan County, Blanding, and Monticello (1976)

	San Juan County	Blanding	Monticello
Number of retail establishments	101	35	40
Retail sales	$15,300,000	$7,150,000	$7,280,000
Number of wholesale establishments	9	3	3
Wholesale sales	$ 5,600,000	NA[a]	NA

[a]NA: Information is not available.

Source: Utah Industrial Development Information System, *Economic Facts for San Juan County, Blanding, and Monticello*, 1977.

As in Blanding, Monticello has a separate fund for operating public utilities. Over $350,000 was spent during fiscal year 1977-1978. Slightly over half of the city's nearly $150,000 in general fund revenues for the fiscal year ending June 1978 came from sales and use taxes, while property taxes contributed another 25%. Unlike the county, both Monticello and Blanding receive more of their general funds from sales taxes than from property taxes. The largest expenditure in 1978 was the $54,800 spent on administration. This figure was followed by the $49,400 spent for police protection.

2.4.2.3 Transportation

A system of two-lane paved highways and unimproved roads accounts for virtually all transport of people and products in and out of San Juan County. Although Blanding, Bluff, Monticello, and Canyonlands National Park have small municipal airports, there is no rail, bus, or commercial air service (ER, p. 2-30).

U.S. Route 163 receives a greater amount of traffic than any other road in the county. This highway runs between I-70 on the north [approximately 161 km (100 miles) from the proposed mill] and U.S. Route 160 in Arizona to the south; the highway passes through Monticello, Blanding, and Bluff. The heaviest traffic in the county is on this artery just north of Monticello, where the average daily vehicles were about 2685 in 1975. More recent figures indicate a 43% increase in traffic in this area between 1975 and 1977 (ER, p. 2-30).

Traffic volumes on Utah Route 95 from the Blanding area to Hanksville are much lighter but have been increasing in recent years (Table 2.14). From 1975 to 1977, an increase of 33% was observed on Highway 95 south of Hanksville (ER, p. 2-30). U.S. Route 666 from Monticello to Cortez, Colorado, also carries a significant amount of traffic.[8] All of the roads in this area carry a substantial amount of out-of-state traffic (Table 2.14).

2.5 LAND USE

2.5.1 Land resources

Southeastern Utah is known as the Canyonlands area; an arid climate and rugged terrain have limited permanent settlement of this region. Large rock formations and deep, narrow canyons are characteristic of the area, and these, combined with the Indian ruins found here, are attracting increasing numbers of tourists (ER, p. 2-23). Much of this area is isolated, however, and the population density is low (Sect. 2.4.1.1).

The site of the proposed White Mesa Uranium Mill consists of 600 ha (1480 acres), approximately 8 km (5 miles) south of the city of Blanding off U.S. Route 163. About one-half of the total site is scheduled to be actually used for mill operations and tailings disposal. The immediate area is bordered by both privately owned and Federal land.

Table 2.14. Traffic volumes in 1975 for San Juan County and Blanding-Hanksville route

Highway	Segment	Average daily traffic counts[a]	Approximate percentage of out-of-state passenger traffic
Utah Route 95	Blanding to Natural Bridges Natl. Monument	310	20
	Natural Bridges to Hite	95	10
	Hite to Hanksville	95–290	10–20
U.S. Route 163	Monticello to La Sal Junction	1490–2685	20–35
	Monticello to Blanding	860–1985	10–25
	Blanding to Utah Route 262 turnoff	740–925	20–30
	Utah Route 262 to Bluff	530	40
	Bluff to Mexican Hat	560	40
Utah Route 263	Route 95 to Halls Crossing at Glen Canyon	25–35	20
Utah Route 261	Route 95 to Mexican Hat	130	50

[a] Two figures in this column represent values given for different points along the route. One figure indicates that a traffic count was taken at only one location.

Source: ER, Table 2.2-9.

Much of the land in San Juan County is Federally owned (see Table 2.15). Approximately two-thirds of this land is administered by the U.S. Bureau of Land Management for multiple uses such as grazing, mineral extraction, timber production, and wildlife management. Another one-fifth of the Federal land is managed by the National Park Service and slightly less than one-sixth is under the control of the U.S. Forest Service (ER, p. 2-25). One-fourth of the total area is Indian land. Nearly all of this territory is part of the Navajo Indian Reservation, but a small portion belongs to the Ute Mountain tribe (ER, pp. 2-23 to 2-26). The State owns 6.5% of San Juan County, leaving only 8.3% in private hands (Table 2.15).

Table 2.15. Land ownership, Wayne, Garfield, and San Juan counties, 1967

	Wayne County			Garfield County			San Juan County		
	ha	acres	Percentage	ha	acres	Percentage	ha	acres	Percentage
Federal	542,055	1,338,875	84.2	1,195,842	2,953,729	89.0	1,208,247	2,985,630	59.8
State	59,373	146,651	9.2	90,167	222,712	6.7	131,707	325,317	6.5
Indian	0	0	0	0	0	0	505,086	1,247,563	25.0
Private	40,472	99,965	6.3	53,578	132,337	4.0	168,664	416,600	8.3
Urban and transportation	2,193	5,416	0.3	3,507	8,662	0.3	6,177	15,253	0.3
Small water[a]	54	133	*b*	389	960	*b*	404	997	*b*
Total area	644,146	1,591,040	100.0	1,343,481	3,318,400	100.0	2,019,940	4,991,360	100.0

[a] Includes water areas of 0.8 to 16 ha (2 to 40 acres) and streams less than 0.20 km (0.125 mile) in length.

[b] Less than 0.1%.

Source: ER, Table 2.2-23.

In Wayne County, much of the land is Federally owned (Table 2.15). As in San Juan County, administration is split between the U.S. Bureau of Land Management, the U.S. Forest Service, and the National Park Service. The State controls 9.2% of the land in Wayne County, and 6.3% is in private hands. There is no Indian land.

Garfield County exhibits almost the same ownership pattern as neighboring Wayne County. Federal land control is exercised by the U.S. Bureau of Land Management, the U.S. Forest Service, and the National Park Service (ER, p. 2-63). State land accounts for 6.7% of the total, and private land comprises another 4%. There is no Indian land (Table 2.15).

Because of the arid nature of this area, the primary agricultural use of the non-Federal property in all three counties is rangeland (Table 2.16). The land within 8 km (5 miles) of the proposed mill is primarily used for grazing. In addition to the uranium ore buying station currently operated at the site by Energy Fuels Nuclear, Inc., nonagricultural land uses in this area include the Blanding airport, a small commercial establishment, a part of the Ute Mountain Indian community of White Mesa, several structures connected with the U.S. Army's Blanding Launch Site, and another ore-buying station, operated by Plateau Resources, Inc. (ER, p. 2-29).

Table 2.16. Land use in Wayne, Garfield, and San Juan counties excluding Federal land, 1967[a]

	Wayne County			Garfield County			San Juan County		
	ha	acres	Percentage	ha	acres	Percentage	ha	acres	Percentage
Cropland	8,829	21,815	8.6	13,651	33,732	9.2	59,093	146,016	7.3
Irrigated	8,829	21,815	8.6	12,897	31,869	8.7	2,878	7,111	0.4
Nonirrigated	0	0	0	754	1,863	0.5	56,215	138,905	6.9
Pasture	0	0	0	1,481	3,660	1.0	24,497	60,531	3.0
Rangeland	69,465	171,645	68.0	91,923	227,139	62.3	511,139	1,263,007	63.0
Forest	4,235	10,464	4.2	24,331	60,120	16.5	187,100	462,318	23.0
Other[b]	17,277	42,691	16.9	12,302	30,398	8.3	23,314	57,608	2.9
Urban and transportation	2,192	5,416	2.1	3,506	8,662	2.4	6,173	15,253	0.8
Small water[c]	54	133		389	960	0.3	403	997	
Total non-Federal	10,205	252,165	100.0	147,582	364,671	100.0	811,719	2,005,730	100.0
Federal	541,843	1,338,875		1,195,374	2,953,729		1,208,284	2,985,630	
Total county acreage	643,894	1,591,040		1,342,956	3,318,400		2,020,003	4,991,360	

[a]Water areas of more than 16 km (40 acres) and rivers wider than 0.20 km (0.125 mile) are excluded.

[b]"Other" includes strip mine areas, salt flats, mud flats, marshes, rock outcrops, feed lots, farm roads, ditch banks, and miscellaneous agricultural land.

[c]Includes water areas of 0.8 to 16 ha (2 to 40 acres) and streams less than 0.20 km (0.125 mile) in length.

Source: ER, Tables 2.2-8 and 2.2-24.

2.5.1.1 Mill ownership

The surface area of the entire 600-ha (1480-acre) project site is currently owned by Energy Fuels Nuclear, Inc. (ER, p. 2-4).

2.5.1.2 Farmlands

Because the rugged terrain and arid climate of the White Mesa region have restricted development of cultivated croplands, grazing is the predominant agricultural land use (Table 2.16). Dry farming produces primarily wheat and beans.

The Federal government owns and administers, through the U.S. Bureau of Land Management, approximately 60% of the total land area of San Juan County (ER, Sect. 2.2.1.3). This land, classified as multiple use, is leased for grazing, oil and gas exploration, and mining claims, and is managed for wildlife and recreation. The majority (63%) of the private land in San Juan County is rangeland (Table 2.16).

The site for the proposed uranium mill (Fig. 2.2) was previously used for grazing. Also, potential grazing land lies on all sides of the applicant's property (Fig. 2.2). Based upon primary production for rangeland in fair condition, and assuming 50% of the primary production will be grazed, grazing capacity of rangeland in the vicinity of the site is conservatively estimated at about .69 to 1.24 animal unit months (AUMs) per hectare (0.28 to 0.5 AUMs per acre);[9] that is, about 0.8 to 1.4 ha (2 to 3.6 acres) of rangeland are required to support one cow or five sheep for one month per year. The nearest cultivated cropland (alfalfa) occurs 2.4 km (1.5 miles) north of the site boundary, and the nearest garden plot lies approximately 1.6 km (1 mile) north.[9]

2.5.1.3 Urban areas

The communities of Blanding, Monticello, and Bluff, all within 48 km (30 miles) of the proposed White Mesa mill site, and the town of Hanksville, 16 km (10 miles) from the Hanksville ore buying station, have been discussed in detail in Sects. 2.4.1.1, 2.4.1.2, and 2.4.2.1. The two largest of these, Blanding and Monticello, have a number of regulations governing land use, including zoning, subdivision regulations, and building codes (City Manager of Blanding, Utah, and City Manager of Monticello, Utah, personal communications, July 10, 1978, and July 20, 1978, respectively).

2.5.2 Historical, scenic, and archaeological resources

2.5.2.1 Historical sites

Although there are no cultural sites on or adjacent to the proposed mill site which are presently included in the National Register of Historic Places (National Register), the State Historic Preservation Officer of Utah is considering nominating White Mesa to the Register as an archaeological district. The applicant will be required to have a historical survey conducted on the proposed mill site to identify historical sites that may meet National Register criteria. Landmarks of southeastern Utah in the National Register are summarized in Table 2.17. Closest to the proposed mill site is the Edge of Cedars Indian Ruin, located in Blanding (approximately three miles north of the proposed mill site).

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 interesting geologic formations, and the Glen Canyon National Recreation Area on Lake Powell, a man-made lake on the Colorado River. Capitol Reef National Park contain numerous colorful stone formations. At Natural Bridges 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. In addition, the area contains an abundnace of Indian ruins and petroglyphs. Newspaper Rock State Park, Edge of the Cedars State Park, and Hovenweep National Monument are noted areas of scenic and archaeological interest (Fig. 2.1). Closest to the proposed mill site is Edge of the Cedars State Park (historical monument), located in Blanding (approximately three miles north of the proposed mill site).

2.5.2.3 Archaeological sites

An archaeological survey of portions of the project site was conducted in the fall of 1977 by archaeologists from Southern Utah State College. The total area surveyed contained parts of Sections 21, 28, 32, and 33 of T37S, R22E, and encompassed 500 ha (1260 acres), of which 73 ha (180 acres) are administered by the U.S. Bureau of Land Management. The remaining acreage is privately owned. During the survey, 57 sites were recorded and all were determined to have an affiliation with the San Juan Anasazi who occupied this area of Utah from about 0 A.D. to 1300 A.D. All but four of the sites were within the project boundaries. Table 2.18 summarizes the recorded sites according to their probable temporal positions. The dates of occupation are the best estimates available, based on professional experience and expertise in the interpretation of archaeological evidence. Available evidence suggests that settlement on White Mesa reached a peak in perhaps 800 A.D. Occupation remained at approximately that level until some time near the end of Pueblo II or in the Pueblo II/Pueblo III transition period. After this period, the population density declined sharply, and it may be assumed that the White Mesa was, for the most part, abandoned by about 1250 A.D.

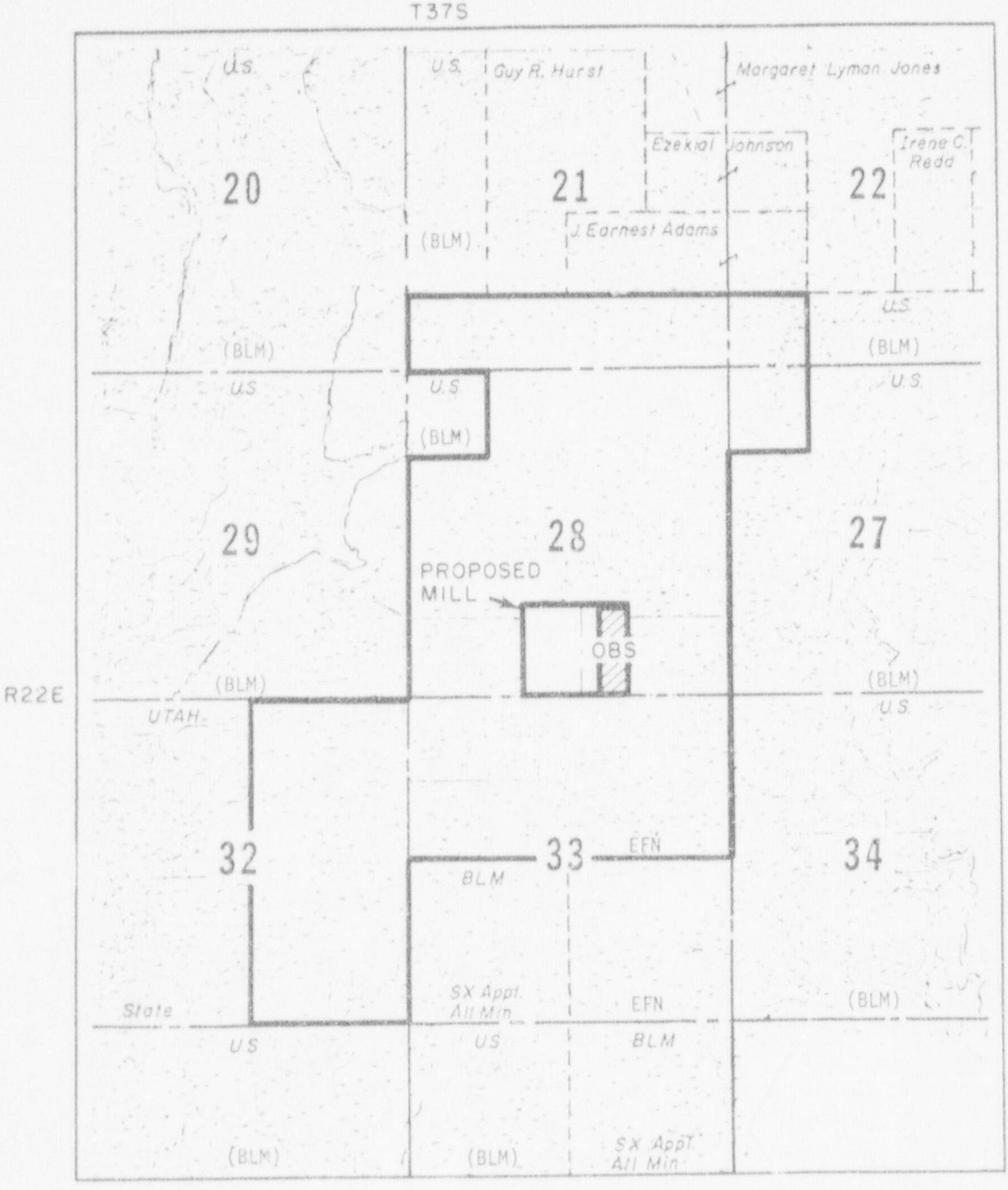

Fig. 2.2. Land Ownership in the vicinity of the project site (OBS = ore-buying station). Source: ER, Plate 2.1-3 and Sect. 2.1.

Note: Energy Fuels Nuclear currently owns T37S R22E Section 33, SE¼, but this quarter section is not part of the proposed project.

Table 2.17. Historic sites in southeastern Utah included in the "National Register of Historic Places"

Location	Site
San Juan County	
Blanding (3 mi north of site)	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	
46 miles south of Hanksville	Starr Ranch
South of Hanksville	Susan's Shelter
Near Panquitch	Bryce Canyon Airport Hanger

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

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

The survey crews recorded evidence of structures at 31 of the 57 sites. At 12 sites, depressions, apparently pit houses or kivas, were reported with diameters ranging from 5 to 15 m. Twenty-seven sites contained evidence of other, presumably surface, structural forms; and at eight sites, depressions, apparently kivas, combined with surface structures were noted.

Archaeological test excavations were conducted by the Antiquities Section, Division of State History, in the spring of 1978[32], on 20 sites located in the area to be occupied by tailings cells 2,3 and 4. Of these sites, twelve were deemed by the State Archaeologist to have significant National Register potential and four possible significance. The primary determinant of significance in this study was the presence of structures, though storage features and pottery artifacts were also common.

In the fall of 1978, a surface survey was conducted on much of the previously unsurveyed portions of the proposed mill site. Approximately 25 archaeological sites were located during this survey, some of which are believed to be of equal or greater significance than the more significant sites from the earlier study. Determination of the actual significance of all untested sites will require additional field investigation. Requirements for further action by the applicant are discussed in Section 4.2.2. (Note that Table 2.18 does not contain information obtained during the 1978 surveys.)

Table 2.18. Distribution of recorded sites according to temporal position

Temporal position	Approximate dates[a] (A.D.)	Number of sites
Basket Maker III/ Pueblo I	575–850	6
Pueblo I	750–850	11
Pueblo I/Pueblo II	850–950	6
Pueblo II	950–1100	12
Pueblo II/Pueblo III	1100–1150	4
Pueblo III	1150–1250	5
Pueblo II+	*b*	5
Multicomponent	*c*	3
Unidentified	*d*	5

[a] Includes transitional periods.

[b] Although collections at these locations were lacking in diagnostic material, available evidence indicates that the site would have been used or occupied no earlier than 900 A.D. and possibly later.

[c] Ceramic collections from each of these sites indicate an occupation extending from Pueblo I through Pueblo II and into Pueblo III.

[d] Four of these sites produced shards that could not be identified. The fifth site lacked ceramic evidence but contained an ovoid outline of vertical slabs. This evidence was not strong enough to justify any identification.

Source: Adapted from ER, Table 2.3-2.

2.6 WATER

2.6.1 Surface water

2.6.1.1 Surface-water description

The proposed mill site is located on White Mesa, a gently sloping (1% SSW) plateau that is physically defined by the adjacent drainages which have cut deeply into regional sandstone formations (Sect. 2.7.1 and Fig. 2.8). There is a small drainage area of approximately 25 ha (62 acres) above the proposed site that could yield surface runoff to the site. Runoff from the project area is conducted by the general surface topography to either Westwater Creek, Corral Creek, or to the south into an unnamed branch of Cottonwood Wash. Local porous soil conditions, topography, and low average annual rainfall (30 cm (11.8 in.)) cause these streams to be intermittently active, responding to spring snowmelt and local rainstorms (particularly thunderstorms). Surface runoff from approximately 155 ha (384 acres) of the project site drains westward and is collected by Westwater Creek, and runoff from another 155 ha (384 acres) drains east into Corral Creek. The remaining 289 ha (713 acres) of the southern and southwestern portions of the site drain indirectly into Cottonwood Wash (ER, p. 2-143). The site and vicinity drainages carry water only on an intermittent basis. The major drainages in the project vicinity are depicted in Fig. 2.3 and their drainages tabulated in Table 2.19. Total runoff from the site (total yield per watershed area) is estimated to be less than 1.3 cm (0.5 in.) annually (ER, p. 2-143).

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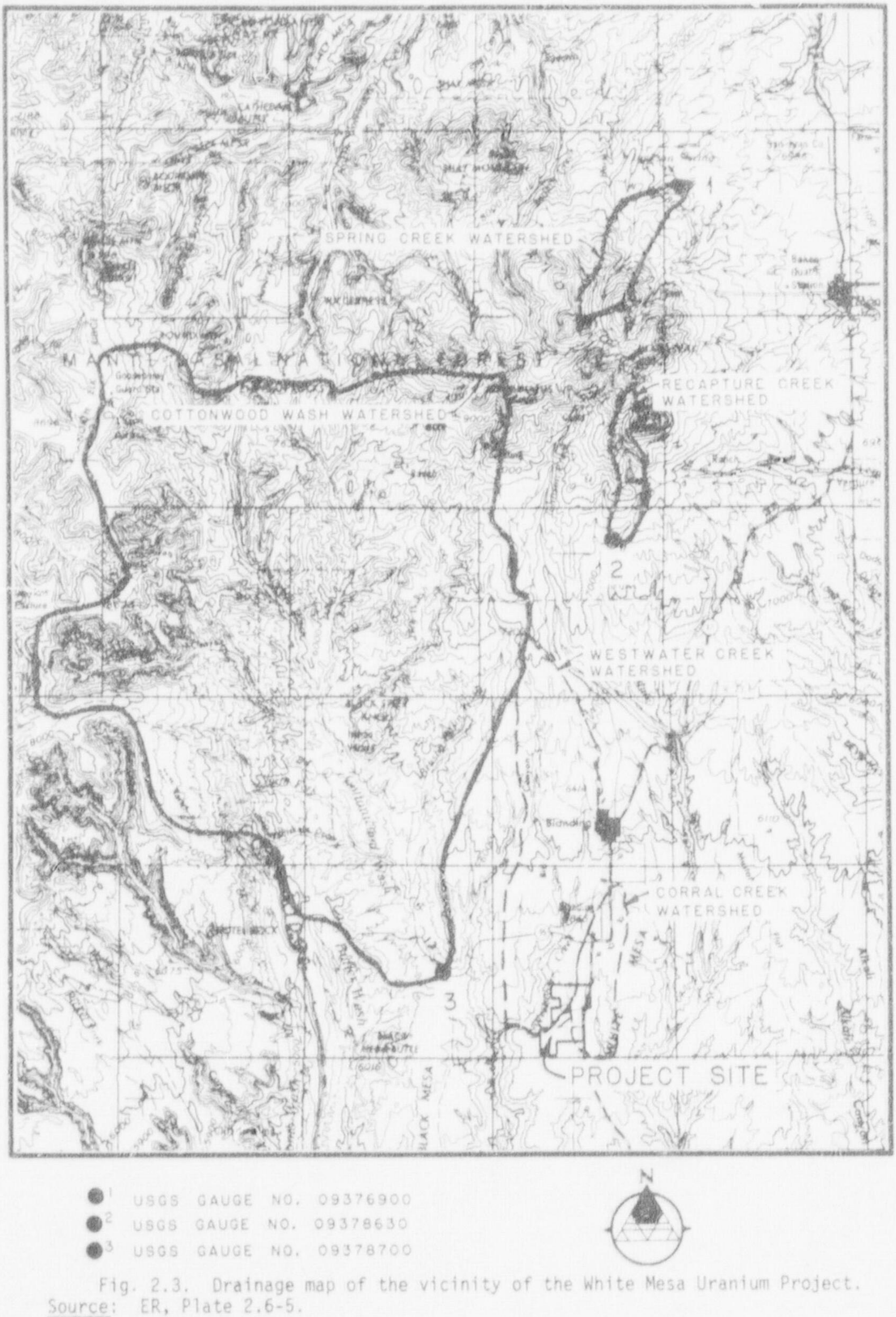

Fig. 2.3. Drainage map of the vicinity of the White Mesa Uranium Project. Source: ER, Plate 2.6-5.

Table 2.19. Drainage areas of project vicinity and region

Basin description	Drainage area	
	km²	sq miles
Corral Creek at confluence with Recapture Creek	15.0	5.8
Westwater Creek at confluence with Cottonwood Wash	68.8	26.6
Cottonwood Wash at USGS gage west of project site	≤531	≤205
Cottonwood Wash at confluence with San Juan River	≤860	≤332
Recapture Creek at USGS gage	9.8	3.8
Recapture Creek at confluence with San Juan River	≤518	≤200
San Juan River at USGS gage downstream of Bluff, Utah	≤60,000	≤23,000

Source: ER, Table 2.6-3.

There are no perennial surface waters on or in the vicinity of the project site. This is due to the gentle slope of the mesa on which the site is located, the low average annual rainfall of 29.7 cm (11.8 in.) per year at Blanding (ER, p. 2-168), local soil characteristics (Sect. 2.8), and the porous nature of local stream channels. Two small ephemeral catch basins are present on the site to the northwest and northeast of the present buying station (Sect. 2.9.2).

Corral Creek is an intermittent tributary to Recapture Creek. The drainage area of that portion of Corral Creek above and including drainage from the eastern portion of the site is about 13 km² (5 sq miles). Westwater Creek is also an intermittent tributary of Cottonwood Wash. The Westwater Creek drainage basin covers nearly 70 km² (27 sq miles) at its confluence with Cottonwood Wash 2.5 km (1.5 miles) west of the project site. Both Recapture Creek and Cottonwood Wash are similarly intermittently active, although they carry water more often and for longer periods of time due to their larger watershed areas. They both drain to the south and are tributaries of the San Juan River. The confluences of Recapture Creek and Cottonwood Wash with the San Juan River are approximately 29 km (18 miles) south of the project site. The San Juan River, a major tributary for the upper Colorado River, has a drainage of 60,000 km² (23,000 sq miles) measured at the USGS gage to the west of Bluff, Utah (ER, p. 2-130).

Storm runoff in these streams is characterized by a rapid rise in the flow rates, followed by rapid recession primarily due to the small storage capacity of the surface soils in the area (Sect. 2.8). For example, on August 1, 1968, a flow of 581 m³/sec (20,500 cfs) was recorded in Cottonwood Wash near Blanding. The average flow for that day, however, was only 123 m³/sec (4340 cfs). By August 4, the flow had returned to 0.5 m³/sec (16 cfs) (ER, p. 2-135). Monthly streamflow summaries are presented in Fig. 2.4 for Cottonwood Wash and Recapture Creek. Flow data are not available for the two smaller watercourses closest to the project site, Corral Creek and Westwater Creek, because these streams carry water infrequently and only in response to local heavy rainfall and snowmelt, which occurs primarily in the months of April, August, and October. According to the applicant, flow typically ceases in Corral and Westwater creeks within 6 to 48 hr after precipitation or snowmelt ends.

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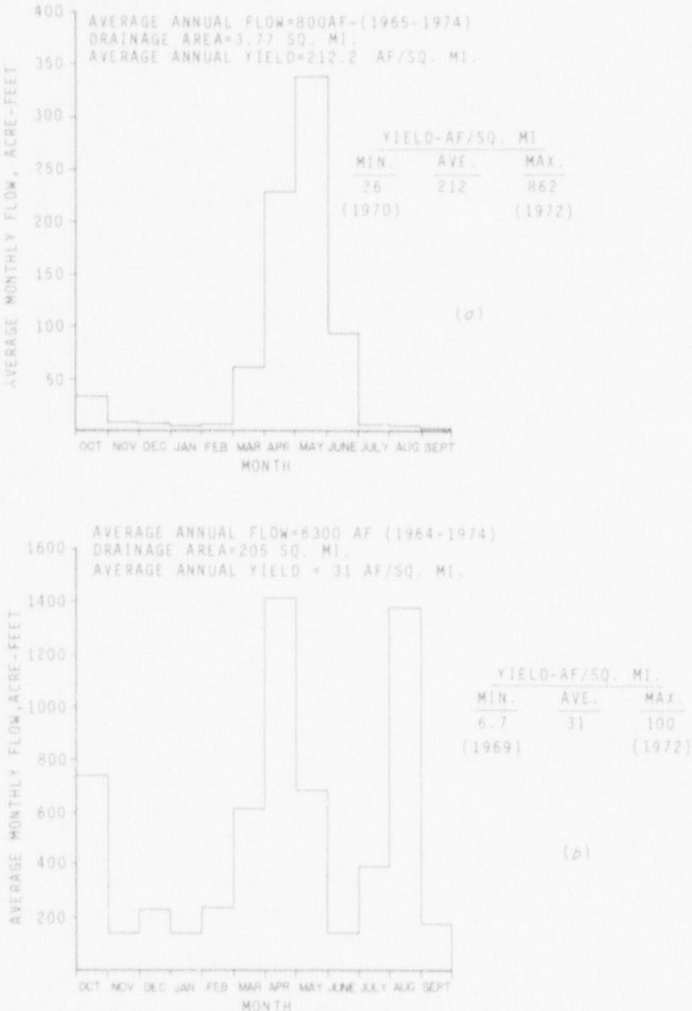

Fig. 2.4. Streamflow summary in the Blanding, Utah, vicinity. *(a)* Upper portion of the watershed near the headwaters of Recapture Creek near Blanding at 7200 ft MSL; USGS gage 09378630. *(b)* Cottonwood Wash about 11 km (7 miles) southwest of Blanding at 5138 ft MSL; USGS gage 09378700. Source: Adapted from the ER, Plate 2.6-6.

2.6.1.2 Surface-water quality

The applicant began sampling surface-water quality in the project vicinity in July 1977 and continued through March 1978. Baseline data describe and evaluate existing conditions at the project site and vicinity. Sampling of the temporary onsite surface waters (two catch basins) has been attempted but without success because of the lack of naturally occurring water in these basins. The basin to the northeast of the proposed mill site has been filled with well water by the applicant to serve as a nonpotable water source during planned construction of office and laboratory buildings in conjunction with the proposed mill (approximately six months). This water has not been sampled by the applicant but presumably reflects the poor quality associated with local groundwater (Sect. 2.6.2). Sampling of ephemeral surface waters in the vicinity has necessitated correlation with major precipitation events as these watercourses are normally dry at other times.

The chemical and physical water quality parameters measured by the applicant are listed in Table 2.20. The locations of the surface-water sample sites are presented in Table 2.21 and Fig. 2.5, and the water quality values obtained for these sample sites are given in Table 2.22. Water quality samples were collected during the spring at several intermittently active streams (Fig. 2.5) that drain the project area. These streams include Westwater Creek, (S1R, S9), Corral Creek below the small irrigation pond (S3R), the junction of Corral Creek and Recapture Creek (S4R), and Cottonwood Creek (S8R). Samples were also taken from a surface pond southeast of the proposed mill (S5R). No samples were taken at S2R on Corral Creek or at the small wash (S6R) located south of the site.

Surface-water quality in the vicinity of the proposed mill is generally poor. Waters in Westwater Creek (S1R and S9) were characterized by high total dissolved solids (TDS; mean of 674 mg/liter, and sulfate levels (mean 117 mg of SO_4 per liter). The waters were typically hard (total hardness measured as $CaCO_3$; mean 223 mg/liter) and had an average pH of 8.25. Estimated flow rates for Westwater Creek averaged <0.08 m/sec (<0.3 fps) at the time of sampling.

Samples from Cottonwood Creek (S8R) were similar in quality to Westwater Creek water samples, although the TDS and sulfate levels were lower (TDS averaged 264 mg/liter; SO_4 averaged 40 mg/liter during heavy spring flow conditions [24 m/sec (80 fps) streamflow].

The concentrations of TDS increased downstream in Corral Creek, averaging 3180 mg/liter at S3R and 6660 mg/liter (one sample) at S4R. Total hardness averaged in excess of 2000 mg/liter, and pH values were slightly alkaline. Estimated flows in Corral Creek were typically less than 0.03 m/sec (0.1 fps) during sampling.

The spring sample collected at the surface pond south of the project site (S5R) indicated a TDS concentration of less than 300 mg/liter. The water was slightly alkaline with moderate dissolved sulfate levels averaging 42 mg/liter.

During heavy runoff, the concentration of total suspended solids in these streams increased sharply to values in excess of 1500 mg/liter (Table 2.22).

High concentrations of certain trace elements were measured in some sampling areas. Levels of mercury (total) were reported as high as 0.002 mg/liter (S3R, 7/25/77; S8R, 7/25/77). This level is 40 times the EPA recommended limit for the protection of freshwater aquatic life (0.05 μg/liter).[10] Total iron measured in the pond (S5R, 11/10/77) was 9.4 mg/liter, over nine times the EPA recommended limit of 1 mg/liter for the protection of aquatic life. These values appear to reflect groundwater quality in the vicinity (Sect. 2.6.2) and are probably due to evaporative concentration and not due to human perturbation of the environment.

2.6.1.3 Surface-water utilization

Regional surface water is primarily used for agricultural irrigation and stock-watering purposes. Water usage from the San Juan River in Utah alone amounts to approximately 12.2×10^3 m^3 (9900 acre-ft) per year. Table 2.23 lists the existing surface water appropriations within the project vicinity. Water uses in San Juan County are presented in Table 2.24.

Table 2.20. Physical and chemical water quality parameters

Specific conductance (field), micromhos/cm	Manganese
Total suspended solids	Aluminum
Temperature (field)	Arsenic
pH (lab, field)	Barium
Redox potential	Boron
Total dissolved solids	Cadmium
Dissolved oxygen (field)	Chromium
Oil and grease	Copper
Total hardness as $CaCO_3$	Lead
Total alkalinity as $CaCO_3$	Mercury
Carbonate as CO_3	Molybdenum
Chloride	Nickel
Cyanide	Selenium
Fluoride	Strontium
Nitrate as N	Vanadium
Sulfate as SO_4	Zinc
Calcium	Silver
Iron, total and dissolved	Po-210
Magnesium	Pb-210
Ammonia as N	Th-230
Phosphorus, total as P	Uranium (natural)
Potassium	Ra-226
Silica	Gross α
Sodium	Gross β
Chemical oxygen demand (COD)	

Source: ER, Table 6.1-1.

Table 2.21. Water sampling stations

Station no.	Location
S1R	Westwater Creek at downstream (south) side of Highway 95 bridge
S2R	Corral Creek at downstream (south) side of small bridge
S3R	Corral Creek at spillway of small earthen dam
S4R	Corral Creek at junction with Recapture Creek 0.40 km (0.25 mile) from end of jeep road
S5R	Surface pond south of mill site, 0.20 km (0.125 mile) west of Highway 47
S6R	Small wash south of mill site, 1.6 km (1.0 mile) west of Highway 47
S7R	East side of Cottonwood Creek, at jeep trail intersection south-southwest of mill site
S8R	East side of Cottonwood Creek, at jeep trail intersection west-southwest of mill site
S9	East side of Westwater Creek, at jeep trail intersection

Source: ER, p. 6-1.

Table 2.22. Water quality of surface waters in project vicinity, Blanding, Utah

Zero values (0.0) are below detection limits.

Parameter	Sampling for dates as given						
	7/25/77	11/10/77	3/23/78	3/23/78[a]	7/25/77	11/10/77	3/23/78
	Westwater Creek, S1R[c]				Corral Creek, S2R[c]		
Field specific conductivity, μmhos/cm	*b*	490	620		*b*	*b*	
Field pH		7.6	8.3				
Dissolved oxygen							
Temperature, °C		3	14				
Estimated flow, m/hr (fps)		21.9 (0.02)	39.9 (0.03)				
Determination, mg/liter							
pH	*b*	8.2	8.35		*b*	*b*	
TDS (at 180°C)		496	559				
Redox potential		220	186				
Alkalinity (as $CaCO_3$)		206	229				
Hardness, total (as $CaCO_3$)		262	289				
Carbonate (as CO_3)		0.0	2.3				
Aluminum, dissolved		0.2	0.10				
Ammonia (as N)		<0.1	0.18				
Arsenic, total			0.007				
Barium, total		<0.2	0.22				
Boron, total		0.1	<0.1				
Cadmium, total		<0.002	<0.005				
Calcium, dissolved		75	140				
Chloride		17	38				
Sodium, dissolved		31	60				
Silver, dissolved			<0.005				
Sulfate, dissolved (as SO_4)		103	163				
Vanadium, dissolved		<0.01	<0.005				
Manganese, dissolved		0.030	0.04				
Chromium, total		<0.01	0.01				
Copper, total		<0.005	0.01				
Fluoride, dissolved		0.3	0.4				
Iron, total		0.28	1.5				
Iron, dissolved		0.17	0.21				
Lead, total		<0.05	<0.05				
Magnesium, dissolved		17.0	26				
Mercury, total		<0.0005	<0.00003				
Molybdenum, dissolved			0.002				
Nitrate (as N)		<0.05	<0.05				
Phosphorus, total (as P)		0.05	0.06				
Potassium, dissolved		2.8	2.0				
Selenium, dissolved			0.003				
Silica dissolved (as SiO_2)		7	9				
Strontium, dissolved		0.44	0.76				
Uranium, total (as U)		0.006	0.004				
Uranium, dissolved (as U)		0.002	0.003				
Zinc, dissolved		0.09	0.04				
Total organic carbon		6	7				
Chemical oxygen demand		23	48				
Oil and grease		1	1				
Total suspended solids		12	47				
Determination, pCi/liter							
Gross alpha ± precision	*b*	0.1 ± 1.1	4.5 ± 2.0	*b*	*b*	*b*	
Gross beta ± precision		0 ± 9	8 ± 11				
Ra-226 ± precision		0.2 ± 0.3	0.2 ± 0.3				
Th-230 ± precision		0.0 ± 0.4	0.1 ± 0.4				
Pb-210 ± precision		0.7 ± 2.3	1.1 ± 3.8				
Po-210 ± precision		0.1 ± 0.5	0.0 ± 0.7				

Table 2.22. (Continued)

Parameter	Sampling for dates as given						
	7/25/77	11/10/77	3/23/78	3/23/78[a]	7/25/77	11/10/77	3/23/78
	Corral Creek, S3R[c]				Junction c Corral and Recapture c eks, S4R[c]		
Field specific conductivity, μmhos/cm	2000	2400	3500	3500	*d*	*d*	6000
Field pH	6.8		7.9	7.8			7.9
Dissolved oxygen							
Temperature °C	27.7	8	13	13			14
Estimated flow, m/hr (fps)	98.7 (0.09)	21.9 (0.02)	65.8 (0.06)	65.8 (0.06)			10.9 (0.01)
Determination, mg/liter							
pH	6.7	8.0	8.23	8.15	*d*	*d*	8.11
TDS (at 180°C)	1350	3160	4095	4130			6660
Redox potential	260	240	190	193			195
Alkalinity (as $CaCO_3$)	70	172	236	236			274
Hardness, total (as $CaCO_3$)	853	1910	2200	2200			2100
Carbonate (as CO_3)	0.0	0.0	0.0	0.0			0.0
Aluminum, dissolved	0.04	<0.1	<0.1	<0.1			<0.1
Ammonia (as N)	0.15	<0.1	<0.1	0.13			<0.1
Arsenic, total	<0.01		0.011	0.013			0.010
Barium, total	0.36	0.4	0.18	0.22			0.29
Boron, total	0.1	0.2	0.2	0.2			0.2
Cadmium, total	0.004	0.006	0.01	0.01			0.02
Calcium, dissolved	150	78	546	571			649
Chloride	54	152	214	189			556
Sodium, dissolved	115	160	312	315			1205
Silver, dissolved	0.004		0.02	0.01			0.02
Sulfate, dissolved (as SO_4)	803	2000	2596	2854			3760
Vanadium, dissolved	0.004	<0.01	0.005	<0.005			<0.005
Manganese, dissolved	0.20	0.030	0.05	0.04			0.32
Chromium, total	0.02	0.01	0.02	0.04			0.04
Copper, total	0.01	0.010	0.02	0.03			
Fluoride, dissolved	0.32	0.6	0.8	0.8			
Iron, total	0.08	0.09	0.09	0.12			0.30
Iron, dissolved	0.12	0.07	0.09	0.04			0.10
Lead, total	0.04	0.15	0.10	0.08			0.14
Magnesium, dissolved	120	20	359	376			353
Mercury, total	0.002	<0.0005	0.00003	0.00009			0.00002
Molybdenum, dissolved	<0.01		0.004	0.003			0.004
Nitrate (as N)	0.21	0.11	0.81	0.81			<0.05
Phosphorus, total (as P)	0.21	0.06	<0.02	<0.02			0.06
Potassium, dissolved	13	4.8	6.9	6.8			6.8
Selenium, dissolved	0.16		0.032	0.027			0.005
Silica, dissolved (as SiO_2)	10	2	3	3			11
Strontium, dissolved	1.9	2.2	5.0	5.1			12
Uranium, total (as U)	0.005	0.028	0.046	0.038			0.085
Uranium, dissolved (as U)	0.002	0.028	0.046	0.036			0.082
Zinc, dissolved	0.06	0.02	0.02	0.01			0.02
Total organic carbon		11	17	18			22
Chemical oxygen demand		79	234	155			61
Oil and grease		1	2	<1			1
Total suspended solids		9	6	9			24
Determination, pCi/liter							
Gross alpha ± precision	15 ± 2	19 ± 6	13.4 ± 6.6	0 ± 11	*d*	*d*	7.0 ± 2.9
Gross beta ± precision	180 ± 20	0 ± 29	95 ± 50	37 ± 4			25 ± 18
Ra-226 ± precision	0.0 ± 0.3	0.3 ± 0.3	0.4 ± 0.4	0.09 ± 0.03			0.2 ± 0.3
Th-230 ± precision	3.1 ± 0.5	0.1 ± 0.5	1.3 ± 0.6	0 ± 0.1			1.5 ± 0.7
Pb-210 ± precision	.4 ± 2.1	2.4 ± 2.6	1.4 ± 3.6	0 ± 1			1.4 ± 3.7
Po-210 ± precision	0.0 ± 0.3	0.6 ± 0.7	0.5 ± 0.9				1.4 ± 1.1

Table 2.22. (Continued)

Parameter	Sampling for dates as given						
	7/25/77	11/10/77	3/23/78	3/23/78[a]	7/25/77	11/10/77	3/23/78
	Surface pond, S6R[c]			Unnamed Wash, S6R[c]		Cottonwood Creek, S7[c]	
Field specific conductivity, μmhos/cm	*e*	100	250	*d*	*d*		320
Field pH		6.8	8.4				8.2
Dissolved oxygen							
Temperature, °C		7	20				12
Estimated flow, m/hr (fps)							1097 (10)
		Determination, mg/liter					
pH	*e*	6.9	7.94	*d*	*d*		8.36
TDS (at 180°C)		264	291				295
Redox potential		280	130				172
Alkalinity (as $CaCO_3$)		218	138				149
Hardness, total (as $CaCO_3$)		67	129				154
Carbonate (as CO_3)		0.0	0.0				2.3
Aluminum, dissolved		2.0	1.0				2.4
Ammonia (as N)		<0.1	0.19				0.15
Arsenic, total			0.008				0.027
Barium, total		<0.2	0.33				0.66
Boron, total		0.2	0.1				<0.1
Cadmium, total		<0.002	<0.005				0.006
Calcium, dissolved		22	72				134
Chloride		8	10				7
Sodium, dissolved		0.6	5.4				20
Silver, dissolved			<0.005				<0.005
Sulfate, dissolved (as SO_4)		64	20.3				52.6
Vanadium, dissolved		<0.01	0.012				0.012
Manganese, dissolved		0.095	0.15				0.69
Chronium, total		0.04	0.04				0.03
Copper, total		0.005	0.02				0.04
Fluoride, dissolved		<0.1	0.1				0.2
Iron, total		9.4	11				3.9
Iron, dissolved		1.2	1.0				1.7
Lead, total		<0.05	<0.05				0.08
Magnesium, dissolved		3.2	8.8				25
Mercury, total		<0.0005	0.00005				0.00007
Molybdenum, dissolved			0.002				0.004
Nitrate (as N)		4.26	0.05				0.14
Phosphorus, total (as P)		0.04	0.37				0.85
Potassium, dissolved		14	13				2.3
Selenium, dissolved			<0.005				<0.005
Silica, dissolved (as SiO_2)		2	7				10
Strontium, dissolved		0.10	0.34				0.49
Uranium, total		0.004	0.002				0.011
Uranium, dissolved (as U)		0.003	<0.002				0.007
Zinc, dissolved		0.02	0.10				0.050
Total organic carbon		15	20				10
Chemical oxygen demand		71	58				60
Oil and grease		2	1				1
Total suspended solids		268	210				1600
		Determination, pCi/liter					
Gross alpha ± precision	*e*	1.1 ± 1.1	1.2 ± 1.1	*d*	*d*		3.2 ± 1.8
Gross beta ± precision		15 ± 10	27 ± 8				22 ± 11
Ra-226 ± precision		0.2 ± 0.3	0.1 ± 0.9				0.6 ± 1.5
Th-230 ± precision		0.0 ± 0.4	0.9 ± 0.6				0.2 ± 0.4
Pb-210 ± precision		2.6 ± 2.2	0.0 ± 3.8				4.3 ± 3.7
Po-210 ± precision		0.2 ± 0.5	0.0 ± 0.6				0.0 ± 0.7

Table 2.22. (Continued)

Parameter	Sampling for dates as given						
	7/25/77	11/10/77	3/23/78	3/23/78[a]	7/25/77	11/10/77	3/23/78
	Cottonwood Creek, S8R[c]				Westwater Creek, S9[c]		
Field specific conductivity, μmhos/cm	550	445	240	240	*d*	*d*	320
Field pH	6.6	6.9	8.1	7.9			8.0
Dissolved oxygen							
Temperature, °C	35	6.0	7	7			9
Estimated flow, m/hr (fps)	0.4	0.7	80	80			0.28
	Determination, mg/liter						
pH	7.5	8.2	8.21	8.09	*d*	*d*	8.20
TDS (at 180°C)	944	504	275	253			969
Redox potential	220	260	210	224			190
Alkalinity (as $CaCO_3$)	134	195	155	155			147
Hardness, total (as $CaCO_3$)	195	193	148	154			117
Carbonate (as CO_3)	0.0	0.0	0.0	0.0			0.0
Aluminum, dissolved	3.0	0.7	2.4	0.16			4.0
Ammonia (as N)	0.12	<0.1	0.13	0.16			0.75
Arsenic, total	0.02		0.041	0.032			0.037
Barium, total	1.2	0.2	0.85	1.1			0.81
Boron, total	0.1	0.2	0.1	<0.1			0.1
Cadmium, total	0.004	<0.002	<0.005	0.01			0.006
Calcium, dissolved	79	54	178	72			172
Chloride	13	24	7	6			18
Sodium, dissolved	36	66	23	21			125
Silver, dissolved	0.002		<0.005	<0.005			0.006
Sulfate, dissolved (as SO_4)	564	132	39.7	39.7			85
Vanadium, dissolved	0.003	<0.01	<0.005	<0.005			0.008
Manganese, dissolved	0.84	0.065	0.78	0.02			0.60
Chronium, total	0.14	<0.01	0.04	0.05			0.60
Copper, total	0.09	0.005	0.05	0.05			0.05
Fluoride, dissolved	0.36	0.2	0.2	0.2			0.2
Iron, total	150	5.9	50	53			44
Iron, dissolved	1.4	0.62	1.9	0.11			2.5
Lead, total	0.14	0.05	0.10	0.10			0.10
Magnesium, dissolved	24	17	28	17			13
Mercury, total	0.002	<0.0005	0.00006	0.0012			0.00012
Molybdenum, dissolved	<0.01	0.10	0.002	0.002			0.006
Nitrate (as N)	1.77	0.14	0.13	0.12			0.05
Phosphorus, total (as P)	0.05	3.2	0.96	0.84			0.88
Potassium, dissolved	6.9	3.2	2.5	1.2			3.2
Selenium, dissolved	0.08		<0.005	<0.005			<0.005
Silica, dissolved (as SiO_2)	10	8	11	18			11
Strontium, dissolved	0.64	0.60	0.56	0.34			0.65
Uranium, total	0.027	0.004	0.014	0.014			0.004
Uranium, dissolved (as U)	0.015	0.004	0.008	0.006			0.002
Zinc, dissolved	0.06	0.05	0.06	0.008			0.12
Total organic carbon		7	12	11			16
Chemical oxygen demand		61	163	111			66
Oil and grease		2	2	2			1
Total suspended solids		146	2025	1850			1940
	Determination, pCi/liter						
Gross alpha ± precision	16 ± 3	2.9 ± 1.5	7.3 ± 2.4	23 ± 3	*d*	*d*	
Gross beta ± precision	72 ± 17	0 ± 10	28 ± 11	110 ± 6			
Ra-226 ± precision	0.6 ± 1.3	1.1 ± 0.5	1.9 ± 1.7	2.0 ± 0.1			
Th-230 ± precision	0.9 ± 0.6	0.0 ± 0.4	0.0 ± 0.3	0.2 ± 0.1			
Pb-210 ± precision	0.8 ± 1.9	0.0 ± 2.2	2.5 ± 4.3	0 ± 1			
Po-210 ± precision	0.0 ± 0.3	0.6 ± 0.7	0.0 ± 0.6				

[a] Replicate sample analyzed for quality assurance on radioactivity.
[b] Not enough water in stream to sample adequately.
[c] See table 2.21 for locations of sampling stations.
[d] No water in stream to sample.
[e] Not sampled.
Source: Adapted from ER, Table 2.6-7.

ES-4589

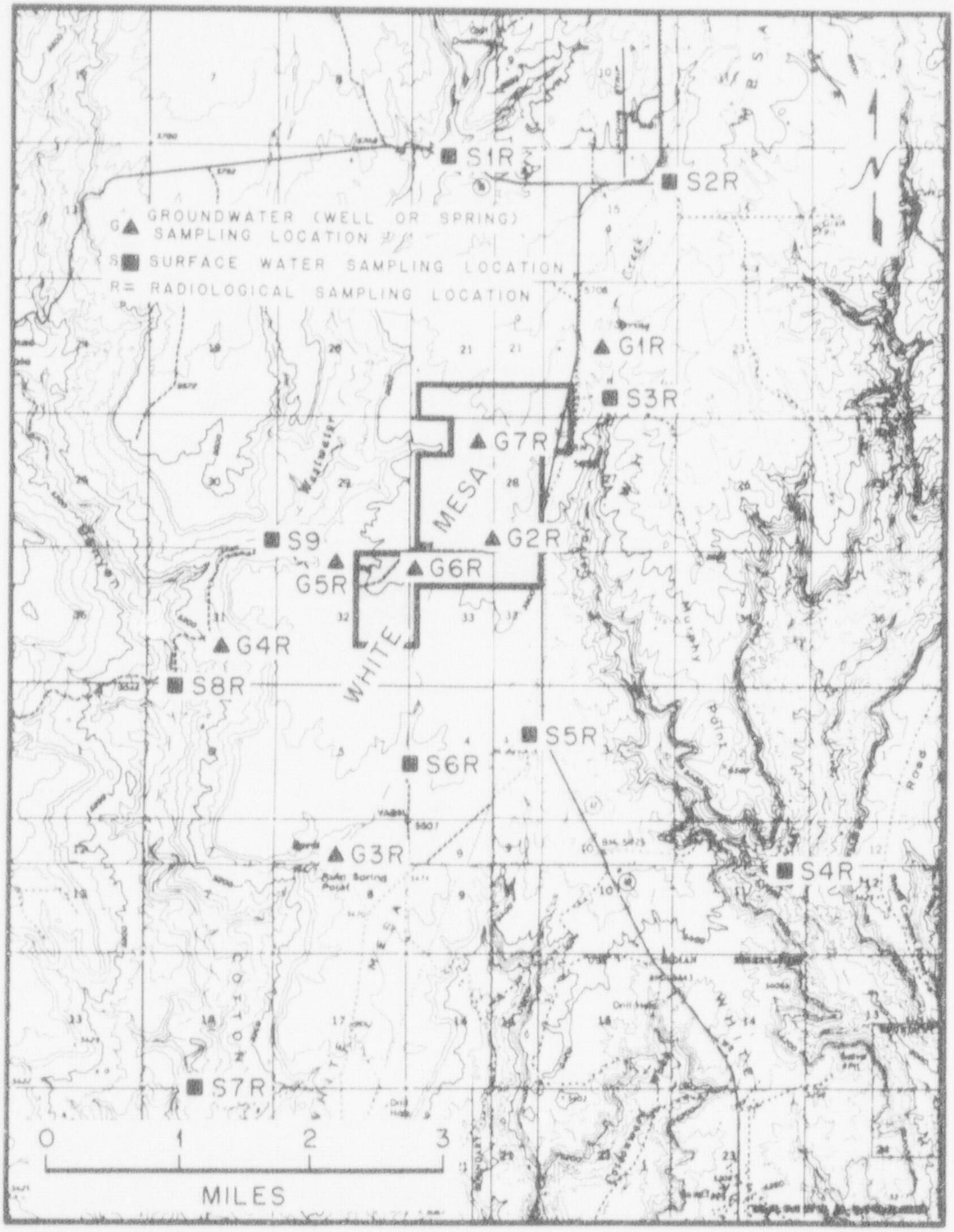

Fig. 2.5. Preoperational water quality sampling stations in the White Mesa project vicinity. Source: ER, Plate 2.6-10.

Table 2.23. Current surface water users in project vicinity

Name	Address	Application date	Application number	Quantity	
				cfs	m^3/sec
		Corral Creek			
Fred Halliday	Blanding, Utah	August 12, 1971	40839	0.5	0.014
		Cottonwood Creek or Wash			
William Keller	Moab, Utah	November 12, 1907	1647	1.0	0.028
Hyrum Perkins	Bluff, Utah	June 22, 1910	3322	5.49	0.156
U.S. Indian Service	Ignacia, Colorado	March 12, 1924	9486	1.18	0.033
U.S. Indian Service	Ignacia, Colorado	March 24, 1924	9491	0.738	0.021
U.S. Indian Service	Ignacia, Colorado	March 24, 1924	9492	0.298	0.008
Kloyd Perkins	Blanding, Utah	April 13, 1928	10320	1.455	0.041
W. R. Young	Blanding, Utah	October 22, 1928	104935	0.0015	0.00004
W. R. Young	Blanding, Utah	October 23, 1928	10496	0.0022	0.0006
W. R. Young	Blanding, Utah	October 22, 1928	10497	0.002	0.00005
San Juan County water Conservation district	Monticello, Utah	October 10, 1962	34666	12,000 (acre-ft)	1500 (ha-m)
Earl Perkins	Blanding, Utah	April 16, 1965	36924	5.0	0.142
		Westwater Creek			
Seth Shumway	Blanding, Utah	January 7, 1929	10576	0.005	0.002
H. E. Shumway	Blanding, Utah	Segregation date: February 28, 1970	37101a	0.7623	0.022
Preston Nielson	Blanding, Utah	Segregation date: October 22, 1970	37601a	0.2377	0.007
Parley Redd	Blanding, Utah	Claim date: October 16, 1970	Claim 2373	0.015	0.0004
Kenneth McDonald	Blanding, Utah	Change of Appropriation: June 12, 1974	42302	1.0	0.028

Source: ER, Table 2.6-4.

Table 2.24. Water use of San Juan County, 1965

Use	Consumption	
	$m^3 \times 10^3$	Acre-ft
Irrigated crops (5000 acres)	6,785	5,500
Reservoir evaporation	123	100
Incidental use[a]	1,603	1,300
Municipal and industrial[b]	2,220	1,800
Minerals[b]	1,357	1,100
Augmented fish and wildlife[b]	123	100
Total	12,211	9,900

[a] Incidental use of irrigation water by phreatophytes and other miscellaneous vegetation.

[b] Includes evaporation losses applicable to these sources of depletion.

Source: ER, Table 2.6-5.

2.6.2 Groundwater

A generalized section of the stratigraphic and water-bearing units in southeastern Utah is shown in Fig. 2.6. Recharge of these aquifers occurs from seasonally variable rainfall infiltrating along the flanks of the Abajo, Henry, and La Sal mountains and along the flanks of folds. Recharge water also originates from precipitation on the flat-lying beds where it percolates into the groundwater region along joints.

In the White Mesa area, 39 groundwater appropriations (applications for water wells) are on file with the Utah State Engineers Office for wells lying within an 8-km (5-mile) radius of the project site. All but one of these wells produce from the Dakota and Morrison formations. Thirty-five of these are for wells which are actually constructed (ER, Table 2.6-1). Most of these wells produce less than 55 m^3/day (10 gpm) and are used for domestic, irrigation, and stock-watering purposes. The remaining well, which was drilled to a depth of 548 m (1800 ft) by Energy Fuels Nuclear, withdraws water from the Navajo Sandstone. The majority (31) are hydrologically upgradient or cross gradient with respect to the project site. The remaining four wells (three onsite and one offsite, south) are on land owned by the applicant. Two of the onsite wells are located in the area of the proposed tailings impoundment and will be capped.[9] The well which is offsite and south will be capped or used for monitoring purposes.

As is the case throughout most of the Four Corners region, the Blanding area depends largely on groundwater for its water supply. A porous soil, underlain by the Dakota Sandstone on top of a regional aquiclude (the Brushy Basin Member of the Morrison Formation), provides the Blanding area with a near-surface source of groundwater. This situation is somewhat uncommon in the highly dissected south-central portion of the Colorado Plateau.

In the immediate vicinity, only the Dakota Sandstone and the Salt Wash Member (including the Westwater Member) are significant aquifers. The Entrada and Navajo formations contain larger quantities of water, but their depth prohibits common exploitation, in use for domestic water supplies.

Comb Ridge and the Abajo Mountains are significant areas of recharge for the Salt Wash and deeper aquifers. General gradients of groundwater movement in these aquifers follow the regional structure, and the water discharges ultimately in the vicinity of the San Juan River.

Because the Brushy Basin Member acts as an aquiclude to the Salt Wash Member in the uplands, the primary recharge areas for this aquifer are Brushy Basin Wash to the northwest of Blanding, Cottonwood Creek to the west and southwest of the town, and the upper reaches of Montezuma Creek, especially along Dodge and Long canyons.

Several permeability tests were conducted at the mill and tailings retention sites. The results of these tests show a hydraulic conductivity of 1.5 to 3 m (5 to 10 ft) per year (see Fig. 2.7). The shallow groundwater movement at the mill site is estimated to be about 0.3 to 0.6 cm (0.01 to 0.02 ft) per year toward the south-southwest and the shallow groundwater movement at the tailings site is about 0.08 to 0.3 cm (0.0025 to 0.01 ft) per year in the same direction. The values were derived using the following formula based on Darcy's Law:

$$V = Ki/\theta ,$$

where

V = the rate of movement of groundwater through the formation,

K = the hydraulic conductivity of formation 1.5 to 3 m/year (5 to 10 ft/year),

i = gradient (calculated as 0.03 at mill site and 0.01 at tailings site),

θ = porosity of formation (assumed as 20%).

Table 2.25 is a tabulation of groundwater quality of the Navajo Sandstone aquifer. The TDS range from 244 to 1110 mg/liter in three samples taken over a period from January 27, 1977, to May 4, 1977. High iron (0.57 mg/liter) concentrations are found in the Navajo Sandstone. The U.S. Environmental Protection Agency recommends 0.3 mg of dissolved iron per liter for drinking water.[11] Feltis[12] noted that the total dissolved solids in the alluvium and at shallow depths in the Dakota Sandstone, the Burro Canyon Formation, and the Morrison Formation range from 300 to 2000 mg/liter.

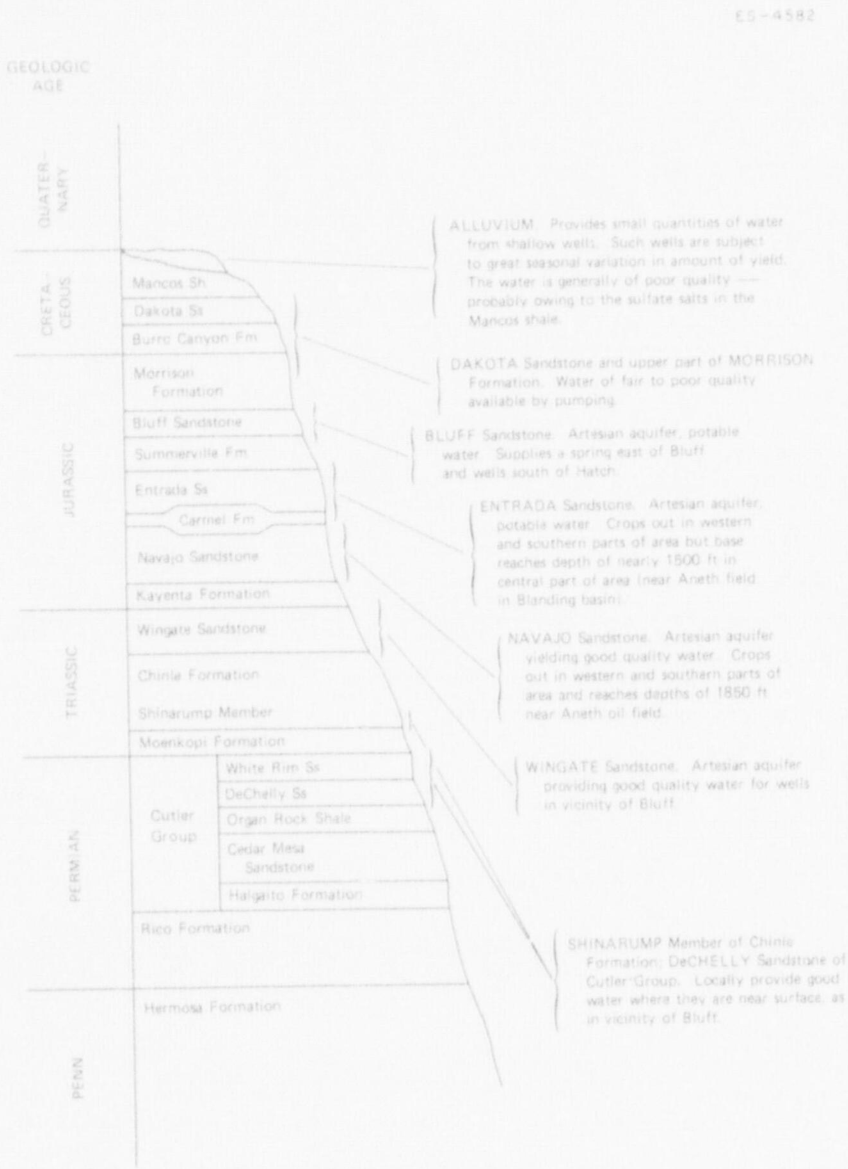

Fig. 2.6. Generalized stratigraphic section showing freshwater-bearing units in southeastern Utah. Source: ER, Plate 2.6-1.

DRILL HOLE NO	DATE	LAND SURFACE ELEVATION	DEPTH TO WATER	ELEVATION OF WATER
3	09/19/77	5634.4	56.5'	5577.9
	09/22/77		56.0'	5578.4
	09/27/77		56.5'	5577.9
	11/04/77		56.8'	5577.6
9	09/30/77	5679.3	100.0'	5579.3
	11/04/77		99.8'	5579.5
12	09/30/77	5648.1	75.0'	5573.1
	11/04/77		81.3'	5566.8
19	09/27/77	5600.3	110.0'	5490.3
	11/04/77		110.0'	5490.3
28	09/22/77	5547.6	75.0'	5472.6
	09/27/77		76.0'	5471.6
	11/04/77		75.7'	5471.9
N. E.	11/04/77	5472	34.7'	5637.3
N.	09/16/77	5653	93.0'	5560.0
	09/22/77		93.5'	5559.5
	09/27/77		94.0'	5559.0
	09/08/77		94.0'	5559.0
S. E.	09/08/77	5595	96.0'	5499.0
	09/16/77		84.0'	5511.0
	09/22/77		84.5'	5510.5
	09/27/77		84.5'	5510.5
S. W.	09/08/77	5595	91.0'	5504.0
	09/16/77		90.0'	5505.0
	09/22/77		90.5'	5504.5
	09/27/77		90.0'	5505.0
	11/04/77		90.7'	5504.3

KEY

—5520'— ELEVATION OF WATER TABLE (FEET ABOVE MSL)

← DIRECTION OF SHALLOW GROUND WATER MOVEMENT

○28 BOREHOLE LOCATION AND NUMBER ENCOUNTERING WATER

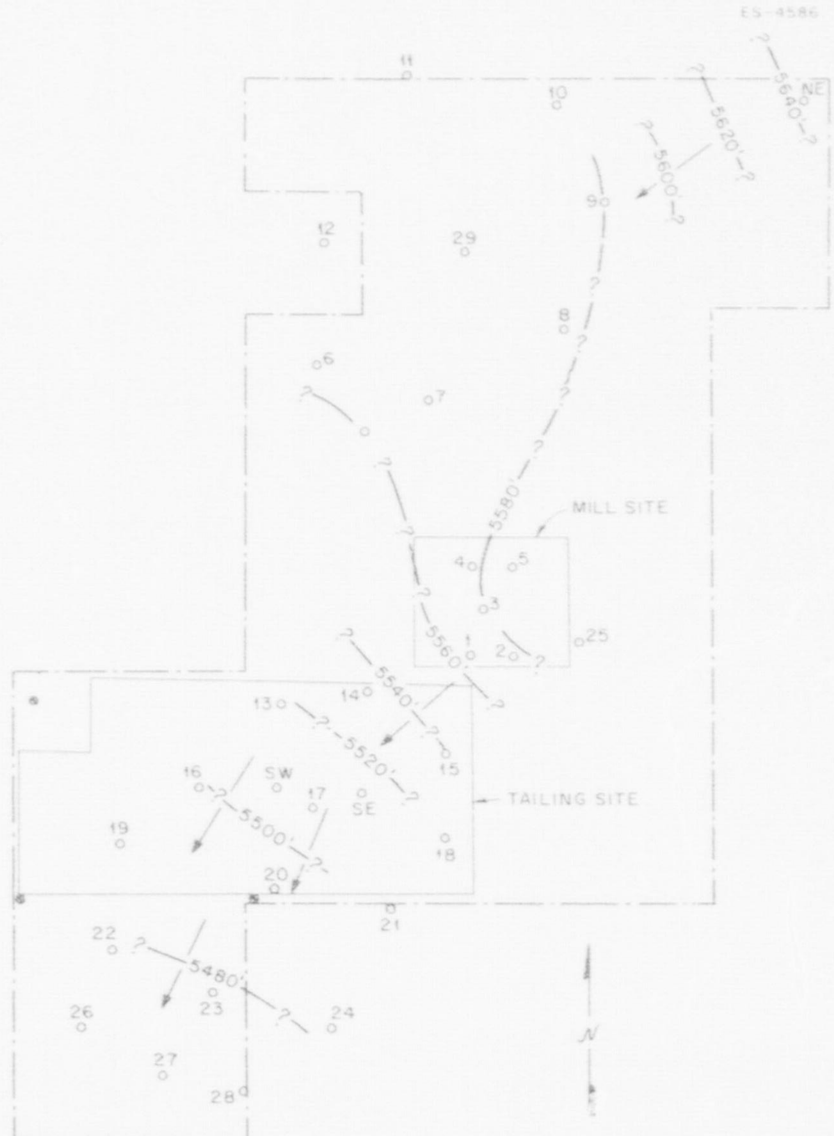

Fig. 2.7. Groundwater-level map of the White Mesa site.
Source: ER, Plate 2.6-2.

Table 2.25. Water quality of groundwater in the project vicinity[a]
Zero values (0.0) are below detection limits

Parameter	Blanding mill site well in Navajo Sandstone, G2R				
	1/27/77[b]	5/4/77[c]	7/25/77	12/05/77	3/23/78
Field specific conductivity, µmhos/cm			400		310
Field pH			6.9		7.6
Dissolved oxygen					--
Temperature °C			22.2		11
Estimated flow, m^3/day (gpm)			109 (20)		--
Determination, mg/liter					
pH	8.0	7.9	7.7	7.9	8.16
TDS (at 180°C)	244	245	1110	446	216
Redox potential			220	220	211
Alkalinity (as $CaCO_3$)	189	180	224	185	187
Hardness, total (as $CaCO_3$)	196		208	195	177
Carbonate (as CO_3)	0.0		0.0	0.0	0.0
Aluminum, dissolved			<0.01	<0.1	<0.1
Ammonia (as N)	0.0		<0.1	<0.1	0.16
Arsenic, total	0.014		<0.01	<0.01	0.007
Barium, total	<0.0		0.13	<0.1	0.15
Boron, total	0.040		<0.1	0.11	<0.1
Cadmium, total	0.0		0.004	<0.02	<0.005
Calcium, dissolved	51	49	51	57	112
Chloride	0.0	50	<1	2	4
Sodium, dissolved	8.0		5.3	23	13
Silver, dissolved	0.0		<0.002	0.010	0.006
Sulfate, dissolved (as SO_4)	24	17	17	83	26.7
Vanadium, dissolved			<0.002	0.16	0.005
Manganese, dissolved	0.020		0.03	0.03	0.03
Chromium, total	0.0		0.02	<0.05	0.02
Copper, total	0.0		0.005	<0.010	0.005
Fluoride, dissolved	0.17	0.1	0.22	0.2	0.2
Iron, total	0.54		0.61	0.35	2.1
Iron, dissolved			0.57	0.30	2.3
Lead, total	0.0		0.02	<0.05	<0.05
Magnesium, dissolved	17	19	18	15	21
Mercury, total	0.0	0.0	0.002	<0.00002	0.00002
Molybdenum, dissolved			<0.01	0.010	0.004
Nitrate (as N)	0.05	0.12	<0.05	<0.05	<0.05
Phosphorus, total (as P)	0.03		<0.01	<0.02	0.03
Potassium, dissolved	3.0		3.2	2.8	2.4
Selenium, dissolved	0.0		0.05	0.014	<0.005
Silica, dissolved (as SiO_2)	12	5.8	12	6	8
Strontium, dissolved			0.67	0.5	0.60
Uranium, total (as U)			<0.002	0.16	<0.002
Uranium, dissolved (as U)			<0.002	0.031	<0.002
Zinc, dissolved	0.0		0.39	0.007	0.12
Total organic carbon				1.1	16
Chemical oxygen demand				<1	66
Oil and grease				1.0	1
Total suspended solids				6	1940
Determination (pCi/liter)					
Gross alpha ± precision		7	10.2 ± 2.6	1.6 ± 1.3	1.9 ± 1.4
Gross beta ± precision		<20	73 ± 19	8 ± 8	9 ± 8
Ra-226 ± precision			0.1 ± 0.3	0.6 ± 0.4	0.3 ± 0.3
Th-230 ± precision			0.7 ± 2.7	0.3 ± 0.6	0.1 ± 0.4
Pb-210 ± precision			1.0 ± 2.0	0.7 ± 2.1	0.0 ± 4.0
Po-210 ± precision			0.0 ± 0.3	0.0 ± 0.8	0.0 ± 0.6

[a] The spring in Corral Creek, Station No. G1R, was tested on July 25, 1977, and again on November 10, 1977. Because of the low flow, the spring could not be located.

[b] Utah State Division of Health Analysis, Lab No. 77061.

[c] Partial analysis by Hazen Research, Inc., Sample No. HRI-11503.

Source: Adapted from ER, Table 2.6-6.

2.7 GEOLOGY, MINERAL RESOURCES, AND SEISMICITY

2.7.1 Geology

2.7.1.1 Regional geology

The proposed project site is near the western margin of the Blanding Basin in southeastern Utah. Thousands of feet of marine and nonmarine sedimentary rocks have been uplifted, moderately deformed, and subsequently eroded. North of the site is the Paradox fold and fault belt; to the west, the Monument uplift; to the south is the San Juan River and the Tyende Saddle; and to the east is the Four Corners platform (the Canyonlands section merges with the Southern Rocky Mountain province; see Fig. 2.8). The area is characterized by deeply eroded canyons, mesas, and buttes formed from sedimentary rocks of pre-Tertiary age. Regionally, elevations range from about 900 m (3000 ft) to more than 3350 m (11,000 ft). With the exception of the deeper canyons and isolated mountain peaks, the average elevation is approximately 1500 m (5000 ft).

Exposed sedimentary rocks in southeastern Utah have an aggregate thickness of about 1800 to 2100 m (6000 to 7000 ft) and range in age from Pennsylvanian to Late Cretaceous.

Shoemaker noted three origins of the structural features seen in the project area: (1) structures related to large-scale regional epeirogenic deformation (Monument Uplift and Blanding Basin), (2) structures formed due to diapiric deformation of thick evaporities, and (3) structures formed due to magmatic intrusions (Abajo Mountains).[13,14]

2.7.1.2 Blanding site geology

The proposed site is located near the center of White Mesa. The nearly flat surface of the mesa has a thin veneer of loess and is underlain by resistant sandstone caprock. Surface elevations across the site range from 1690 to 1720 m (5550 to 5650 ft). The maximum relief between White Mesa and the adjacent Cottonwood Canyon is about 230 m (750 ft).

White Mesa is drained to the west by Cottonwood Wash and Westwater Creek and to the east by Recapture Creek. There streams are intermittent and flow into the San Juan River. In the project area, exposed rocks are of Jurassic, Cretaceous, and Pleistocene-Recent age (see Fig. 2.9). The Jurassic to Upper Cretaceous rocks are represented, in ascending order, by the San Rafael Group, the Morrison Formation, the Burro Canyon Formation, the Dakota Sandstone, and the Mancos Shale. The rocks are primarily cross-bedded sandstones, conglomeratic sandstones, claystones, mudstones with some sandy shales, and limestones. Cenozoic rocks include eolian loess, stream-born alluvium, colluvium, and talus.

The structure of White Mesa is simple. The Dakota Sandstone and Burro Canyon Formation are essentially flat with gentle undulations and are commonly jointed. Two joint directions are found usually perpendicular to each other.

2.7.2 Mineral resources

2.7.2.1 Uranium deposits

Two types of uranium mineralization exist in the region: (1) tabular deposits nearly parallel to the bedding of fine-grained to conglomeritic sandstone lenses and (2) fracture-controlled deposits. None of the fracture-controlled deposits have yielded large production.[15] The tabular deposits occur in the Chinle, Morrison, and Cutler formations. Vanadium is a common byproduct of most uranium produced from the Morrison Formation. Principal uranium minerals are uraninite and coffinite.

2.7.2.2 Other mineral resources

Seven wildcat oil wells were drilled about 6 km (4 miles) west of the proposed site. All were dry and were abandoned.

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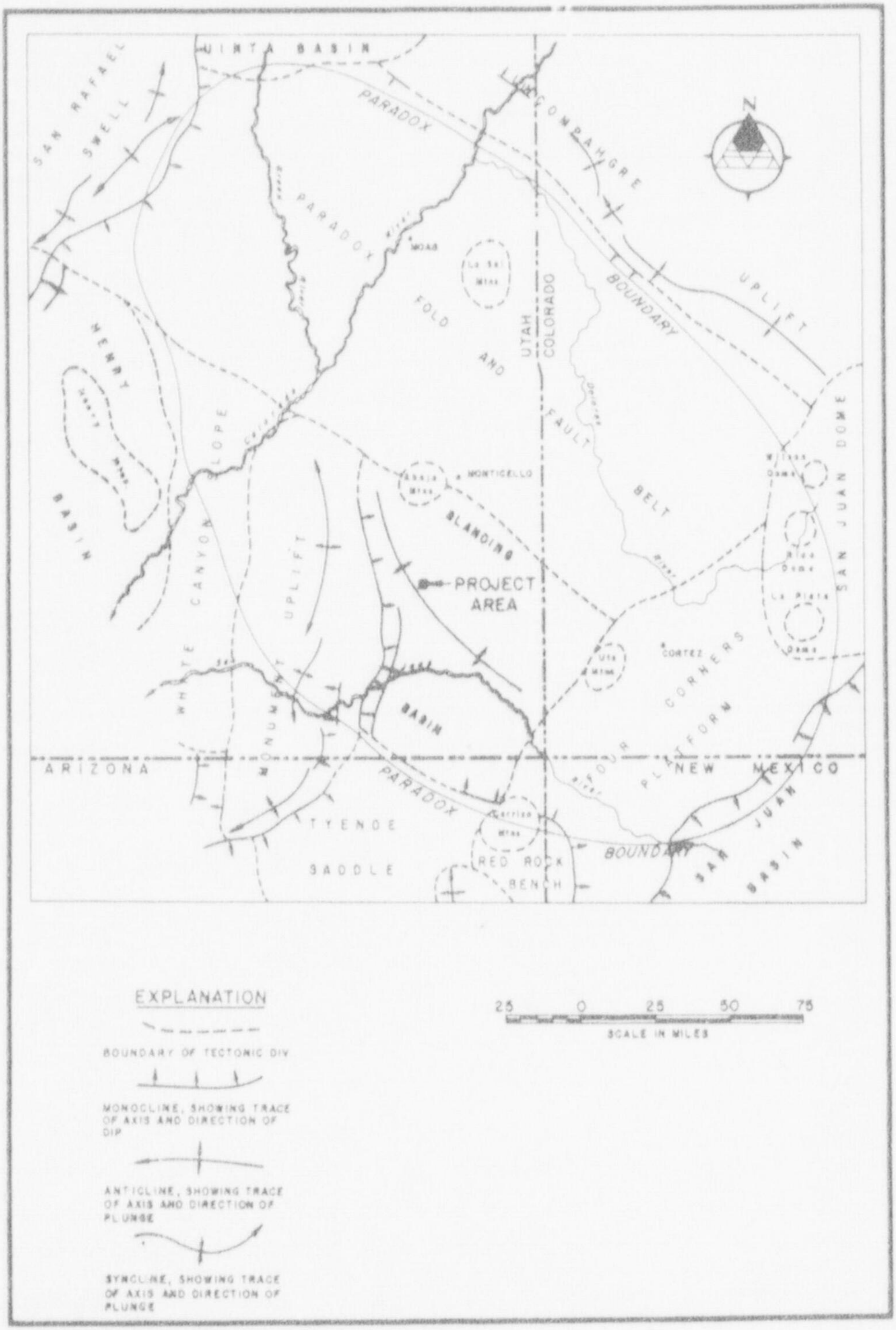

Fig. 2.8. Tectonic index map. Source: ER, Plate 2.4-1.

ES-4588

ERA	SYSTEM	SERIES (Age)	STRATIGRAPHIC UNIT		THICKNESS* (ft)	LITHOLOGY
CENOZOIC	QUATERNARY	Holocene to Pleistocene		Alluvium	2-25+	Silt, sand and gravel in arroyos and stream valleys.
				Colluvium and Talus	0-15+	Slope wash, talus and rock rubble ranging from cobbles and boulders to massive blocks fallen from cliffs and outcrops of resistant rock.
				Loess	0-22+	Reddish-brown to light-brown, unconsolidated, well-sorted silt to medium-grained sand; partially cemented with caliche in some area; reworked partly by water.
			Unconformity			
MESOZOIC	CRETACEOUS	Upper Cretaceous		Mancos Shale	0-11(?)	Gray to dark-gray, fissile, thin-bedded marine shale with fossiliferous sandy limestone in lower strata.
				Dakota Sandstone	30 - 75	Light yellowish-brown to light gray-brown, thick bedded to cross-bedded sandstone, conglomeratic sandstone; interbedded thin lenticular gray carbonaceous claystone and impure coal; local course basal conglomerate.
			Unconformity			
		Lower Cretaceous		Burro Canyon Formation	50 - 150	Light-gray and light-brown, massive and cross-bedded conglomeratic sandstone and interbedded green and gray-green mudstone; locally contains thin discontinuous beds of silicified sandstone and limestone near top.
			Unconformity(?)			
	JURASSIC	Upper Jurassic	Morrison Formation	Brushy Basin Member	200-450	Variegated gray, pale-green, reddish-brown, and purple bentonitic mudstone and siltstone containing thin discontinuous sandstone and conglomerate lenses.
			Morrison Formation	Westwater Canyon Member	0-250	Interbedded yellowish- and greenish-gray to pinkish-gray, fine- to course-grained arkosic sandstone and greenish-gray to reddish-brown sandy shale and mudstone.
			Morrison Formation	Recapture Member	0-200	Interbedded reddish-gray to light brown fine- to medium-grained sandstone and reddish-gray silty and sandy claystone.
			Morrison Formation	Salt Wash Member	0-350	Interbedded yellowish-brown to pale reddish-brown fine-grained to conglomeritic sandstones and greenish- and reddish-gray mudstone.
			Unconformity			
			San Rafael Group	Bluff Sandstone	0-150+	White to grayish-brown, massive, cross-bedded, fine- to medium-grained eolian sandstone.
			San Rafael Group	Summerville Formation	25-125	Thin-bedded, ripple-marked reddish-brown muddy sandstone and sandy shale.
			San Rafael Group	Entrada Sandstone	150-180	Reddish-brown to grayish-white, massive, cross-bedded, fine- to medium-grained sandstone.
		Middle Jurassic	San Rafael Group	Carmel Formation	20-100+	Irregulary bedded reddish-brown muddy sandstone and sandy mudstone with local thin beds of brown to gray limestone and reddish- to greenish-gray shale.
			Unconformity			

*To convert feet to meters, multiply feet by 0.3048.

Fig. 2.9. Generalized stratigraphic section of exposed rocks in the project vicinity. Source: ER, Table 2.4-2.

Thin, discontinuous beds of impure lignite and coal up to 0.6 m (2 ft) thick occur throughout the Dakota Sandstone. Although several of these coal beds have been mined on a limited scale in the Blanding area, most of the coals are too impure for commercial use.[16]

Copper deposits are associated with the fracture-controlled uranium-vanadium deposits in the Abajo Mountains and with some sedimentary deposits. The copper content may e as high as 3%. Sand and gravel deposits are mined on the east and south slopes of the Abajo Mountains for pavement construction material.

Although water is produced from wells drilled to the Burro Canyon Formation and the Dakota Sandstone, this water is commonly mineralized and in some localities unfit for human consumption.[17] Deep wells drilled to the Entrada and Navajo sandstones yield potable water.[15,17] Several springs in the project vicinity discharge groundwater from the Burro Canyon Formation.

2.7.3 Seismicity

Within a 320-km (200-mile) radius of the site, 450 seismic events occurred between 1853 and 1978. Of these, at least 45 had an intensity of VI or greater on the Modified Mercalli Scale.

Within a 160-km (100-mile) radius of the project area, 15 earthquakes have been recorded. Of these, only one had an intensity of V, and the rest were IV or less. The nearest event occurred in Glen Canyon National Recreation Area, about 70 km (43.5 miles) northwest of the proposed site. The next closest event occurred about 94 km (58.5 miles) to the northeast. The event of intensity V occurred on August 29, 1941, just east of Durango, Colorado.[18] It is doubtful that any of these events would have been felt in the vicinity of Blanding.

Based on the region's seismic history, the probability of a major damaging earthquake occurring at or near the proposed site is remote. Algermissen and Perkins[19] indicate that there is a 90% probability that horizontal acceleration of 40% gravity (0.4 g) would not be exceeded within 50 years.

2.8 SOILS

The majority (99%) of the soil on the project site consists of the Blanding soil series (ER, Sect. 2.10.1.1). The remaining 1% of the site is in the Mellenthin soil series. Because the Mellenthin soil occurs only on the eastern-central edge of the site (ER, Plate 2.10-1), it should not be affected by construction and operation of the mill.

The mill and associated tailings disposal ponds will be located on Blanding silt loam, a deep soil formed from wind-blown deposits of fine sands and silts. Although soil textures are predominantly silt loam, silty-clay-loam textures are found at some point in most profiles (ER, Table 2.10-2). This soil generally has a 10- to 13-cm (4- to 5-in.) reddish-brown, silt-loam A horizon and a reddish-brown, silt-loam to silty-clay-loam B horizon. The B horizon extends downward about 30 to 40 cm (12 to 16 in.) where the soil then becomes calcareous silt-loam or silty-clay-loam, signifying the C horizon. The C horizon and the underlying parent material are also reddish-brown in color.

The A and B horizon both have an average pH of about 8.0, whereas the average pH at the C horizon is about 8.5. Subsoil sodium levels range up to 12% in some areas, which is close to the upper limit of acceptability for use in reclamation work (ER, Sect. 2.10.1.1). Other elements, such as boron and selenium, are well below potentially hazardous levels. Potassium and phosphorus values are high in this soil (ER, Table 2.10-2) and are generally adequate for plant growth. Nitrogen, however, is low (ER, Sect. 2.10.1.1) and may have to be provided for reclamation.

With the well-drained soils, relatively flat topography (Sect. 2.3) and low precipitation (Sect. 3.2.1), the site generally has a low potential for water erosion. However, the flows resulting from thunderstorm activity are nearly instantaneous and, if uncontrolled, could result in substantial erosion. When these soils are barren, they are considered to have a high potential for wind erosion. Although the soil is suitable for crops, the low percentage of available moisture (6 to 9%) is a limiting factor for plant growth; therefore, light irrigation may be required to establish native vegetation during reclamation.

2.9 BIOTA

2.9.1 Terrestrial

2.9.1.1 Flora

The natural vegetation presently occurring within a 40-km (25-mile) radius of the site is very similar to that of the potential,[20] being characterized by pinyon-juniper woodland intergrading with big sagebrush (*Artemesia tridentata*) communities. The pinyon-juniper community is dominated by Utah juniper (*Juniperus osteosperma*) with occurrences of pinyon pine (*Pinus edulis*) as a codominant or subdominant tree species. The understory of this community, which is usually quite open, is composed of grasses, forbs, and shrubs that are also found in the big sagebrush communities. Common associates include galleta grass (*Hilaria jamesii*), green ephedra (*Ephedra viridis*), and broom snakeweed (*Gutierrezia sarothrae*). The big sagebrush communities occur in deep, well-drained soils on flat terrain, whereas the pinyon-juniper woodland is usually found on shallow rocky soil of exposed canyon ridges and slopes.

Seven community types are present on the project site (Table 2.26 and Fig. 2.10). Except for the small portions of pinyon-juniper woodland and the big sagebrush community types, the majority of the plant communities within the site boundary have been disturbed by past grazing and/or treatments designed to improve the site for rangeland. These past treatments include chaining, plowing, and reseeding with crested wheatgrass (*Agropyron desertorum*). Controlled big sagebrush communities are those lands containing big sagebrush that have been chained to stimulate grass production. In addition, these areas have been seeded with crested wheatgrass. Both grassland communities I and II are the result of chaining and/or plowing and seeding with crested wheatgrass. The reseeded grassland II community is in an earlier stage of recovery from disturbance than the reseeded grassland I community. The relative frequency, relative cover, relative density, and importance values of species sampled in each community are presented in the ER, Table 2.8-2. The percentage of vegetative cover in 1977 was lowest on the reseeded grassland II community (10.7%) and highest on the big sagebrush community (33%) (Table 2.27).

Table 2.26 Community types and expanse within the project site boundary

Community type	Expanse	
	ha	acres
Pinyon–juniper woodland	5	13
Big sagebrush	113	278
Reseeded grassland I	177	438
Reseeded grassland II	121	299
Tamarisk-salix	3	7
Controlled big sagebrush	230	569
Disturbed	17	41

Table 2.27. Ground cover for each community within the project site boundary

Community type	Percentage of each type of cover		
	Vegetative cover	Litter	Bare ground
Pinyon–juniper woodland[a]	25.9	15.6	55.6
Big sagebrush	33.3	16.9	49.9
Reseeded grassland I	15.2	24.2	61.0
Reseeded grassland II	10.7	9.5	79.7
Tamarisk-salix	12.0	20.1	67.9
Controlled big sagebrush	17.3	15.3	67.4
Disturbed	13.2	7.0	80.0

[a] Rock covered 4.4% of the ground.

Based upon dry weight composition, most communities on the site were in poor range condition in 1977 (ER, Tables 2.8-3 and 2.8-4). Pinyon-juniper, big sagebrush, and controlled big sagebrush communities were in fair condition. However, precipitation for 1977 at the project site was classed as drought conditions (ER, Sect. 2.8.2.1). Until July, no production was evident on the site.

No proposed endangered plant species[21] occur on or near the project site (ER, Sect. 2.8.2.1). Of the 65 proposed endangered species in Utah, six have documented distributions in San Juan County.[22] A careful review of the habitat requirements and known distributions of these species indicates that, because of the disturbed environment, these species would probably not occur on the project site.

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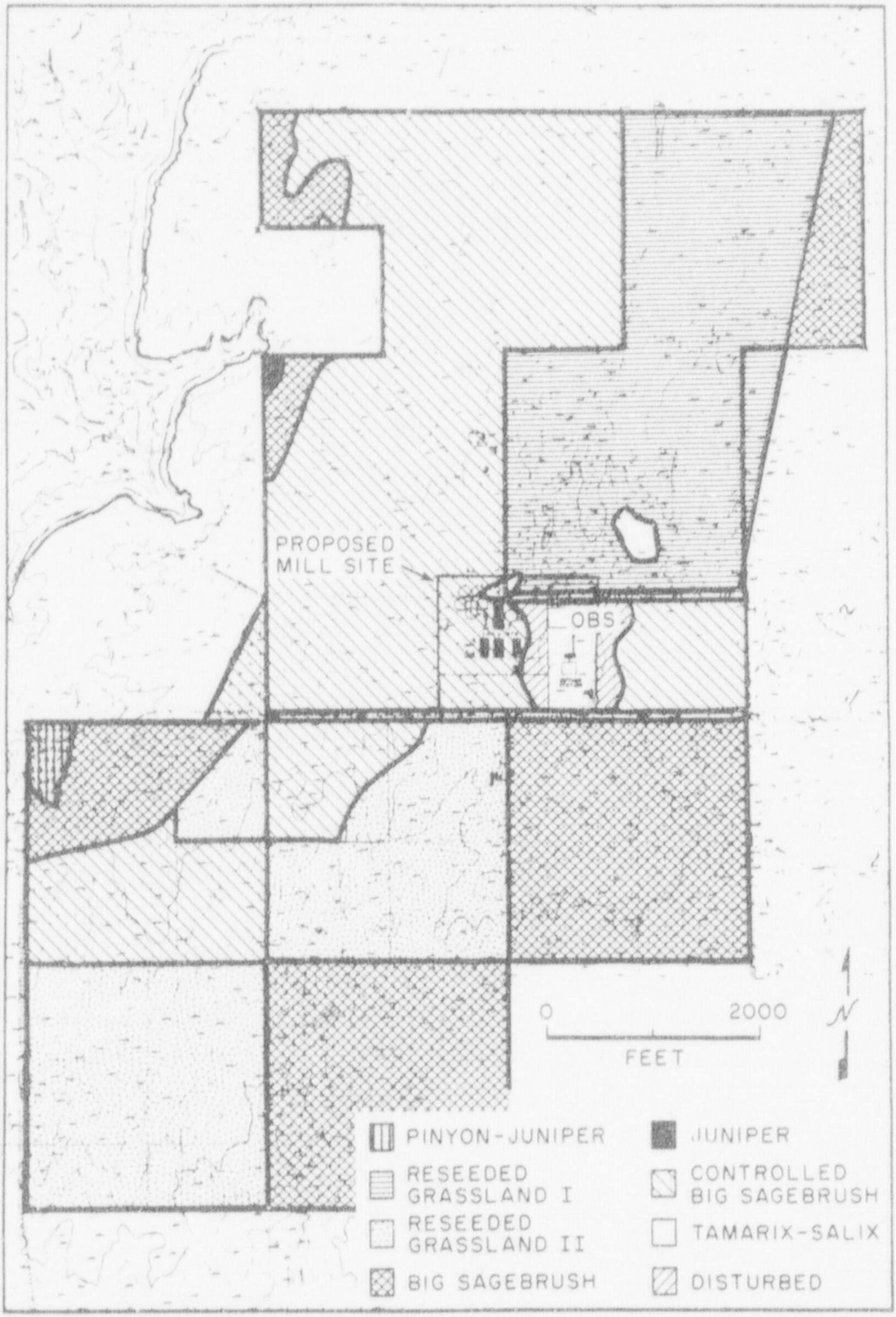

Fig. 2.10. Community types on the White Mesa project site. Source: Energy Fuels Nuclear, Inc., "Responses to Comments Telecopied from NRC to Energy Fuels Nuclear, Sept. 25, 1978," Oct. 4, 1978, Plate 2.8-2.

2.9.1.2 Fauna

The applicant has collected wildlife data through four seasons at several locations on the site (Fig. 6.1). The presence of a species was based on direct observations, trappings, and signs such as the occurrence of scat, tracks, or burrows. A total of 174 vertebrate species potentially occur within the vicinity of the proposed mill (ER, Appendix D), 78 of which were confirmed (ER, Sect. 2.8.2.2).

Although seven species of amphibians are thought to occur in the area, the scarcity of surface water limits the use of the site by amphibians. The tiger salamander (*Ambystoma tigrinum*) was the only species observed. It appeared in the pinyon-juniper woodland west of the project site (ER, Sect. 2.8.2.2).

Eleven species of lizards and five snakes potentially occur in the area. Three species of lizards were observed: the sagebrush lizard (*Sceloparae graciosus*), western whiptail (*Cnemidophorus tigris*), and the short-horned lizard (*Phrynosoma douglassi*) (ER, Sect. 2.8.2.2). The sagebrush and western whiptail lizard were found in sagebrush habitat, and the short-horned lizard was observed in the grassland. No snakes were observed during the field work.

Fifty-six species of birds were observed in the vicinity of the project site (Table 2.28). The abundance of each species was estimated by using modified Emlen transects and roadside bird counts in various habitats and seasons. Only four species were observed during the February sampling. The most abundant species was the horned lark (*Eremophila aepestis*) followed by the common raven (*Corvus corax*), which were both concentrated in the grassland. Avian counts increased drastically in May. Based on extrapolation of the Emlen transect data, the avian density on grassland of the project site during spring was about 305 per square kilometer (123 per 100 acres). Of these individuals, 94% were horned larks and western meadowlarks (*Sturnella neglecta*). This density and species composition are typical of rangeland habitats.[23] In late June the species diversity declined somewhat in grassland but peaked in all other habitats. By October the overall diversity decreased but again remained the highest in grassland.

Raptors are prominent in the western United States. Five species were observed in the vicinity of the site (Table 2.28). Although no nests of these species were located, all (except the golden eagle, *Aquila chrysaetos*) have suitable nesting habitat in the vicinity of the site. The nest of a prairie falcon (*Falco mexicanus*) was found about 1.2 km (3/4 mile) east of the site. Although no sightings were made of this species, members tend to return to the same nests for several years if undisturbed (ER, Sect. 2.8.2.2).

Of several mammals that occupy the site, mule deer (*Odocoileus hemionus*) is the largest species. The deer inhabit the project vicinity and adjacent canyons during winter to feed on the sagebrush and have been observed migrating through the site to Murphy Point (ER, Sect. 2.8.2.2). Winter deer use of the project vicinity, as measured by browse utilization, is among the heaviest in southeastern Utah [61 days of use per hectare (25 days of use per acre) in the pinyon-juniper–sagebrush habitats in the vicinity of the project site].[24] In addition, this area is heavily used as a migration route by deer traveling to Murphy Point to winter. Daily movement during winter periods by deer inhabiting the area has also been observed between Westwater Creek and Murphy Point.[24] The present size of the local deer herd is not known.

Other mammals present at the site include the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cineroargenteus*), striped skunk (*Mephitis mephitis*), badger (*Taxidea taxus*), longtail weasel (*Mustela frenata*) and bobcat (*Lynx rufus*). Nine species of rodents were trapped or observed on the site, the deer mouse (*Peromyscus maniculatus*) having the greatest distribution and abundance. Although desert cottontails (*Sylvilagus auduboni*) were uncommon in 1977, black-tailed jackrabbits (*Lepus californicus*) were seen during all seasons.

Three currently recognized endangered species of animals[25] could occur in the project vicinity. However, the probability of these animals occurring near the site is extremely low. 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. Although the black-footed ferret (*Mustela nigripes*) once ranged in the vicinity of the site, it has not been sighted in Utah since 1952,[26] and the Utah Division of Wildlife feels it is highly unlikely that this animal is present (ER, Sect. 2.8.2.2).

Table 2.28. Birds observed in the vicinity of the proposed White Mesa Uranium Project

Species	Statewide relative abundance and status[a]	Species	Statewide relative abundance and status[a]
Mallard	CP	Pinyon jay	CP
Pintail	CP	Bushtit	CP
Turkey vulture	US	Bewick's wren	CP
Red-tailed hawk	CP	Mockingbird	US
Golden eagle	CP	Mountain bluebird	CS
Marsh hawk	CP	Black-tailed gnatcatcher	H
Merlin	UW	Ruby-crowned kinglet	CP
American kestrel	CP	Loggerhead shrike	CS
Sage grouse	UP	Starling	CP
Scaled quail	Not listed	Yellow-rumped warbler	CS
American coot	CS	Western meadowlark	CP
Killdeer	CP	Red-winged blackbird	CP
Spotted sandpiper	CS	Brewer's blackbird	CP
Mourning dove	CS	Brown-headed cowbird	CS
Common nighthawk	CS	Blue grosbeak	CS
White-throated swift	CS	House finch	CP
Yellow-bellied sapsucker	CP	American goldfinch	CP
Western kingbird	'S	Green-tailed towhee	CS
Ash-throated flycatcher	CS	Rufous-sided towhee	CP
Say's phoebe	CS	Lark sparrow	CS
Horned lark	CP	Black-throated sparrow	CS
Violet-green swallow	CS	Sage sparrow	US
Barn swallow	CS	Dark-eyed junco	CW
Cliff swallow	CS	Chipping sparrow	CS
Scrub jay	CP	Brewer's sparrow	CS
Black-billed magpie	CP	White-crowned sparrow	CS
Common raven	CP	Song sparrow	CP
Common crow	CW	Vesper sparrow	CS

[a]W. H. Behle and M. L. Perry, *Utah Birds,* Utah Museum of Natural History, University of Utah, Salt Lake City, 1975.

Relative abundance	Status
C = common	P = permanent
U = uncommon	S = summer resident
H = hypothetical	W = winter visitant

Source: ER, Table 2.8-5.

2.9.2 Aquatic biota

Aquatic habitat at the project site ranges temporally from extremely limited to nonexistent due to the aridity, topography, and soil characteristics of the region and consequent dearth of perennial surface water. Two small catch basins (Sect. 2.6.1.1), approximately 20 m in diameter, a: located on the project site, but these only fill naturally during periods of heavy rainfall (spring and fall) and have not held rainwater during the year-long baseline water quality monitoring program. Although more properly considered features of the terrestrial environment, they essentially represent the total aquatic habitat on the project site. When containing water, these catch basins probably harbor algae, insects, other invertebrate forms, and amphibians. They may also provide a water source for small mammals and birds. Similar ephemeral catch and seepage basins are typical and numerous to the northeast of the project site and south of Blanding. The basin to the northeast of the present ore buying station has been filled with well water to be used during construction of the adjacent office and laboratory facilities. Present plans are for it to contain water for approximately six months. This basin has not been sampled for aquatic biota since filling.

Aquatic habitat in the project vicinity is similarly limited. The three adjacent streams (Corral Creek, Westwater Creek, and an unnamed arm of Cottonwood Wash) are only intermittently active, carrying water primarily in the spring during increased rainfall and snowmelt runoff, in the autumn, and briefly during localized but intense electrical storms. Intermittent water flow most typically occurs in April, August, and October in these streams. Again, due to the temporary nature of these streams, their contribution to the aquatic habitat of the region is probably limited to providing a water source for wildlife and a temporary habitat for insect and amphibian species.

No known populations of fish are present either on the project site or in its immediate vicinity; however, the temporary watercourses in the vicinity (Corral, Recapture, and Westwater creeks, and Cottonwood Wash) were not sampled for aquatic biota by the applicant during periods of waterfill. These streams, although ephemeral, might support fish populations during these times (with fish immigrating up- or downstream from more permanent aquatic habitats). The closest perennial aquatic habitat to the proposed mill appears to be a small irrigation basin (approximately 50 m in diameter) about 6 km (3.8 miles) upgrade to the northeast. This habitat was not sampled for biota by the applicant, who reports that the pond is intermittent and probably does not harbor any fish species.

The closest perennial aquatic habitat known to support fish populations is the San Juan River 29 km (18 miles) south of the project site. Five species of fish Federally designated (or proposed) as endangered or threatened occur in Utah (Table 2.29). One of the five species, the woundfin (*Plegopterus argentissimus*), does not occur in southeastern Utah where the proposed mill site is located.[27] The Colorado squawfish (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*), however, are reported as inhabiting large river systems in southeastern Utah. The bonytail chub (*Gila elegans*), classified as threatened by the State and proposed as endangered by Federal authorities is also limited in its distribution to main channels of large rivers. The humpback sucker (razorback sucker; *Xyrauchen texanus*), protected by the State and proposed as threatened by the Federal authorities, is found in southeastern Utah inhabiting backwater pools and quiet areas of mainstream rivers. The closest habitat suitable for the Colorado squawfish, humpback chub, bonytail chub, and humpback sucker is the San Juan River, 29 km (18 miles) south of the proposed site.

Table 2.29. Threatened and endangered aquatic species occurring in Utah

Species	Habitat	Listing	Occurrence in southeastern Utah
Woundfin *Plegopterus argentissimus*	Silty streams; muddy, swift-current areas; Virgin River critical habitat[a]	Federal – endangered[b] State – threatened	No
Humpback chub *Gila cypha*	Large river systems, eddies, and backwater	Federal – endangered[b] State – endangered	Yes
Colorado River squawfish *Ptychocheilus lucius*	Main channels of large river systems in Colorado drainage	Federal – endangered[b] State – endangered	Yes
Bonytail chub *Gila elegans*	Main channels of large river systems in Colorado drainage	Federal – proposed endangered[c] State – threatened	Yes
Humpback sucker (razorback sucker) *Xyrauchen texanus*	Backwater pools and quiet-water areas of main rivers	Federal – proposed threatened[c] State – threatened	Yes

[a] "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 42(211): 57329 (1977).
[b] "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 42(135): 36419–39431 (1977).
[c] "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 43(79): 17375–17377 (1978).

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 were made at the proposed mill site using thermoluminescent dosimeters (TLDs). The results indicate an average total-body dose of 142 millirems per year, of which 68 millirems is attributable to cosmic radiation and 74 millirems to terrestrial sources. The cosmogenic radiation dose is estimated to be about 1 millirem per year.[28] Terrestrial radiation originates from the radionuclides potassium-40, rubidium-87, and daughter isotopes from the decay of uranium-238, thorium-232, and, to a lesser extent, uranium-235. The dose from ingested radionuclides is estimated at 18 millirems per year to the total body.[28] The dose to the total body from all sources of environmental radioactivity is estimated to be about 161 millirems per year.

The concentration of radon in the area is estimated to be in the range of 500 to 1000 pCi/m^3, based on the concentration of radium-226 in the local soil.[28,29] Exposure to this concentration on a continuous basis would result in a dose of up to 625 millirems per year to the bronchial epithelium.[30] As ventilation decreases, the dose increases; for example, in unventilated enclosures, the comparable dose might reach 1200 millirems per year.

The medical total-body dose for Utah is about 75 millirems per year per person.[31] The total dose in the area of the proposed mill from natural background and medical exposure is estimated to be 236 millirems per year.

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3. OPERATIONS

3.1 MINING OPERATIONS

The White Mesa Uranium Project will process ores originating in independent and company-owned mines. Mines within 160 km (100 miles) of Energy Fuels ore buying stations (in Blanding or Hanksville) are expected to supply virtually all of the ore processed by the facility. Energy Fuels controls reserves of approximately 8600 metric tons (MT) (9500 tons) of U_3O_8 with an average ore grade of 0.125% U_3O_8 (ER, p.1-1). Additional ore will be purchased from independent mines. There will be no onsite mining activity. The environmental effects of the Blanding ore buying station (on the project site) are included in this assessment.

3.2 THE MILL

The proposed mill will utilize an acid leach-solvent extraction process for uranium recovery. Provisions for vanadium byproduct recovery are included in the design. The nominal processing capacity of the mill is 1800 MT (2000 tons) per day. The expected average ore grade is 0.125% U_3O_8. The process will recover approximately 94% of the uranium in the ore. The proposed mill would operate on a 24 hr/day, 340 days per year schedule. Based on the above design parameters, the annual U_3O_8 production of the proposed White Mesa mill will be approximately 730 MT (800 tons). The estimated annual vanadium (V_2O_5) production is 1480 MT (1630 tons).

3.2.1 External appearance of the mill

The plant buildings will be mainly of prefabricated construction. Although the facility will resemble the artist's rendition (Fig. 3.1), the final layout may vary, depending on final equipment selection.

As viewed from U.S. Highway 163, the mill will consist of a series of long buildings. Portions of the mill will stand above the natural skyline. The ore buying station, ore stockpiles, and the natural terrain will obscure the view of portions of the mill. The proposed tailings impoundment should not significantly alter the landscape as seen from the highway, except around soil stock piles and borrow areas.

3.2.2 The mill circuit

3.2.2.1 Uranium circuit

The flow sheet for the uranium circuit of the proposed mill is shown in Fig. 3.2. The ore would undergo a sequence of crushing, grinding, leaching, counter-current decantation, and solvent-extraction steps. The extracted uranium would be precipitated, dried, and packaged for shipment.

All ores would be fed to the mill via the ore buying stations. Because the ores will originate from many different mines, blending will be necessary to ensure optimal processing amenability. This blending will occur as the ore is fed to the mill.

Ore received at the ore buying stations is crushed to less than 3.8 cm (1.5 in.) during the sampling process. As the ore is fed to the mill, a semiautogenous grinding (SAG) mill will reduce the feed size to smaller than a 28-mesh (0.589 mm or 0.0232 in.) screen. The ore slurry produced by the SAG mill will be leached in two stages with sulfuric acid, manganese dioxide (or an equivalent oxidant), and steam in amounts that will produce an acid solution with a temperature of 71°C (160°F). Acid consumption will be reduced by neutralizing the alkaline

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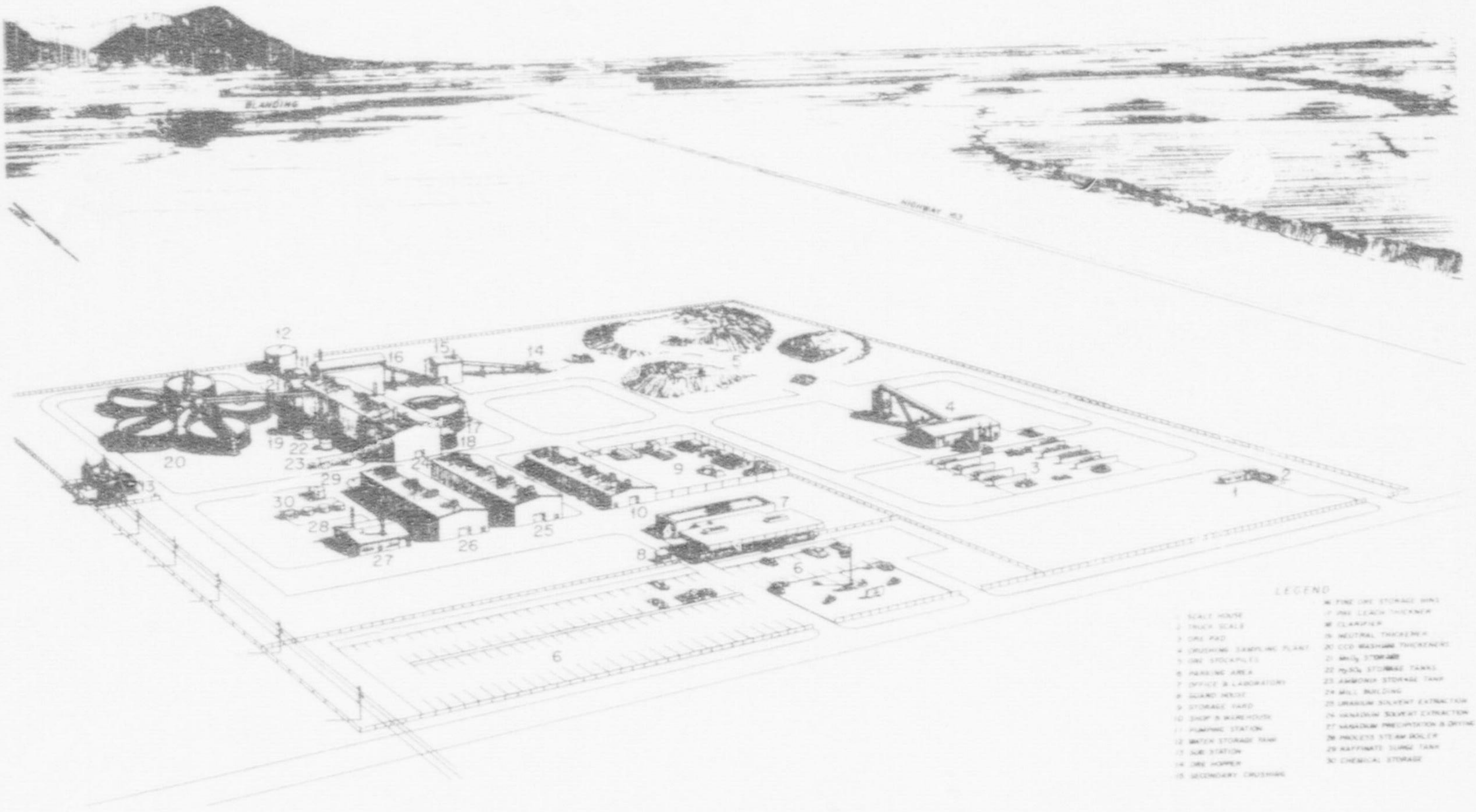

Fig. 3.1. View of the proposed White Mesa Uranium Project. Source: ER, Plate 3.1-1.

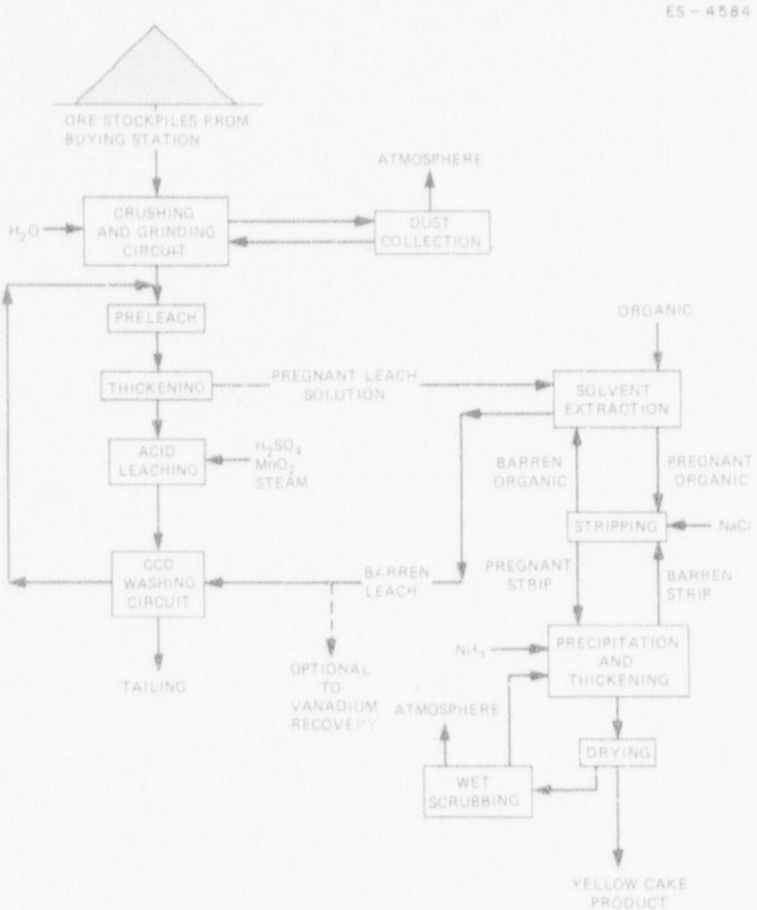

Fig. 3.2. Generalized flowchart for the uranium milling process. Source: ER, Plate 3.2-1.

components of the ore with excess acid in the pregnant leach solution in a preleach stage (Fig. 3.2). It is anticipated that approximately 95% of the uranium contained in the crude ore will be dissolved over a leaching period of up to 24 hr. The uranium-bearing solution will be separated from the barren waste by counter-current decantation using thickeners. Polymeric flocculants will be used to enhance the settling characteristics of the suspended solids. The decanted pregnant leach solution is expected to have a pH of approximately 1.5 and contain less than 1 g of U_3O_8 per liter. The barren waste will be pumped to the tailings retention area.

Solvent extraction will be used to concentrate and purify the uranium contained in the decanted leach solution. In a series of mixing and settling vessels, the solvent extraction process will use an amine-type compound carried in kerosene (organic) which will selectively absorb the dissolved uranyl ions from the aqueous leach solution. The organic and aqueous solutions will be agitated by mechanical means and then allowed to separate into organic and aqueous phases in the settling tank. This procedure will be performed in four stages using a counter-flow principle in which the organic flow is introduced to the preceding stage and the aqueous flow (drawn from the bottom) feeds the following stage. It is estimated that, after four stages, the organic phase will contain about 2 g of U_3O_8 per liter and the depleted aqueous phase (raffinate) about 5 mg per liter. The raffinate will be recycled to the counter-current decantation step previously described or further processed for the recovery of vanadium (Sect. 3.2.2.2). The organic phase will be washed with acidified water and then stripped of uranium by contact with an acidified sodium chloride solution. The barren organic solution will be returned to the solvent extraction circuit, and the enriched stripping solution containing

about 20 g of U_3O_8 per liter will be neutralized with ammonia to precipitate ammonium diuranate (yellow cake). The yellow cake will be settled in two thickeners in series, and the overflow solution from the first will be filtered, conditioned, and returned to the stripping stage.

The thickened yellow cake slurry will be dewatered further in a centrifuge to reduce its water content to about 40%. This slurry will then be pumped to an oil-fired multiple-hearth dryer (calciner) at 650°C (1200°F). The dried uranium concentrate (about 90% U_3O_8) will be passed through a hammer mill to produce a product of less than 0.6 cm (1/4 in.) size. The crushed concentrate, which is the final product of the plant, will then be packaged in 55-gal drums for shipment.

3.2.2.2 By-product vanadium recovery

Vanadium, which is present in some of the ores, will be soluble during leaching. The dissolved vanadium will be present in the uranium raffinate. Depending on its vanadium content, the uranium raffinate will either be recycled to the counter-current decantation step (Sect. 3.2.2.1) or further processed for recovery of the vanadium before recycling.

The vanadium recovery process will consist of a separate solvent extraction step to treat the uranium raffinate and precipitate the vanadium from the stripping solution. The flowchart shown in Fig. 3.3 illustrates the process.

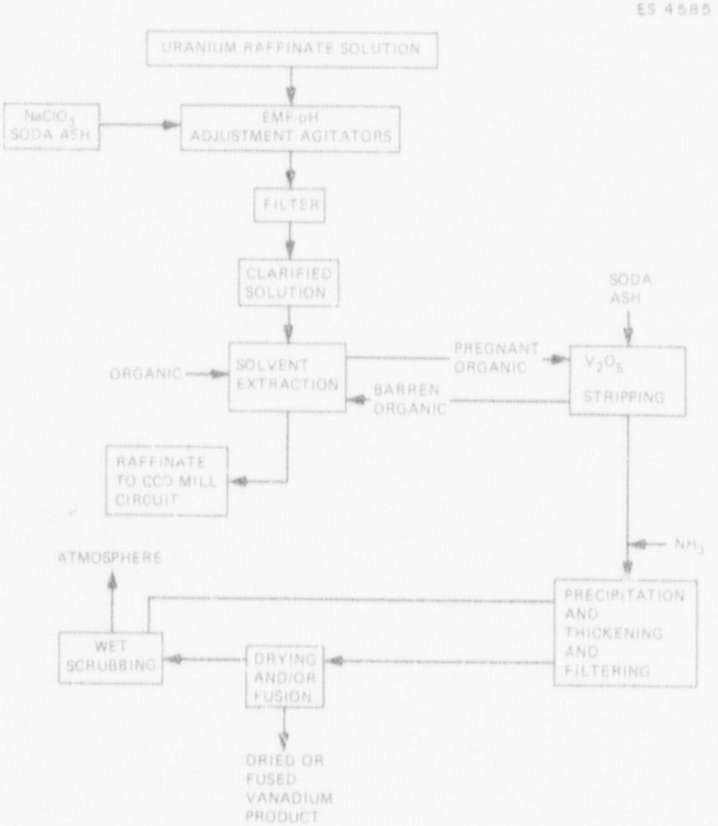

Fig. 3.3. Generalized flowchart showing recovery of vanadium. Source: ER, Plate 3.2-3.

The uranium raffinate will be pumped to a series of agitators where the electromotive force (oxidation potential) will be adjusted to -700 mV with sodium chlorate and the pH raised to 1.8-2.0. The solution may possess some turbidity after this step and will be filtered prior to passing to a five-stage solvent extraction circuit. Except for the one additional stage of extraction, the solvent extraction section will be essentially the same as utilized for the uranium. An amine-type compound carried in kerosene (Sect. 3.2.2.1) will selectively absorb the vanadium ions from the uranium raffinate solution. The organic solution will then be stripped of vanadium by contact with a soda ash solution. The barren organic solution will be returned to the solvent extraction circuit, and vanadium will be precipitated from the enriched stripping solution on a batch basis as ammonium metavanadate.

The vanadium precipitate will be thickened and filtered prior to drying in an oil-fired dryer. The dried precipitate will be subjected to a fusion step at approximately 800°C (1500°F) to produce V_2O_5 (black flake); packaging will be in 55-gal drums. Less than 0.005 percent U_3O_8 will be contained in the vanadium product.[39]

3.2.3 Nonradioactive wastes and effluents

3.2.3.1 Gaseous effluents

Milling operations will result in the release of nonradioactive vapors to the atmosphere.

Leaching

The leaching of ores in the uranium and circuit will produce carbon dioxide gas, sulfur dioxide gas, water vapor, and some sulfuric acid mist. Based on the projected calcite concentration in the ore and process conditions, the applicant estimates emissions of carbon dioxide to be 2200 kg/hr (4800 lb/hr) and emissions of sulfur dioxide and sulfuric acid mist to be 0.023 kg/hr (0.05 lb/hr) from leaching (ER, p. 3-10). The staff agrees with these estimates.

Solvent extraction

The solvent extraction processes used in uranium and vanadium recovery will release organic vapors consisting of kerosene (95%) and small quantities of amine and alcohol compounds used in the extraction. The applicant estimates the organic losses to be approximately 0.046 kg/hr (0.1 lb/hr) (ER, p. 3-10). There are no Federal or State emissions standards applicable to the release of this mixture. However, Federal and State ambient air quality standards have been set at 160 μg/m³, averaged over 3 hr. The applicant states that operation of the proposed mill will not result in hydrocarbon concentrations exceeding this level (ER, p. 3-10).

Product dryers

The yellow cake and vanadium black flake dryers will burn approximately 11 liters/hr (3 gph) of No. 2 fuel oil (<1% sulfur), producing gaseous effluents containing nitrogen, carbon dioxide, water vapor, sulfur dioxide, and nitrogen oxides, as well as some ammonia from decomposition of the concentrate product. Radioactive effluent from this source is discussed in Sect. 3.2.4.6. The applicant estimates that dryer off-gas concentrations of sulfur dioxide and nitrogen oxides will be 0.91 kg/hr (2 lb/hr) and 0.23 kg/hr (0.5 lb/hr) respectively (ER, p. 3-11)

Because the heat input to the yellow cake and vanadium black flake dryers will be only 4.7×10^8 J/hr (4.5×10^5 Btu/hr), no Federal or State emission standards apply to this source. However, Federal and State ambient air quality standards will apply to nitrogen oxides, sulfur dioxide, and particulate concentrations due to dryer operation.

Building and process heating

Steam necessary for building and process heating will be generated from coal-fired boilers. Approximately 55 MT (60 tons) of coal per day will be required at a heat input of approximately 5.3×10^{10} J/hr (5×10^6 Btu/hr). As a result of the boiler combustion, various stack gases will be released to the atmosphere, including carbon dioxide, water vapor, sulfur dioxide, and nitrogen oxides.

State and Federal emission standards are not applicable to a steam generating boiler of this small size. Likewise, significant deterioration regulations are not applicable; however, Federal and State ambient air quality standards will apply to the resulting ambient concentrations. The combustion of 55 MT (60 tons) per day of 0.3% sulfur coal would generate approximately 33 kg (720 lb) of sulfur dioxide per day (ER, p. 3-21). Based on an industrial NO_x emission factor of 10 kg/MT (20 lb/ton) of coal burned, the staff estimates nitrogen oxide emissions to be 545 kg/day (1200 lb/day). Fly ash emissions from this proposed boiler are discussed in Sect. 3.2.3.3.

Analytical laboratory

The mill facility will be complemented with an analytical laboratory that will routinely assay products of ore, process streams, and final products to assure adequate quality control and plant operating efficiency. The laboratory fume hoods will collect air and mixed chemical fumes for dilution and venting to the atmosphere. These gases will contain nonradioactive chemicals, such as CO_2, HCl, and NO_2. The volume of gaseous fumes emitted from the laboratory operations will be small and, considering the dilution in the collection stack and air eductors, should be inconsequential (ER, p. 3-22).

3.2.3.2 Liquid effluents

All mill process, mill laundry, and analytical laboratory liquid wastes will be discharged to the tailings impoundment for disposal by evaporation (Sect. 3.2.4). Sanitary wastes will be disposed of by a septic tank and leach field designed and operated in accordance with applicable State of Utah, Division of Health, and U.S. Public Health Service standards and regulations.

Storm run-off from the mill, ore storage piles, and ore buying station will be directed to the interceptor drainage ditch (Fig. 3.4) along the eastern margin of the tailings impoundment. The staff recommends that the drainage design be altered to isolate mill site runoff into a retention pond.

3.2.3.3 Solid effluents

Nonradioactive solid wastes will be generated by the coal-fired boiler, the ore buying stations, and by maintenance and administrative activities at the mill. Dusts will be emitted from ore crushing and handling operations, ore storage piles, unstabilized tailings, and from the uranium yellow cake and vanadium black flake dryer stacks. With the exception of the black flake dryer, the dusts from these sources are contaminated with low levels of radioactivity. Radioactive solid effluents are discussed in Sect. 3.2.4.

Building and process heating

The combustion of coal will produce two ash products, fly ash and bottom ash. With a coal usage rate of 55 MT (60 tons) per day, the total ash production would be less than 5.5 MT (6 tons) per day, which will be sent to the tailings retention system. These ash products would settle with the tailings solids and present no additional waste problems.

Stack emissions from the coal-fired boilers will pass through an electrostatic precipitator to remove fly ash, and less than 86 kg (190 lb) per day of particulate matter will be released to the atmosphere. Fly ash deposits from the precipitator will also be sent to the tailings impoundment (ER, p. 3-21).

Ore processing, maintenance, and administration

Scrap iron, wood, and other mine trash removed from the ore during crushing operations will be only slightly contaminated such that it may be disposed of as nonradioactive waste. Trash, rags, wood scrap, and other uncontaminated solid debris will result from maintenance and administrative activities. These materials will be disposed of in land fill areas approved by the State Division of Health and the appropriate local authorities.

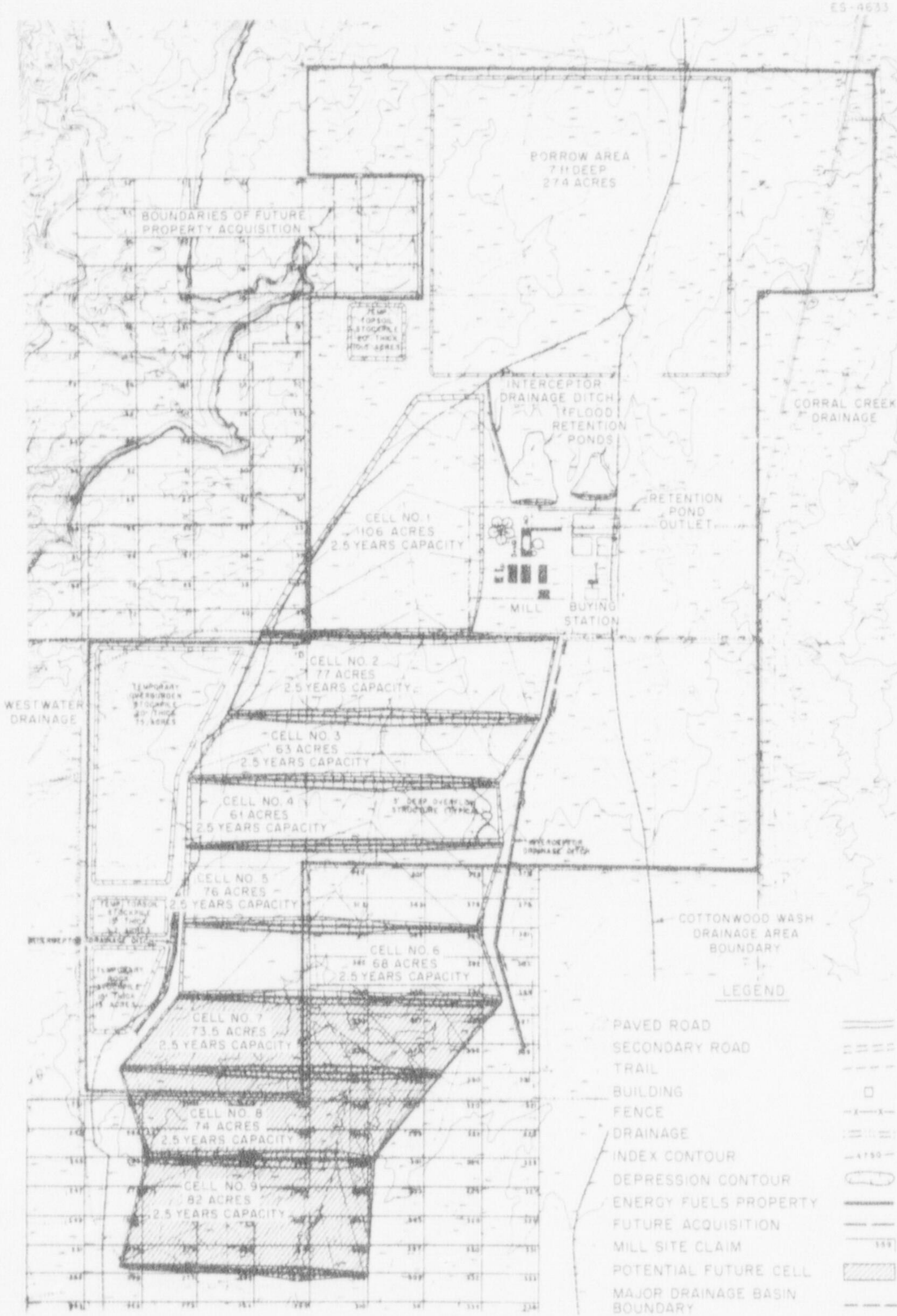

Fig. 3.4. Overall plot plan as proposed for the six-cell tailings disposal system including possible future cell additions. Source: Energy Fuels Nuclear, Inc., "Revised Application for Source Material License (included as Appendix AA in 'Proposed Tailing Disposal System, White Mesa Project,' dated Sept. 20, 1978)," Sept. 26, 1978.

Vanadium product dryer

When ore characteristics permit, the vanadium recovery circuit will extract the vanadium from the uranium circuit effluent (Sect. 3.2.2.2). The precipitated vanadium product will be dried in an oil-fired dryer to give vanadium pentoxide (black flake). Vanadium pentoxide is toxic. Therefore, drying and packaging will occur in an isolated building, and emissions will be controlled by a wet fan scrubber operating at an equivalent venturi scubber pressure of 51 cm (20 in.) of water and an efficiency of 99%. The applicant estimates the particulate release rate from this source to be 0.23 kg/hr (0.5 lb/hr).[1]

3.2.4 Radioactive wastes and effluents

Mining and milling of natural uranium releases 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 White Mesa mill is expected to have an average grade of 0.125% uranium (as U_3O_8). Ore of this grade has an activity of about 320 µCi of uranium-238 per ton of ore. The activity from uranium-235 and its daughters is only 5% of that of the uranium-238 series and may be ignored as it is radiologically insignificant.

Ore buying, shipping, and milling processes offer several pathways for release of radioactive effluents to the environment (Fig. 3.5). The applicant's existing Hanksville and Blanding ore buying stations and the proposed mill are designed to minimize the releases through these pathways. The ore buying stations are the subject of NRC licensing actions independent from the mill source material license, which is the subject of this document. Effluents from the operation of these stations will be considered only as they impact the environment around the site. In the following sections each potential effluent source is discussed, and estimates of effluent releases based on operating data from other similar facilities will be presented.

3.2.4.1 Ore crushing and sampling

Run-of-mine ore will be received at the applicant's ore buying stations at Hanksville and Blanding. Ore from different mines will be segregated into "lots" to facilitate sampling and payment. The raw ore will pass through a primary crusher and be reduced to less than 3.8 cm (1.5 in.). A fraction of the ore will be subjected to a crushing and sampling process that will produce a representative sample of the entire ore lot being processed. During the sampling process, radon gas and low-level radioactive ore dust will be released.

The Blanding ore buying station is expected to process 114 MT (125 tons) of ore per hour, operating on one 8-hr shift per day. All feeders, crushers, screens, chutes, and transfer points are enclosed in hoods connected via ducts to the three baghouse dust filters used in the plant. The filters are cleaned by a reverse jet of air, which knocks the dust into a bin at the bottom of the baghouse. The collected dust is recombined with the ore at appropriate points, so the ore grade is not altered (ER, p. 3-32).

The bag filters have a dust removal efficiency of around 99.5% (ref. 3). Assuming the ore to be fairly dry (<6% moisture) and the dust load to the collector to be 0.008% by weight,[4] the dust loss from the total crushing and sampling process would be approximately 4×10^{-5}%. Conservatively assuming that the entire mill ore demand of 1800 MT per day is processed by the Blanding station primary crusher, the annual dust emission would be 0.245 MT per year. At an average grade of 0.15% U_3O_8, slightly higher than expected, the concentration of uranium-238 in ore would be about 423 pCi/g. Also, the uranium concentration of fine crusher dusts is reported to be about 2.5 times the concentration in the gross ore.[4] Based on these data, and the assumption of secular equilibrium, approximately 2.6×10^{-4} Ci per year of uranium-238 and each radioactive daughter would be released.

Radon-222 gas would be released as a result of disturbance of the ore during processing. Roughly 10% of the equilibrium amount of radon is released during crushing and grinding operations.[5] Use of this value for the Blanding ore buying station is conservative because secondary crushing and grinding do not occur. Based on a 10% radon loss, an ore process rate of 1800 MT per day, and an equilibrium ore concentration of 423 pCi/g, approximately 26 Ci of radon-222 would be released each year.

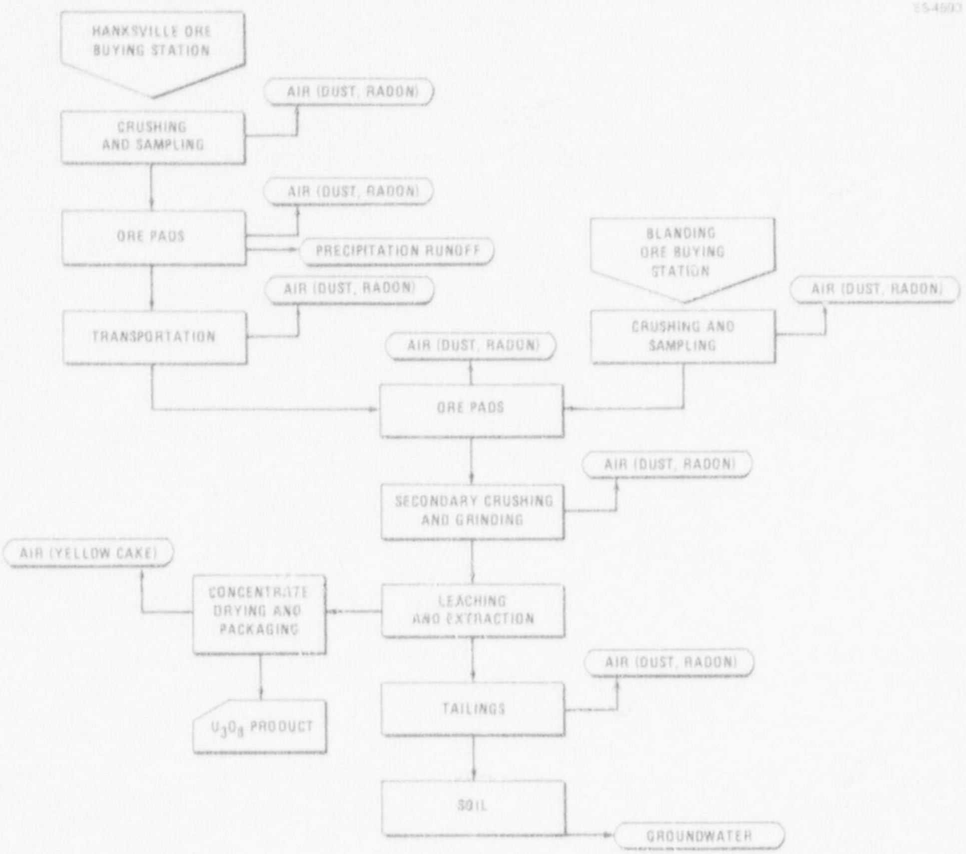

Fig. 3.5. Radionuclide dispersion pathways relevant to the White Mesa Uranium Project.

3.2.4.2 Transportation of ore to the mill

Crushed ore will be transported from the Hanksville buying station to the proposed mill in canvas-covered dump trucks of 30-ton capacity. The ore will not be heaped in the truck beds but will be evenly distributed to prevent ore spillage during transportation. The use of a canvas cover tied over the truck bed will minimize dust loss during haulage (ER, p.3-30).

3.2.4.3 Ore pads

Quantities of ore will be stored in stockpiles at the applicant's ore buying stations at Hanksville and Blanding. These ore buying stations are the subject of two additional licensing actions seperate from the mill application. The effluents from the ore pad at the Blanding ore buying station, however, would act in synergism with the effluents from the proposed mill; therefore, the Blanding ore pad operations and effluents are discussed.

Because of present ore buying operations, the applicant is accumulating ore in a 2.4-ha (6-acre) area north of the existing Blanding ore buying station. The applicant estimates that a maximum of 2.3×10^5 MT (2.5×10^5 tons) of ore will be stockpiled at the Blanding site at the time of mill startup. This quantity of ore would create a pile 6.7 m (22 ft) tall covering the 2.4-ha (6-acre) stockpile area. During operations, the stockpile would be reduced to under 9.1×10^4 MT (1×10^5 tons).

Particulates and radon-222 will be the main atmospheric emissions associated with the ore piles. Based on the meteorological data and the dusting rates for tailings sands (as a function of wind speed) presented in Appendix D, and assuming that ore pile dust emissions will be 1% of those from an equivalent area of fine-grained tailings, the annual average ore pile dusting rate is estimated to be about 1.8×10^{-7} g/m^2-sec. For a surface area of 6 acres (2.4 ha), accounting for side areas and surface roughness, the annual ore pile dust release is estimated to be 162 kg. At a gross ore concentration of 423 pCi/g and a fine concentration of 2.5 times that figure, the annual uranium-238 release from this source would be about 1.7×10^{-4} Ci/yr. The release of each particulate daughter in secular equilibrium would also be 1.7×10^{-4} Ci/yr.

The applicant intends to moisten pile surfaces after ore is added or removed and this will act to reduce these releases. As the release estimates presented here are basically proportional to the area of the ore storage piles, they would not be significantly affected by changes in the volume of stored material as long as it is distributed over the same surface area.

Radon-222 will be produced in the pile from decay of radium-226. Most of the radon decays in place with only a small fraction of the radon escaping the piles via diffusion. The staff estimates the annual radon release for the maximum stockpile case to be approximately 240 Ci/year (see Appendix F). As mill operations progress and the size of the pile decreases to an equilibrium value under 9.1×10^4 MT, the radon release from this smaller pile will depend on pile geometry. The radon flux from the pile surface is virtually independent of thickness for thicknesses greater than 3 m (10 ft). Therefore, if the same area [2.4 ha (6 acres)] is maintained for the equilibrium pile, the annual radon release would be the same as for the maximum stockpile, that is, 240 Ci/year (Appendix F).

Dust control measures such as moistening the surface of the stockpiled ore will also reduce radon releases because the moisture will decrease the diffusion coefficient. This effect is expected to be small.

3.2.4.4 Secondary crushing and grinding

The applicant proposes to use a semiautogenous mill to perform secondary crushing and grinding of the ore. This process uses larger pieces of ore to crush and grind smaller pieces; thus the ore essentially grinds itself. Steel balls may be added as necessary to aid in grinding.

Because the semiautogenous mill is a wet process, particulate releases will be small. Assuming a release fraction of 1×10^{-4}%, a gross ore concentration of 423 pCi/g, a fine concentration 2.5 times higher, and a processing rate of 1800 MT/day, the annual release of uranium-238 and each daughter in secular equilibrium from secondary crushing and grinding is estimated to be 6.5×10^{-4} Ci. Based on a release fraction of 20% the annual release of radon-222 gas from this source is estimated to be 52 Ci.

3.2.4.5 Leaching and extraction

Leaching and extraction are wet processes and should not make any significant contribution to the release of particulates. Because the residence time of ore in the leaching circuit will be short (12 to 24 hr), radon-222 will not build up to concentrations high enough to give a significant gaseous release.

3.2.4.6 Yellow cake drying and packaging

The uranium concentrate (precipitated ammonium diuranate) will be dried at 650°C. The product (yellow cake) will be about 90% U_3O_8 and will contain about 94% of the uranium in the ore. In addition, yellow cake will contain about 5% of the thorium-230 and 0.2% of the radium-226 and daughters originally in the ore. The uranium product dryer and product crusher will be isolated from other mill areas. Emissions will be controlled by wet fan scrubbers operating at an equivalent venturi scrubber pressure of 0.5 m (20 in.) of water with an efficiency of about 99%. The solution and particulates collected from the scrubbers will be recycled to the No. 1 yellow cake thickener in the mill (ER, p. 3-19). Data presented in Table 9.13 of Reference 2 indicate that about 1.2% of the annual yellowcake production may be expected to reach the wet fan scrubbers. At a gross ore grade of 0.15% U_3O_8 and a recovery rate of 94%, the annual production of pure yellowcake (U_3O_8) would be about 863 MT. With a scrubbing efficiency of 99%, the annual yellowcake release would be about 115 kg of which about 104 kg would be U_3O_8. The uranium-238 release rate is then calculated to be about 0.029 Ci/yr. Releases of other isotopes would be about

1.6×10^{-3} Ci/yr of thorium-230 and 6.2×10^{-5} Ci/yr each of radium-226 and lead-210. Releases of radon gas from this source are negligible.

3.2.4.7 Tailings retention area

The tailings discharged from the counter-current decantation unit of the mill is a slurry consisting of 897 kg (1977 lb) of solids and 0.9 m^3 (237 gal) of liquid 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 the leaching and solvent extraction steps. The estimated composition of the waste solution is given in Table. 3.1.

Table 3.1. Composition of liquid in plant tailings slurry based on laboratory test work

Parameter	Amount
Composition (g/liter)	
V	0.24
U	0.0025
Na	4.90
NH_3	0.065
Cl	3.05
SO_4	82.2
Cu	1.62
Ca	0.48
Mg	4.06
Al	4.26
Mn	4.58
Zn	0.09
Mo	0.007
Organics	0.2[a]
pH	1.8–2.0
Radiochemical assay (pCi/liter)	
Gross alpha emissions	2.5×10^5
Gross beta emissions	2.3×10^5
Th-230	1.3×10^5
Ra-226	2.3×10^2
Pb-210	2.8×10^2

[a]Measured in gallons per 1000 gal.

Source: ER, p. 3–12.

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. Approximately 6% of the original uranium, 95% of the thorium, and 99.8% of the radium remain with the tailings. The radioactive components of the waste show generally low solubility and remain mostly in the solids. The applicant conducted assays of synthetic tailings generated under conditions expected to be found in the mill and measured the thorium-230 and radium-226 contents at 1.5×10^2 pCi and 3.7×10^2 pCi per gram of solids (ER, p. 3-12). The actual concentrations found in the mill tailings will depend on the actual grade of the ore fed to the mill. The soluble radioisotope concentrations are listed in Table 3.1.

Because of the adverse radiological and chemical nature of uranium mill tailings, permanent environmental isolation is required. The tailings management plan should prevent excessive release of solids by wind erosion and of liquids by seepage, leakage, or overflow during operation of the mill. Following the 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 methods are discussed in Sect. 10.

The applicant proposes to build a six-cell impoundment system immediately to the west and south of the proposed mill (Fig. 3.4). The design storage volume of this system is 15 years. The applicant has also described how the impoundment might be expanded by the addition of three cells contiguous to the proposed six-cell system. These potential cells could be proposed if ore supplies warrant operation of the mill beyond 15 years. The impoundment would be constructed in a swale, a shallow natural basin. A cell would be constructed by excavating the bottom of the swale and placing an embankment across the swale to form the downstream side of the cell. Seepage will be controlled by state-of-the-art synthetic liners placed over and overlain by layers of packed silt-sand materials available onsite (see Sect. 10.3.2 for description). No seepage problems with this liner system are anticipated.

The embankments surrounding the cells will be constructed of compacted soil available on the site. The embankments would vary in height from a meter or more near the ridges of the swale to as much as 9 m (30 ft) for dikes at the lowest point in the swale. Overflow structures will be provided for all dikes between the individual tailings cells. The overflow structures will limit the pond elevation to 1.5 m (5 ft) below dike crest, allowing any excess liquids to spill into the next completed cell for disposal by evaporation. On completion of fill operations in a cell, the tailings slurry pipeline will be routed through the structure to the next cell. All dikes would be 6 m (20 ft) thick at the crest (allowing for an access road on the dike) and would have slopes no steeper than 3:1 (horizontal to vertical; Fig. 3.6). The final exterior slopes on the perimeter of the impoundment will have a slope of 6:1 and will be covered with excavated rock (Fig. 3.7). Because the dikes will not saturate during the brief period a given cell is in operation, engineered embankments are not utilized.

Geotechnical studies performed for the applicant indicate that the proposed slopes would withstand an earthquake with a magnitude of VI on the Modified Mercalli Scale. To prevent overflow of the impoundment by flooding, interceptor ditches and retention ponds will direct drainage around the impoundment.

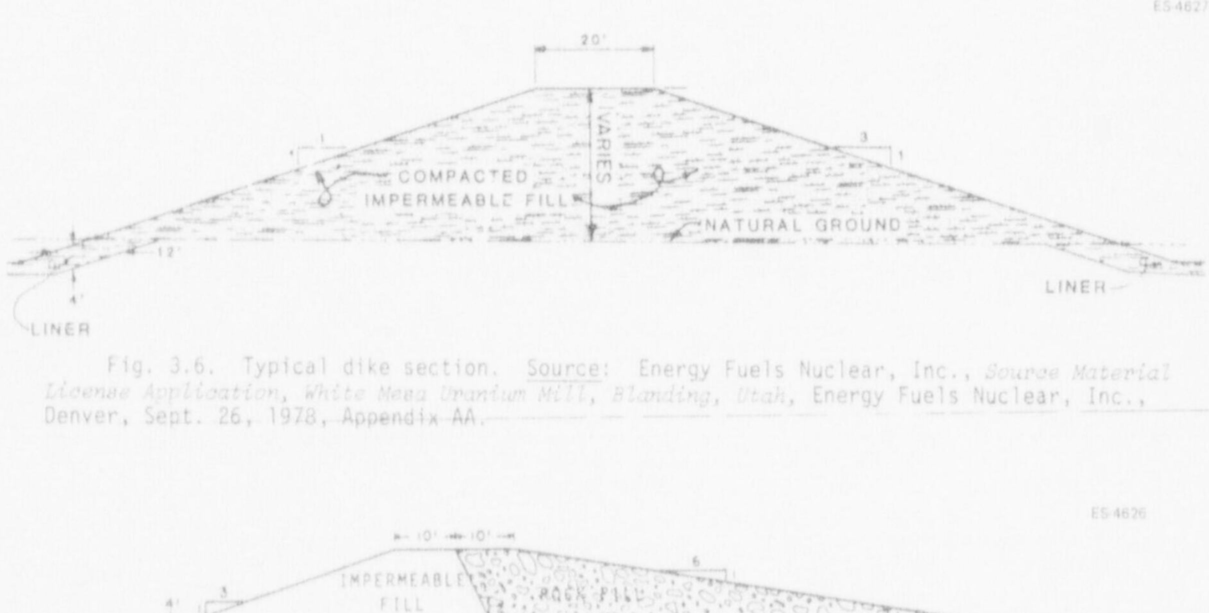

Fig. 3.6. Typical dike section. Source: Energy Fuels Nuclear, Inc., *Source Material License Application, White Mesa Uranium Mill, Blanding, Utah*, Energy Fuels Nuclear, Inc., Denver, Sept. 26, 1978, Appendix AA.

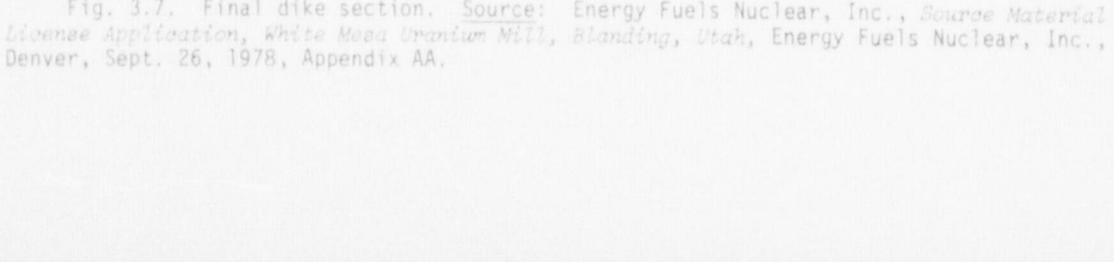

Fig. 3.7. Final dike section. Source: Energy Fuels Nuclear, Inc., *Source Material License Application, White Mesa Uranium Mill, Blanding, Utah*, Energy Fuels Nuclear, Inc., Denver, Sept. 26, 1978, Appendix AA.

The proposed tailings system features simultaneous construction, operation, closure, and reclamation activities. The first two cells would be constructed before commencement of mill operation, with tailings being initially deposited in the first cell. The second cell would act as a downstream catchment area for any release of tailings material in the event of failure of the first dike. As the filling of the first cell nears completion and before any tailings materials are pumped into the second cell, the third cell would be excavated and lined to maintain a catchment area downstream of the active cells. After construction of the third cell, water and slimes would be decanted from the first cell to the second cell to maintain the water balance and to allow for the deposition of tailings slimes at the bottom of cell 2. After the first cell is filled to its final grade, the tailings disposal pipeline would be moved to the second cell. While the second cell is being filled, reclamation of the first cell would commence after the tailings have dried. Except for a small channel, which would be maintained through the cover of the first cell (and each subsequent cell) for placement of the tailings slurry pipeline, the first cell would be completely reclaimed. (In the event of a rupture in the tailings pipeline, the tailings would be contained.) This pattern of operation would continue until the last cell is constructed. To increase the evaporative capacity of the system and to allow for complete filling of the final cell, excess liquids in the last cell would be pumped back to the previous (fifth) cell. Closure and reclamation of the last two cells would be completed as soon as the tailings surface is sufficiently dry for movement of heavy equipment over the pile.

The staff has examined the water balance for the impoundment and has concluded that careful water management will be necessary to allow operation of the impoundment on the proposed schedule. The pond area required for evaporation (water balance) is estimated by the staff to be at least 33.2 ha (81 acres). The capacity requirements would be difficult to meet under the proposed plan because the total surface area of most of the cells is less than estimated to be necessary. The staff has concluded that the impoundment design or operational sequence will have to be modified to provide the necessary evaporative capacity.

Effluents from the proposed impoundment will consist of wind-blown particulates, and radon-222. During tailings cell fill operations, wind erosion of the tailings will be minimized by keeping the entire tailings surface moist by regularly shifting the location of the slurry discharge spigot. However, as the final layer of sands are deposited in a cell, the tailings discharge line will be moved toward the downstream dike, allowing the upper end of the cell to dry out. Additional drying will be necessary to allow operation of heavy equipment during reclamation of the cell. The staff will require the use of crusting agents, water spray, or similar means to minimize the erosion of the tailings by wind. If no successful mitigating measures are taken, the annual average dry tailings pile dusting rate, on the basis of data presented in Appendix D, would be about 1.8×10^{-5} g/m^2-sec which is equivalent to about 2.2 MT/acre-yr. Corresponding estimated radioactivity release rates are 1.4×10^{-4} Ci/acre-yr for U-238, 2.2×10^{-3} Ci/acre-yr for Th-230, and 2.3×10^{-3} Ci/acre-yr for Ra-226 and Pb-210 (each).

As stated above, if liners are used the required pond evaporation area would be 33.2 ha (81 acres). Usage of liners may also substantially increase the period of time necessary for drying prior to cell reclamation. Due to these uncertainties, the staff has conservatively assumed (for purposes of radiological impact analysis) that each cell would have an area of 40 ha (100 acres) and that the time interval for drying between the cessation of cell use and the initiation of reclamation is approximately 5 years. Under these conditions, if each cell can store 2.5 years worth of tailings, there may be 2 cells drying out while a third is being filled. If the cell being filled is 50% beach, there could be a total of approximately 100 ha (250 acres) of tailings areas available for dusting. The staff has assumed that control measures to be implemented by the applicant will reduce dust emissions from non-operational cells by 80%. Under these conditions total annual radioactive particulate releases are estimated to be 0.013 Ci of U-238, 0.20 Ci of Th-230, and 0.21 Ci of Ra-226 and Pb-210 (each).

Radon-222 gas is expected to be released in significant quantities from dry tailings areas. Releases from saturated tailings, or tailings that are under water, are severely limited due to the low diffusivity of radon gas in water. The staff assumes that two 40-ha (100-acre) cells may be drying prior to reclamation while a third cell is being filled. Radon releases from the driest cell (8% moisture content), the other cell drying out prior to reclamation (15% moisture content), and the beach area of the filling cell (50% beach, 37% moisture content) are estimated to be 5550 Ci/yr, 2480 Ci/yr, and 30 Ci/yr, respectively (see Appendix F for details). The total annual radon-222 release is estimated to be 8060 Ci/yr. Radon releases from underwater tailings materials or reclaimed tailings cells are insignificant in comparison and have been ignored.

3.2.4.8 Uranium concentrate transportation

The uranium concentrate will be transported in 55-gal drums by truck because no rail transportation is available at the site. Uranium shipment, about 2000 drums each year, will result in an external radiation dose[6] to an individual of 2 mR/hr at any edge of the truckbed. Under normal operating conditions, no significant release of radioactive particulates would occur. However, release could occur during transportation accidents as discussed in Sect. 5.3.1.

3.2.4.9 Source terms

Sections 3.2.4.1 through 3.2.4.8 describe the nature and quantity of radioactive effluents conservatively estimated to be generated by milling operations at the White Mesa Uranium Project. Estimates employed in the above discussions were derived from project design parameters and data from similar mills.[7-38] 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 startup. Therefore, the use of full-scale operation as the basis for estimates adds some additional conservatism to the analysis. Table 3.2 gives the design parameters used in estimates of radioactive release rates. The source terms for the milling operations and areas are presented in Table 3.3.

3.3 INTERIM STABILIZATION, RECLAMATION AND DECOMMISSIONING

3.3.1 Interim stabilization of the 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 White Mesa mill during the 15 years of operation (for in-use and drying cells) and the years required to dry the final tailings cell after operation (see Section 10.2) prior to reclamation.

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

3.3.2 Reclamation of the 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 stabilization 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).

The proposed reclamation program calls for a 0.6-m (2.0-ft) layer of compacted Mancos Shale and a 3-m (10-ft) layer of silt-sand material over the tailings area. The proposed cover is considered sufficient to reduce the radon flux to twice background and the gamma radiation to background levels (see Appendices F and G).

The cover would also be graded and sloped at a grade of 2% or less to prevent impoundment of surface runoff. A layer of topsoil 0.23 m (0.75 ft) thick will be placed over the cover. The area would be fertilized and revegetated with a suitable mixture of grasses, forbs, and shrubs. Grasses and shrubs whose root structures would penetrate the cover will not be planted. The approximate volumes of material required would be 4,498,400 m^3 (5,883,700 yd^3) of the silt-sand soil and 461,700 m^3 (603,900 yd^3) of topsoil. Staged construction, operation, and reclamation will minimize stockpiling and handling requirements.

The reclamation plans have been developed from recommendations from the U.S. Department of Agriculture (USDA) Soil Conservation Service and Forest Service (ER, Sect. 9.4). These plans are also in accordance with the regulations of the State of Utah Division of Oil, Gas, and Mining.[38,39]

The project site will be revegetated to return it to the original uses of grazing and wildlife habitation. The soils are relatively uniform and adequate for these reclamation procedures (ER, Sect. 9.1.1). The reclamation schedule for the project site is depicted in Fig. 3.8. The tailings cells will be reclaimed sequentially as each cell is filled, beginning after about the 30th month of operation and every 30 months thereafter until termination of project operations. A Mancos Shale cap [0.6 m (2 ft)] and on-site clayey-silt soil [3m (10 ft)] will be placed over the dried tailings. Except for the rock-lined drainage ditches, rock-filled slopes along the edges of the soil-covered tailings cells, and the rock-filled southernmost dike of cell 6, about 23 cm (9 in.) of topsoil will be placed on the surface of all disturbed areas and seeded with a mixture of grasses, forbs, and shrubs (Table 3.4). Any excess rock will be disposed of at the 111-ha (274-acre) borrow area prior to its reclamation.

Table 3.2 Principal parameter values used in the radiological assessment of the White Mesa Uranium Project

Parameter	Value[1]
I. General Data	
Average ore grade, % U_3O_8	0.15
Ore concentration, pCi/g U-238 and daughters	423
Ore processing rate, MT/d	1800
Days/yr operational	340
II. Blanding Ore Crusher	
Ore processing rate, MT/d	1800
Fraction released as particulates	4×10^{-7}
Fraction of radon released	0.1
Dust/ore concentration ratio	2.5
III. Ore Storage Piles[2]	
Actual area, acres	6
Effective dusting area, acres	7.3
Annual average dust loss rate, g/m^2-sec	1.8×10^{-7}
Dust/ore concentratration ratio	2.5
IV. Secondary Crusher	
Ore processing rate, MT/d	1800
Fraction released as particulates	1×10^{-6}
Fraction of radon released	0.2
Dust/ore concentration ratio	2.5
V. Yellowcake Drying and Packaging	
Fraction U to yellowcake	0.94
Fraction Th to yellowcake	0.05
Fraction Ra and Pb to yellowcake	0.002
Annual U_3O_8 production, MT	863
Annual yellowcake production, MT	959
Fraction of yellowcake to scrubber	0.012
Scrubber release fraction	0.01
VI. Tailings Impoundment System[2,3]	
Fraction U to tailings	0.06
Fraction Th to tailings	0.95
Fraction Ra and Pb to tailings	0.998
Area, acres per cell	100
Drying time prior to reclamation, yrs	5
Area subject to dusting, acres	250
Annual average dust loss rate, g/m^2-sec	1.8×10^{-5}
Dust/tails concentration ratio	2.5

Notes: 1) Parameter values presented here are those selected by the staff for use in its radiological impact assessment of the White Mesa Uranium Project. They represent conservative selections from ranges of potential values in instances where insufficient data has been available to be more specific.

2) Appendix F provides additional information regarding the calculation of radon releases.

3) Effective dusting area is 90 acres; 20% of two 100-acre cells drying prior to reclamation and 50% of a 100-acre operational cell.

Table 3.3 Estimated annual releases of radioactive materials resulting from the White Mesa Uranium Project

Source	Annual Releases, Ci(1)			
	U-238	Th-230	Ra-226	Rn-222
Blanding ore crusher	2.6×10^{-4}	2.6×10^{-4}	2.6×10^{-4}	2.6×10^{1}
Ore storage piles	1.7×10^{-4}	1.7×10^{-4}	1.7×10^{-4}	2.4×10^{2}
Secondary crusher	6.5×10^{-4}	6.5×10^{-4}	6.5×10^{-4}	5.2×10^{1}
Yellowcake scrubber	2.9×10^{-2}	1.6×10^{-3}	6.2×10^{-5}	0.0
Tailings system	1.3×10^{-2}	2.0×10^{-1}	2.1×10^{-1}	8.1×10^{3}

(1) 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.

Table 3.4 Species, seeding rates, and planting depths of tentative seed mixture to be used in reclamation of the project site

Species	Seeding rate		Depth	
	kg/ha	lb/acre	cm	in.
Grasses				
"Luna" pubescent wheatgrass	6.16	5.5	0–0.64	0–0.25
Fairway (crested) wheatgrass	1.68	1.5	0–0.64	0–0.25
Forbs				
Yellow sweetclover	1.12	1.0	1.27–2.54	0.5–1.0
Palmer penstemon	0.112	0.1	0–0.64	0–0.25
Alfalfa	1.12	1.0	1.27–2.54	0.5–1.0
Shrubs				
Fourwing saltbush	0.56	0.5	0.64–1.27	0.5–1.0
Common winterfat	0.56	0.5	0.64–1.27	0.5–1.0
Big sagebrush	0.112	0.1	0.64–1.27	0.5–1.0
Total	11.424	10.2		

Source: Energy Fuels Nuclear, Inc., *Source Materials License Application, White Mesa Uranium Mill, Blanding, Utah*, Denver, Sept. 26, 1978.

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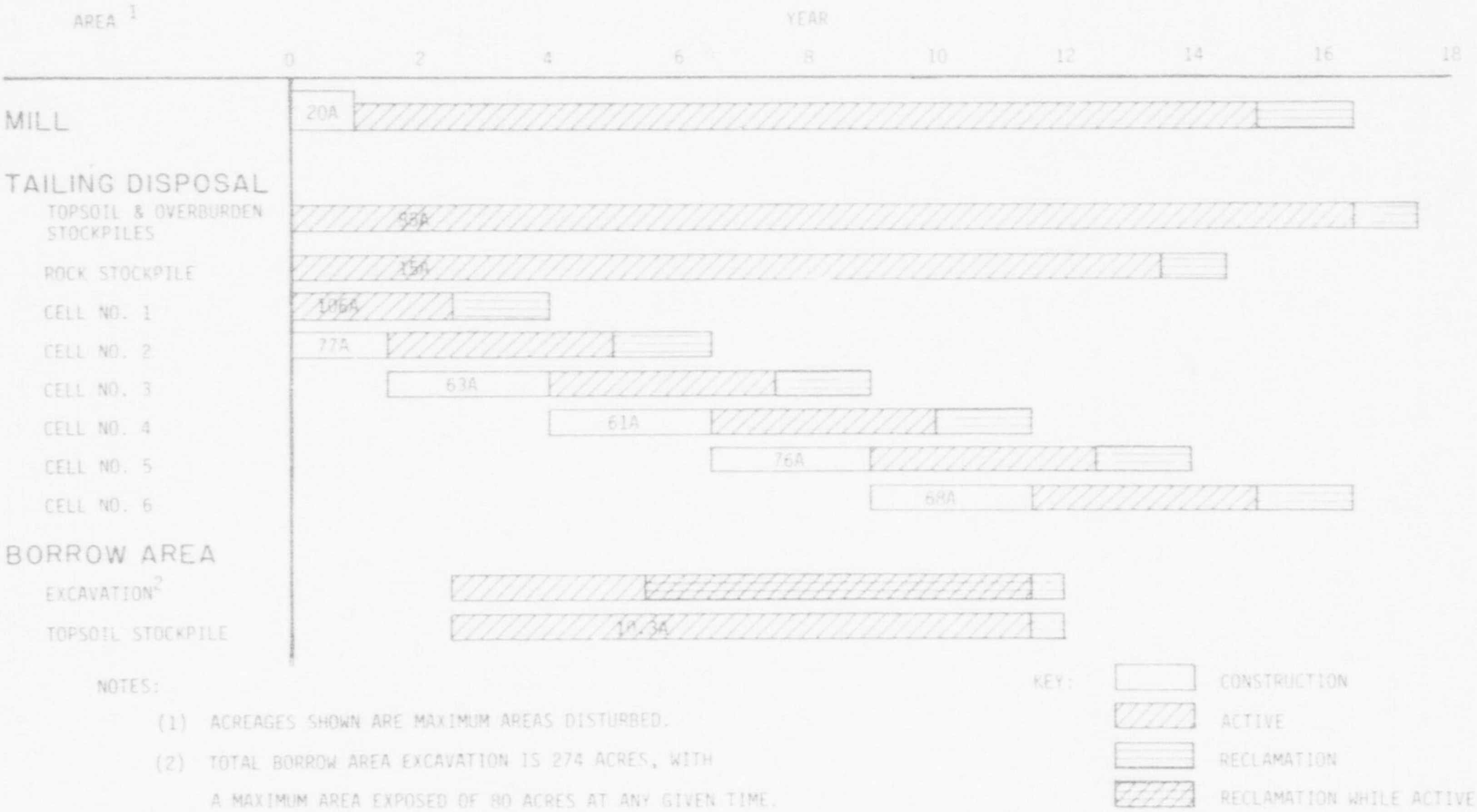

Fig. 3.8. Reclamation schedule. Source: Energy Fuels Nuclear, Inc., *Source Materials License Application, White Mesa Uranium Mill, Blanding, Utah*, Denver, Sept. 26, 1978, Plate 12.

The applicant's selection of seeds is representative of the vegetation on the site prior to construction and will suffice in reclaiming the site to the preconstruction land condition. The staged reclamation plan will permit optimizing the seed mixture for a maintenance-free vegetative cover which will maximize soil stability. In the long-term native vegetation is expected to return to the area. The seed should be obtained from those areas that have soil characteristics and climate similar to the project site.[39]

The mixture of seed will be planted in November with a rangeland drill. Because soil nitrogen is low (ER, Sect. 2.10.1), it may be necessary to apply an appropriate fertilizer prior to seeding. The applicant claims that the topsoil will contain sufficient debris so that mulching will not be required. However, by the time reclamation begins, much of the debris will be decomposed. Mulches increase infiltration and reduce erosion and evaporation, thereby encouraging seed germination and plant growth. Therefore, 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 White Mesa 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 White Mesa 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.

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4. Ref. 2, Table 9.12.

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

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4. ENVIRONMENTAL IMPACTS

4.1 AIR QUALITY

4.1.1 Construction

The major nonradiological 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 to air quality.

The maximum expected emission rate for any of the major 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 H, Table H.1), the staff calculated the annual atmospheric concentration of each pollutant per vehicle to be less than 1 $\mu g/m^3$ at the property boundary in the direction of the prevailing wind.

Fugitive dust associated with construction of the facility will average about 0.4 to 0.7 MT/ha (1 to 2 tons/acre) per month.[2] Based on a total of about 200 ha (485 acres) disturbed at any one time (Sect. 4.2.1), about 170 to 340 g/sec of particulates will be emitted. Annual average atmospheric concentrations of particulates were calculated by the staff using the χ/Q values (Appendix H, Table H.1) for the 16 compass directions at a distance of 2.4 km (1.5 miles). The average of these 16 concentrations indicate that particulate loading due to construction will range from 37 to 74 $\mu g/m^3$, thereby occasionally violating the 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 would deposit rapidly, another condition not accounted for in the calculation. Although dust could cause occasional localized degradation of air quality at the site, the duration will be only during the one-year construction phase. To minimize fugitive dust, the applicant will frequently water exposed areas and heavily traveled areas, and all vehicles will be operated at a reduced speed.[3]

4.1.2 Operation

Air quality during operation of the facility could be affected by atmospheric releases principally from the building and processing boiler, yellow cake and vanadium dryers, tailings disposal system, and ore stockpiles. The applicant's consultant's estimates of emissions from each primary source and their release heights are listed in Table 4.2. The staff estimates (Sect. 3) are somewhat different, but the conclusions drawn (below) remain the same. In addition, insignificant quantities will be released from other sources including the coal stockpiles, ore transport systems, and acid leach system. Atmospheric dispersion coefficients (χ/Q) for each release height are listed in Appendix H, Tables H.1 through H.4. Assuming all processes are operating simultaneously, annual atmospheric concentrations of particulates, SO_2, and NO_x at the property boundary in the direction of the prevailing wind were calculated by the staff to be approximately 13, 9, and 4 $\mu g/m^3$ respectively. These concentrations are well below applicable Federal and State air quality standards (Table 4.1). For reasons stated earlier, the particulate concentrations are quite conservative. The applicant calculated the atmospheric concentrations of the major pollutants using the CRSTER program, a program used by the U.S. Environmental Protection Agency.[4] Calculations were for five distances: 2, 4, 6, 8, and 10 km (3.2, 6.4, 9.7, 12.9, and 16.1 miles). Concentrations were the largest at the 2-km (3.2-mile) distance and are as follows: particulates, annual average = 0.26 $\mu g/m^3$, 24-hr average = 3.7 $\mu g/m^3$; SO_2, annual average = 1.1 $\mu g/m^3$, 24-hr average = 15.4 $\mu g/m^3$, 3-hr average = 66.6 $\mu g/m^3$; NO_x, annual average = 0.51 $\mu g/m^3$.

Although operation of the mill facility should not have any 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 the lowest discharge rates that are reasonable and practical. While 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 coal and oil, used as fuels, to no greater than 1.0 and 1.5% respectively.

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 2.7–19.

Table 4.2. Emission rates, sources, and release heights of major air pollutants associated with operation of the White Mesa mill

Air pollutant and source	Emission rate (g/sec)	Release height (m)
Suspended particulate		
Boiler	1.0	27.4
Yellow cake dryer	0.05	13.7
Vanadium dryer	0.06	13.7
Tailings	1.01	1.0
Ore stockpiles	1.08	3.0–6.0
SO_2		
Boiler	4.0	27.4
Yellow cake dryer	0.25	13.7
Vanadium dryer	0.25	13.7
NO_x		
Boiler	2.0	27.4
Yellow cake dryer	0.06	13.7
Vanadium dryer	0.06	13.7

Sources: Dames and Moore, "Responses to Comments from the U.S. Nuclear Regulatory Commission, June 7, 1978, White Mesa Uranium Project Environmental Report," Denver, June 28, 1978; Dames and Moore, "Supplemental Report, Meteorology and Air Quality, Environmental Report, White Mesa Uranium Project, San Juan County, Utah, for Energy Fuels Nuclear, Inc.," Denver, Sept. 6, 1978; Dames and Moore, "Responses to Comments Telecopied from NRC to Energy Fuels Nuclear, 25 September 1978," Denver, Oct. 4, 1978.

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. The White Mesa Uranium Project is currently being evaluated by the appropriate regulatory authorities to ascertain if the project is defined as a major source. If the project is deemed to be a major source, then the applicant will be required to file for the appropriate PSD permit and to comply with all regulations therein. Initial indications are that the atmospheric concentrations of pollutants associated with mill operation will be well within the PSD allowable increments.

4.2 LAND USE

4.2.1 Land resources

4.2.1.1 Nonagricultural

The proposed White Mesa Uranium Project is not expected to alter the basic pattern of land ownership in the area (Table 2.15). Area land uses will change, however, as a result of the proposed mill. About 600 ha (1480 acres) are owned by Energy Fuels Nuclear, Inc.; roughly 358 ha (885 acres) will be directly used during operations (Sect. 2.5.1) for milling, ore buying, and tailings disposal. Increased residential and commercial land use is expected in neighboring communities to serve mill-produced population growth (Sects. 4.8.1 and 4.8.2). The volume of traffic using the highways in this area is also expected to grow substantially (Sect. 4.8.5), and mineral extraction is expected to increase in the project area in response to the mill's demand for uranium ore (Sect. 4.8.1.2).

4.2.1.2 Agricultural

Construction and operation of the facility will disturb about 20 ha (50 acres) directly (Table 4.3). In addition, the tailings will cover a total of about 180 ha (450 acres), and 155 ha (385 acres) will be used for stockpile and borrow areas. Because the tailings disposal system will be constructed as six separate cells, with a full cell being reclaimed as a new cell is opened, a total maximum surface area of about 100 ha (245 acres) will be disturbed at any one time by the tailings system. Also, a maximum of about 30 ha (80 acres) of borrow area will be exposed at any given time. Therefore, total land area disturbed at any one time by construction and operation of the mill facilities will be about 200 ha (485 acres). However, until all operations have terminated, at least 365 ha (900 acres) will be unavailable for grazing. Based on the capacity of the tailings cells, the mill has a potential to operate 15 years. The duration of the impact will be somewhat longer than this depending on 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 on each reclaimed area. Therefore, a realistic estimate of the amount of time the land will be disturbed is about 20 years.

Upon termination of the mill operations, all remaining disturbed areas will be reclaimed to ultimately restore the land to its original grazing use (Sect. 3.3.2). Loss of nearly 365 ha (900 acres) of grazing land each year the land is disturbed represents less than 0.1% of the private rangeland in San Juan County (Table 2.16). With successful reclamation (Sect.3.3.2), this land could be returned to its original grazing capacity.

4.2.2 Historical and archaeological resources

The project will have no effect on any known historical resources; however, as discussed in Section 2.5.2.1, a historical survey remains to be conducted.

As discussed in Sect. 2.5.2.3, both surface and subsurface archeological surveys have been conducted on the site since the fall of 1977. While additional field work will be required to determine the significance of all identified archeological sites, the NRC, after consultation with the Utah State Historic Preservation Officer (SHPO), has determined that, based on the results of subsurface testing, this area of White Mesa contains numerous sites which are likely to yield information important in the prehistory of the region, and therefore appear to be eligible for nomination to the National Register of Historic Places (National Register). An opinion concerning the eligibility of the properties will be requested from the Secretary of the Interior. It is anticipated that an affirmative response will be received and that the NRC will enter into a Memorandum of Agreement under 36 CFR Part 800, Procedures for the Protection of Historic and Cultural Properties. As a National Register eligible site, each of the significant archaeological sites would be evaluated against the criteria for "adverse effect" and "no adverse effect" in 36 CFR Part 800, and the Advisory Council on Historic Preservation (Advisory Council) guidelines.

Table 4.3. Land disturbed by construction and operation of the White Mesa Uranium Project

Area	Area to be disturbed	
	ha	acres
Mill[a]	20	50
Tailings cell 1	43	106
Tailings cell 2	31	77
Tailings cell 3	25	63
Tailings cell 4	25	61
Tailings cell 5	31	76
Tailings cell 6	28	68
Topsoil stockpiles	8	20
Overburden stockpile	30	75
Rock stockpile	6	15
Borrow area[b]	111	274
Total	358	885

[a] Includes 6 ha (16 acres) occupied by an ore buying station.

[b] A maximum of 32 ha (80 acres) exposed at any given time.

Sou[illegible] [illegible]ergy Fuels Nuclear, Inc., "Source Material [illegible] Application, White Mesa Uranium Mill, Bland[illegible], [illegible]ah," Energy Fuels Nuclear, Inc., Denver, Sept. 26, 1978.

Federal statutes, regulations, and administrative guidelines contemplate that mitigating measures be taken to protect historic and prehistoric cultural resources either through programmed avoidance of sites or through excavation by professionally qualified archaeologists. These measures are imposed not only in all cases where Federal lands are involved, but also in the case of firms using funds backed by Federal guarantees or where an activity requires a Federal license. As a Federal licensing authority, NRC will require appropriate mitigating measures such as:

1. that each significant archaeological site which is not to be disturbed by facility construction or operation be fenced, buried or otherwise protected in a manner agreed to in a Memorandum of Agreement prepared under 36 CFR 800;

2. that adverse effects (by facility construction or operation) to each significant archaeological site be mitigated in accordance with the provisions of the Memorandum of Agreement; and

3. that a professional archaeologist be present during land disturbance and that in the event any unanticipated archaeological sites or artifacts are located during site preparation or mill operation, all construction or operation activities in the area of the find cease, and further action be taken in accordance with the Memorandum of Agreement.

Because of the potential importance of the archaeological sites on the project area to the understanding of the prehistory of the White Mesa region, the NRC will request the comments of the Advisory Council and take mitigatory action as appropriate. Since the measures that will be taken by NRC will be determined after further consultation with others (SHPO, Secretary of the Interior, and the Advisory Council), a precise statement of impacts is not possible at this time.

4.3.1 Surface waters

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). During

periods of flow in local intermittent streams, this natural erosion is reflected in values of total suspended solids which reach levels of >1500 mg/liter (Table 2.22).

Sediment carrying runoff that can enter local streams will originate primarily from the steep sides of the temporary overburden stockpiles. Table 4.4 lists the effects of Phase I construction (mill facilities and the first two retention cells). The net change in tons of sediment transferred to local streams is about -2500 MT (-2800 tons), or a reduction in total sediment transfer.

Table 4.4. Effects of Phase I construction

Location	Area		Yearly sediment production to local streams		Yearly net change		Yearly change	
	ha	acres	MT/ha	tons/acre	MT/ha	tons/acre	MT	tons
Borrow area	12	30	0	0	−22	−10	−270	−300
Topsoil stockpile slopes	0.4	1	1120	500	1098	+490	440	490
Overburden stockpile slopes	2	5	1120	500	1098	+490	2220	2450
Topsoil central stockpile	3.8	9.3	0	0	−22	−10	−84	−93
Overburden central stockpile	28	70	0	0	−22	−10	−630	−700
Tailings cell 1	43	106	0	0	−22	−10	−960	−1060
Tailings cell 2	31	77	0	0	−22	−10	−700	−770
Mill site drainage	113	280	0	0	−22	−10	−2540	−2800
Net							−2520	−2783

Source: Dames and Moore, "Responses to Comments Telecopied from NRC to Energy Fuels Nuclear, 25 September 1978," Denver, Oct. 4, 1978.

There will be no discharge of mill effluents to local surface waters. In addition, sanitary wastes generated by mill operation will be retained in a sanitary drainage field (Sect. 3.2.3.2) and should not affect surface water quality.

The construction and operation of the proposed uranium mill should not affect local surface waters to any significant extent.

4.3.2 Groundwater

4.3.2.1 Water usage

The applicant has obtained a permit to utilize 5.9 x 10^5 m^3 (480 acre-ft) of water per year, which will be withdrawn from the Navajo sandstone aquifer. All other wells within 8 km (5 miles) produce from other formations. This usage will have no effect on other users.

4.3.2.2 Potential degradation of groundwater

The mill will discharge about 1.12 m^3/min (310 gpm) of liquid to the proposed tailings impoundment (Fig. 3.4). The chemical and radiological composition of this waste liquid is given in Table 3.1.

The applicant has proposed to line the impoundment with a multicomponent liner (of synthetic and onsite clayey-silt materials) to essentially eliminate seepage into the underlying Dakota formation; therefore, the possibility of groundwater degradation caused by seepage of tailings liquids is considered to be remote. After reclamation, when deterioration of the liner may have occurred, the staff expects essentially no seepage into the Dakota formation because of the high net evaporation rate in the area. Preoperational and operational monitoring of the groundwater is required (Sect. 6.3), and mitigating measures will be taken if unexpected groundwater contamination is observed.

4.4 MINERAL RESOURCES

Only uranium, vanadium, and copper are present in sufficient quantities to warrant processing. At present copper extraction is uneconomic. If this copper, or any other mineral in the ore, becomes more valuable in the future, the overburden could be removed from the tailings and these minerals extracted; therefore, this project is not expected to have any impact on the availability of other minerals.

4.5 SOILS

Construction of the mill and tailings disposal system will disturb about 360 ha (885 acres) (Table 4.3). The top 23 cm (9 in.) of soil, removed from the mill site, tailings cells, and borrow area, will be stockpiled at two locations totaling 7.9 ha (19.5 acres) (Fig. 3.4). The remaining overburden and rock will be stockpiled at two areas, totaling 30 ha (75 acres) and 6 ha (15 acres) respectively. Removal of topsoil will disrupt existing physical, chemical, and biotic soil processes. Although topsoil will be replaced upon termination of the project operations, a temporary decrease in natural soil productivity is probable.[8]

Removal of topsoil and natural vegetation on the site will accelerate wind and water erosion. Generally, the duration of these impacts will be only during the construction phase, which is expected to take one year. To minimize fugitive dust resulting from construction activity, the applicant will frequently water exposed areas and heavily traveled areas, and all vehicles will be operated at a reduced speed.[3] The tailings impoundment will be constructed as six separate cells (Fig. 3.4), only three of which will be active at any given time. As the first cell is filled and reclaimed, the fourth cell will be constructed. This construction sequence will result in a minimum disturbance of land at any given time. The material excavated from one cell can be hauled directly to a filled cell and placed over the tailings as part of the required cover, thus reducing handling of materials.

All mill facilities will be located upstream of the tailings cells. Tailings cells 1 and 2, which will be constructed simultaneously with the mill facilities, provide dikes that will capture runoff. Although sediment transfer will be increased within the site, the location of the mill facilities and tailings cells should minimize sediment transfer from the site, as discussed in Section 4.3.1. To minimize erosion, the overburden and topsoil stockpiles will be stabilized by seeding with cereal rye and yellow sweet clover.[7] Sunflowers, Russian thistle, and other annual plants will also become established and will aid in preventing erosion of the stockpiles.

Impacts to soils during operation of the mill include wind and water erosion. Soil over much of the site will be stabilized by gravel and the presence of structures. The topography of the site concentrates some of the surface water at two points directly north of the proposed mill (Fig. 3.4). During operations, two retention ponds will be constructed in this area to collect surface runoff from the drainage above this point (25 ha (62 acres) above the mill site and that from the mill site itself); and the discharge from these ponds will be directed to the east away from the tailings cells. Also, drainage ditches will be constructed along the east and portions of the west boundaries of the tailings cells. Rock from excavation of the tailings cells will be placed as riprap in the drianage channels to help prevent severe erosion. Rock will also be placed along the dikes of the retention ponds and at the southern dike of cell 6.

Upon termination of the mill operations, all remaining disturbed areas will be reclaimed to restore the land to preconstruction land uses (Sect. 3.3.2). Reclamation laws require successful establishment of a soil medium that is capable of sustaining vegetation without irrigation or continuing soil amendments. 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 ecological impact of construction and operation of the mill and tailings disposal system will result from the loss of habitat. However, the majority (85%) of the vegetation that will be removed has been previously disturbed to varying degrees by either chaining, plowing, or reseeding (Figs. 2.10 and 3.4; Tables 2.26 and 4.5). Winter deer use of the project vicinity, primarily pinyon-juniper-sagebrush habitats, is among the heaviest in southeastern Utah.[9] However, because similar rangeland is very common throughout the region (Sect. 2.5), it is expected that loss of this relatively small parcel of land (less than 0.1% of the private rangeland in San Juan County) should not significantly reduce the amount of habitat for these animals.

Table 4.5. Community types and approximate expanse to be disturbed by construction and operation of the White Mesa mill

Community type	Area to be disturbed	
	ha	acres
Pinyon-juniper woodland	4	10
Big sagebrush	49	120
Reseeded grassland I	53	130
Reseeded grassland II	81	200
Tamarisk-salix	1	2
Controlled big sagebrush	162	400
Disturbed[a]	11	28

[a] Includes ore buying station.

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 destruction would not be a significant impact because these animals comprise a very small percentage of the total regional populations. Habitat that will be disturbed as a result of construction and operation of the mill represents less than 0.05% of similar habitat in the county.

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 to consumers. 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. Furthermore, 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.[10] Probably, the noisiest period of construction will be during the excavation of the tailings cells. The applicant estimates the average sound level during the excavation phase to be about 66 dB(A) at 300 m (1000 ft) from the center of activity. 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.[10]

To balance yearly water inputs with yearly net evaporation, the tailings cell design will require a surface area of about 28 ha (70 acres) of tailings water.[11] These liquids will be unsuitable for use by wildlife due to radionuclides and other contaminants. However, the fencing around the tailings impoundment will exclude large animals and the acidic nature of the pond (pH of about 1.8 to 2.0) will make it unsuitable for most aquatic organisms and subsequently an unattractive feeding place for waterfowl. However, a few waterfowl or other birds may rest on the impoundment for a short time during migration. Following termination of the mill operations, the tailings disposal area would remain fenced until released from its status as a restricted area and will not be used for any purpose other than tailings stabilization and reclamation.

Increased human population associated with construction and operation of the mill will adversely affect most wildlife in the area. Greater human population will cause an expansion of municipalities for commercial, residential, and recreational purposes. Although some species may benefit from large human populations, most of the larger mammals and predators 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] that have documented distributions in San Juan County[13] are expected to occur on the facility site or immediate vicinity. 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. The black-footed ferret (*Mustela nigripes*), which once ranged in the vicinity of the site, has not been sighted in Utah since 1952,[15] and the Utah Division of Wildlife Resources feels that the presence of this species is highly unlikely (ER, Sect. 2.8.2.2). Therefore, construction and operation of the proposed mill is not expected to impact any endangered species.

4.6.2 Aquatic

The operation of the uranium mill will not entail direct discharge into any surface waters. As the construction and operation of the proposed uranium mill should not affect local surface waters to any significant extent, the staff does not predict any adverse impacts on aquatic biota.

4.7 RADIOLOGICAL IMPACTS

4.7.1 Introduction

The primary sources of radiological impact to the environment in the vicinity of the proposed White Mesa 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 236 mrem/yr (see Section 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 White Mesa mill site. This analysis is primarily based on the estimated annual releases of radioactive materials given in Table 3.3 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 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 (see Figure 4.1). Consideration has also been given to the occupational exposure received by mill employees, and radiation exposure of biota other than 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.

There will be no planned or routine releases of radioactive waste materials directly into surface waters. While 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 perform 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 White Mesa 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).

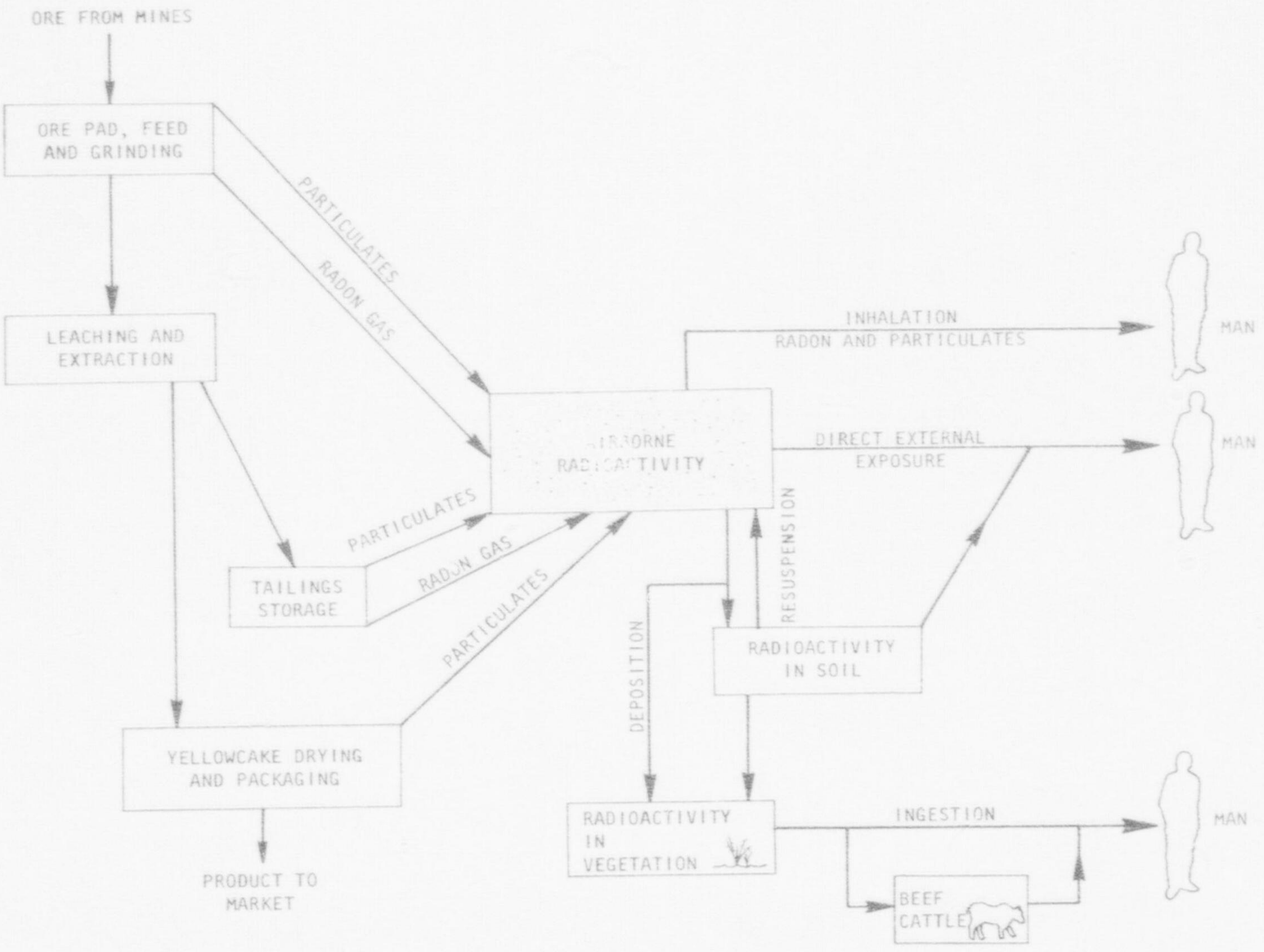

Fig. 4.1. Sources of Radioactive Effluents from the Mill and Exposure Pathways to Man.

4.7.3 Radiation dose commitments to individuals

The nearest known resident lives approximately 4.5 km (2.8 mi) NNE of the proposed location of the mill building (ER, Plate 2.2-1). A mobile home about 3.2 km (2.0 mi) north of the mill was occupied until recently but has since been moved. The nearest residence in the direction of the prevailing winds is located about 6.4 km (4.0 mi) to the south. Nearby population groups include the community of White Mesa, about 8.0 km (5.0 mi) to the SW with a population of about 300, and the city of Blanding, 9.6 km (6.0 mi) to the NNE with a population of about 3300 (ER, Plate 2.2-1).

The nearest potential residence locations are along the northern border of the site, about 1.9 km (1.2 mi) from the mill building. Substantial tracts of privately held acreage exist in this area. All other lands abutting the mill site to the east, south, and west are the property of Energy Fuels Nuclear, Inc. or the U.S. Bureau of Land Management. The area immediately to the north of the mill site, although suitable for residential structures, presently is believed to be used only for the grazing of meat animals (beef). It is assumed that meat animals could be grazed along the northern site boundary and eaten by the nearest actual residents. The calculated ingestion doses for consumption of beef grazed at this location are comparable to those calculated for other locations around the site at which grazing could be expected to occur.

Table 4.6 presents a summary of the individual dose commitments calculated for the nearest actual residence, the nearest actual residence in the prevailing wind direction, and the nearest potential residence. At each of these three locations it is assumed that individuals ingest meat grown at the location of the nearest potential residence, along the northern site boundary. Table 4.6 also presents the inhalation and external doses calculated for the community of White Mesa and the city of Blanding.

4.7.4 Radiation dose commitments to populations

The annual doses to the population estimated to exist within 80 km (50 mi) of the site in the year 2000 are presented in Table 4.7 along with estimated annual doses to the same population from natural background radiation sources. Population dose commitments resulting from the operation of the White Mesa uranium mill represent less than 1% 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 White Mesa site are small fractions of those arising from naturally occurring background radiation (see Table 4.7). They are also small when compared to the average medical and dental X-ray exposures currently being received by the public for diagnostic purposes.

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 4.8 provides a comparison of maximum calculated annual dose commitments with the radiation exposure limits of 10 CFR 20 and 40 CFR 190.

As indicated in Table 4.8, radiation dose commitments to the bone of an individual living at the nearest potential residence could exceed the 25 mrem/yr EPA limit by about 20%. The staff has also determined that bone doses from the ingestion of meat from animals grazed to the south of the present site would be in excess of 40 CFR 190 limits; however, the applicant is currently negotiating to obtain this land and would be able to restrict access by grazing cattle.[7] Meat and/or vegetable ingestion doses could exceed 40 CFR 190 limits at locations to the east if dusting of tailings sands is not controlled adequately. Therefore, the staff would require the applicant to:

1) implement the environmental monitoring program outlined in Table 6.2;

2) perform and document an annual land use survey to determine changes in land use, e.g., for grazing, residence, and well locations; and

3) implement an interim stabilization program for all exposed tailings areas to minimize the blowing of tailings. The program would include a weekly, documented inspection to assess the effectiveness of the control methods being used.

Table 4.6 Annual dose commitments to individuals from radioactive releases due to operation of the White Mesa Uranium Mill

Location	Exposure Pathway	Annual dose commitment, mrem: Total Body	Bone	Lung	Bronchial Epithelium[a]
Nearest residence, 4.5 km (2.8 mi) NNE	Inhalation	3.9×10^{-2}	1.0	8.9×10^{-1}	1.9×10^{1}
	External from cloud	1.2×10^{-1}	1.2×10^{-1}	1.2×10^{-1}	—
	External from ground	8.7×10^{-1}	8.7×10^{-1}	8.7×10^{-1}	—
	Vegetable Ingestion	3.4×10^{-1}	4.0	3.4×10^{-1}	—
	Meat Ingestion	1.0	1.0×10^{1}	1.0	
	Total	2.4	1.6×10^{1}	3.2	1.9×10^{1}
Nearest residence in prevailing wind direction, 6.4 km (4.0 mi) S	Inhalation	1.3×10^{-2}	3.4×10^{-1}	5.5×10^{-1}	2.5×10^{1}
	External from cloud	2.2×10^{-1}	2.2×10^{-1}	2.2×10^{-1}	—
	External from ground	2.4×10^{-1}	2.4×10^{-1}	2.4×10^{-1}	—
	Vegetable ingestion	9.4×10^{-2}	1.1	9.4×10^{-2}	—
	Meat ingestion	1.0	1.0×10^{1}	1.0	—
	Total	1.6	1.2×10^{1}	2.1	2.5×10^{1}
Nearest potential residence, 1.9 km (1.2 mi) N	Inhalation	1.3×10^{-1}	3.5	4.1	7.8×10^{1}
	External from cloud	2.0×10^{-1}	2.0×10^{-1}	2.0×10^{-1}	—
	External from ground	3.2	3.2	3.2	—
	Vegetable ingestion	1.3	1.5×10^{1}	1.3	—
	Meat ingestion	1.0	1.0×10^{1}	1.0	—
	Total	5.8	3.2×10^{1}	9.8	7.8×10^{1}
Community of White Mesa, 8.0 km (5.0 mi) SW	Inhalation	2.3×10^{-2}	6.0×10^{-1}	6.0×10^{-1}	2.0×10^{1}
	External from cloud	1.9×10^{-1}	1.9×10^{-1}	1.9×10^{-1}	—
	External from ground	4.6×10^{-1}	4.6×10^{-1}	4.6×10^{-1}	—
	Total	6.7×10^{-1}	1.3	1.3	2.0×10^{1}
City of Blanding 9.6 km (6.0 mi) NNE	Inhalation	7.4×10^{-3}	2.0×10^{-1}	2.4×10^{-1}	8.1
	External from cloud	9.0×10^{-2}	9.0×10^{-2}	9.0×10^{-2}	—
	External from ground	1.3×10^{-1}	1.3×10^{-1}	1.3×10^{-1}	—
	Total	2.3×10^{-1}	4.2×10^{-1}	4.6×10^{-1}	8.1

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

Table 4.7 Annual Population Dose Commitments Within 80 km (50 mi)

Organ	Population doses, man-rem/yr[a]: Plant Effluents	Natural Background[b]
Total body	3.4	7,500
Bone	6.4	7,500
Lung	7.1	7,500
Bronchial epithelium	132.	23,000

a Based on a projected year-2000 population of 46,500.

b The estimated natural background dose rate to the whole body is 161 mrem/yr. The bronchial epithelium dose from naturally occurring Rn-222 is assumed to be 500 mrem/yr (see Section 2.10).

Table 4.8 Comparison of annual dose commitments to individuals with applicable radiation protection standards

Location	Organ	Estimated dose, mrem/yr	Applicable limit, mrem/yr	Fraction of limit
I. Nearest actual residence, 4.5 km (2.8 mi) NNE	Present NRC regulation (10 CFR Part 20)			
	Total body	2.4	500	0.005
	Bone	16.	3000	0.005
	Lung	3.2	1500	0.002
	Bronchial epithelium	1.5×10^{-4} WL[a]	0.033 WL[a]	0.005
	Future EPA standard (40 CFR Part 190)[b]			
	Total body	1.4	25	0.06
	Bone	15.	25	0.6
	Lung	2.2	25	0.09
	Bronchial epithelium	19.	not limited	-
II. Nearest potential residence, 1.9 km (1.2 mi) N	Present NRC regulation (10 CFR Part 20)			
	Total body	5.8	500	0.01
	Bone	32.	3000	0.01
	Lung	9.8	1500	0.007
	Bronchial epithelium	3.6×10^{-4} WL[a]	0.033 WL[a]	0.01
	Future EPA standard (40 CFR Part 190)[b]			
	Total body	2.5	25	0.1
	Bone	29.	25	1.2
	Lung	6.5	25	0.3
	Bronchial epithelium	78.	not limited	-

[a]Radiation standards for exposure to Rn-222 and its short-lived daughters are expressed in terms of Working Level (WL) concentrations. One WL is the amount of any combination of short-lived radioactive daughters of Rn-222 in 1 liter of air that will release 1.3×10^5 MeV of alpha energy during their decay to Pb-210.

[b]Doses computed for evaluation of compliance with 40 CFR 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. 40 CFR 190 limits do not apply to Rn-222 or its radioactive daughters.

4.7.6 Occupational Dose

Uranium mills are designed and built so as 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[21] 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 20 and that external exposures are normally less than 25% of 10 CFR 20 limits.[21,22] A recent review[39] 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 yellowcake, 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.[23-30] 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

4.8.1 Demography and settlement pattern

4.8.1.1 Population increase from direct employment

A peak employment of 250 construction workers will be reached in August 1979 and maintained for three months. Over a 12-month period, there will be an average of 175 employees. Mill operations are expected to employ 85 workers (Table 4.9). If 60% of the construction workers relocate from outside the project area,[31] an average of 105 workers and a peak of 150 workers will move into the region. If construction workers are accompanied by 0.9 nonworking dependents,[32] the population increase attributable to construction will be as shown in Table 4.10.

During operations, 75% of the jobs available could be filled from the "local" labor pool. Up to 30% of these workers may relocate closer to their new place of employment (Vice-President for Operations, Energy Fuels Nuclear, Inc., personal communication, July 12, 1978). In San Juan County, there are 2.1 nonworking dependents for every worker.[32] If this relationship holds for relocations, the population may grow by 120 individuals.

4.8.1.2 Population increase from indirect employment

Indirect employment is the total of new jobs created in industries that supply factors of production and that produce the goods and services demanded by project workers.[32] Between 0.3 and 0.9 indirect employees are generally needed for each construction worker during the construction phase of an energy project.[33] Because there is normally a lag between the creation of direct jobs and the indirect jobs they induce, it is likely that during the relatively short construction period in question indirect employment will stay at the low end of the scale and not rise above 100 (Table 4.9).

Because there are many clerical, sales, and service workers seeking employment in the Blanding area (Sect. 2.4.2.2), many of the indirect jobs created by mill construction may be filled from the local area. At most, the same proportion of workers will move in as is expected in the case of mill operators (47 employees or less). Including nonworking dependents, 146 persons will move into the area (Table 4.10).

During mill operation, the proportion of indirect to direct employment will increase. To operate at capacity, the White Mesa uranium mill requires 1800 MT (2000 tons) of ore daily, which will be supplied by area mines. According to the applicant, the ore buying stations (one located at the proposed mill site and the other in Hanksville) are currently buying slightly over one-fourth of the ore the mill will consume at peak operations. This fraction means that only one-fourth of the miners that will eventually be needed to supply the mill are already employed. An increase of 220-250 miners over current employment levels is expected (Table 4.9). If between one-half and two-thirds of these future jobs are filled by persons moving into the area, then about 110 to 165 miners will migrate in for a total population gain of 340 to 510, based on 2.1 nonworking dependents for every worker.

Table 4.9 Employment, White Mesa Uranium Project

	Construction		Operations
	Average	Peak	
Direct employment			
Salaried staff			25[a,b]
Construction workers	175	250	
Mill workers			85[b]
Total direct	175	250	110[b]
Indirect employment			
Salaried staff			26[a]
Mining			220–250[a]
Buying station			5[a]
Service (nonbasic)	100	100	578–626[a]
Total indirect	100	100	829–907[a]
Total employment	275	350	939–1017

[a] Represents increases over current employment.

[b] Full capacity.

Sources: ER, p. 4-13; Energy Fuels Nuclear, *Schedule of Projected Manpower Requirements;* Muril D. Vincelette, Vice President for Operations, Energy Fuels Nuclear, Inc., personal communication with Martin Schweitzer, Oak Ridge National Laboratory, July 12, 1978, and August 15, 1978, and Erik J. Stenehjem and James E. Metzger, *A Framework for Projecting Employment and Population Changes Accompanying Energy Development,* Argonne National Laboratory, Argonne, Ill., 1976.

Table 4.10. Population influx associated with the White Mesa Uranium Project

	Construction		Operations
	Average	Peak	
Direct employment			
In-moving workers	105	150	57[a]
Nonworking dependents[b]	95	135	120
Total direct	200	285	177
Indirect employment			
In-moving workers	47	47	432–587
Nonworking dependents[c]	99	99	907–1233
Total indirect	146	146	1339–1820
Total in-moving workers	152	197	489–644
Total influx	346	431	1517–1997

[a] Full capacity.

[b] To find the total number of nonworking dependents, multiply the number of construction workers and operations personnel by 0.9 and 2.1 respectively.

[c] To find the total number of nonworking dependents, multiply the number of workers by 2.1.

Sources: ER, p. 4-13; Energy Fuels Nuclear, *Schedule of Projected Manpower Requirements;* Muril D. Vincelette, Vice President for Operations, Energy Fuels Nuclear, Inc., personal communication with Martin Schweitzer, Oak Ridge National Laboratory, July 12, 1978, and Erik J. Stenehjem and James E. Metzger, *A Framework for Projecting Employment and Population Changes Accompanying Energy Development,* Argonne National Laboratory, Argonne, Ill., August 1976; and Mountain West Research, Inc., *Construction Worker Profile,* Old West Regional Commission, December 1975.

Currently, the Energy Fuels ore buying stations employ ten people. Five additional jobs at the Blanding station when mill operations start will mean an increase of five in area population. The 21 workers employed by Energy Fuels in ore exploration is not expected to change.

In San Juan County's economy, there are 1.6 nonbasic jobs for each basic job. The basic sector brings in revenues from outside the immediate area. The nonbasic sector provides goods and services in response to local demand. Because the White Mesa project is expected to add 361 to 391 new basic jobs to the area economy, it can be predicted that 578 to 626 new jobs will be created in the nonbasic sector. If the proportion of in-migrants taking nonbasic jobs is approximately the same as described earlier, roughly 300 to 400 jobs in the nonbasic sector will be taken by persons moving into the area, causing a population increase of 930 to 1240.

4.8.1.3 Total population increase

About 120 hourly workers and staff will be involved in mill operations. Nearly 60 of these employees should be new to the area. Indirect jobs stimulated by the mill are expected to be in the range of 830 to 910. The total population increase would range from approximately 1500 to 2000 (Table 4.10).

4.8.1.4 Distribution of new residents

The 431 new residents expected as a result of construction of the White Mesa Uranium Project represents 3.3% of the San Juan County population. Their settlement pattern will be determined by a number of factors including the availability of housing, public services, and amenities in the surrounding communities and the proximity of those communities to the mill site. Blanding, Monticello, and Bluff are all within 48 km (30 miles) of the proposed mill and are capable of absorbing the projected population growth.

Because it is closest to the site, Blanding is likely to experience more in-migration than the other two communities.

The population influx during the operations period will be much greater than that associated with construction. The 1500-2000 new residents expected represents 11.5 to 15.4% of San Juan County's current population.

The majority of mill-related personnel are expected to reside in the three above-named communities; however, since the mining operations selling ore to the applicant are geographically dispersed, some in-migrating miners will locate in the outlying rural areas.

4.8.2 Social organization

Studies of other areas impacted by energy projects indicate that rapid population growth can lead to inadequacies in the provision of housing and essential public services, such as water and sewage treatment, education, and health care. An annual growth rate of 15% is often cited as the point where these problems become severe.[34] Assuming that Blanding gets 70% of the population growth induced by the White Mesa uranium mill, Monticello gets 25%, and Bluff receives 5%, none of these communities will experience even a 10% population increase in the one year construction period. However, during the three-year period from early 1980, when mill operations are scheduled to begin, through the end of 1982, when most of the direct and indirect population increases should have occurred, the number of in-migrants will be much greater (Table 4.11). If the total population influx reaches 2000, Blanding's rate of growth will average nearly 15% annually over the three years in question. While Monticello and Bluff will not grow at this rate, their increases will be substantial (see Sect. 2.4.1.2).

Balanced against this rapid growth are plans for providing additional housing and public services in the impacted communities. Action from both the public and private sector are anticipated, which will help reduce the adverse effects that can result from unmanaged growth (Sects. 4.8.2.1 and 4.8.2.2).

4.8.2.1 Housing

During the construction period, 197 workers are expected to relocate in the project area. It is likely that a number of these workers will share accommodations; therefore, between 145 and 197 new housing units will be demanded during this time.

Table 4.11. Mill-induced population influx for the communities of Blanding, Monticello, and Bluff, assuming a 70-25-5% split of the in-moving populatior

	Blanding	Monticello	Bluff
Population in 1977	3075	2208	280
Peak construction-period influx[a]	302	108	22
Peak construction-period influx as a percentage of 1977 population	9.8%	4.9%	7.7%
Operations-period influx[b]	1050–1400	375–500	75–100
Operations-period influx as a percentage of 1977 population	34.1–45.5%	17.0–22.6%	26.8–35.7%

[a]Peak construction-period influx is projected to be 431.
[b]Operations-period influx is projected to be approximately 1500–2000.

In the operations period, 489 to 644 new jobs are expected to be filled by in-migrants. Because these workers are much more likely to become permanent members of the community and to relocate with their families, it will be assumed that one housing unit is required for each of them.

Table 4.11 projects the future growth of each of these communities using previous assumptions (Sect. 4.8.2). If this distribution is used as a guide, roughly 100 to 140 housing units will be needed in Blanding, 35 to 50 in Monticello, and 7 to 10 in Bluff during the construction period. During operations, Blanding will need 340 to 450 units, Monticello 120 to 160, and Bluff 25 to 30 (Table 4.12). Although no new workers are anticipated at the Hanksville ore buying station, mining activity in the area may create some demand for additional housing in the town of Hanksville. Under current conditions this would not be easily accommodated although future improvements in the local water system (ER, p. 2-74) may make residential expansion possible.

Blanding

In August 1978, plans for a 117-space mobile home park, scheduled to be ready for occupancy by February 1979 were approved in a newly annexed portion of the city. At the same time, a 242-unit subdivision was approved in another newly annexed section; construction is scheduled to begin in January 1979.

Table 4.12. Housing demand and supply in Blanding, Monticello, and Bluff caused by the White Mesa Uranium Project

City	Construction period					Operations period				
	Demand[a]	Supply				Demand[a]	Supply[c]			
		Existing[b]	In process	Possible	Total		Existing[b]	In process	Possible	Total
Blanding	100–140	25	149		174	340–450	25	391	200	616
Monticello	35–40	35	23		58	120–160	35	23	200	258
Bluff	7–10	20			20	25–30	20		0–70	20–90
Total	142–200	80	172		252	485–640	80	414	400–470	844–964

[a]Assumes a 70-25-5% split of the in-moving population between Blanding, Monticello, and Bluff.
[b]As of August 1, 1978.
[c]Operations-period supply includes those units developed during the construction period.
Sources: ER, pp. 4-18 and 2-56, and Philip D. Taylor, President, Taylor & Associates, August 17, 1978, Terry Palmer, Palmer Builders, July 13, 1978; Richard Terry, Monticello City Manager, August 4, 1978, private communications with Martin Schweitzer, Oak Ridge National Laboratory.

The 117 mobile home spaces, combined with 25 existing spaces in Blanding (ER, p. 4-18), are sufficient to satisfy the maximum demand projected for the construction period. In addition, a 32-unit apartment complex is now in the financing stages and local builders estimate that 50 to 60 new single-family houses could be constructed annually for at least the next three years on the 200 vacant lots estimated to be available within the city limits (Palmer Builders representative, personal communication, July 13, 1978). The total number of potential additional housing units is around 600, nearly enough to absorb all mill-related growth. Counting only those units now existing or having city approval, the number is still nearly 400, mid-way between the high and low projections of Blanding's share of expected growth (Table 4.12).

Monticello

There are 35 vacancies in a local mobile home park (ER, p. 4-18), and a 23-unit apartment building is being constructed. In addition to these 58 units (more than the 35-50 needed during construction), 200 single family homes are expected to be built by 1981 (Monticello City Manager, personal communication, July 20, 1978). This quantity will be more than enough to accommodate Monticello's expected share of mill-induced growth during the operations period and indicates that this city has the potential of absorbing additional growth (Table 4.12).

Bluff

The 20 mobile home park spaces now available in Bluff (ER, p. 4-18) can accommodate twice the projected growth for the construction period and two-thirds of that expected during operations. Because the town also has 70 empty lots (ER, p. 2-56) suitable for development, it is possible that more growth than was postulated may occur here (Table 4.12).

4.8.2.2 Public services

Blanding

Population increases should not strain the existing electricity distribution or solid waste disposal systems. Streets and recreation facilities are also adequate. Water and sewage systems are adequate for the 300 new residents expected during the construction period (Blanding City Manager, personal communication, June 21, 1978), but they are not sufficient for the mill-induced newcomers. However, expansions in both water and sewer facilities, which are planned for completion by 1981, should be adequate to provide acceptable services to these in-migrants.

Additional public safety and health care services are likely to be necessitated by the operations-period population influx. Blanding has plans to add a new full-time member to the police force in fiscal year 1979 (ER, p. 2-47).

Approximately 120 new school age children are expected during the construction period.[31,35] During the operations period, 384 to 504 new students will be entering Blanding's schools.[35] In the fall of 1978, a new high school in southeastern San Juan County will relieve current overcrowding in San Juan High School and leave it approximately 100 students below capacity. The opening of a second new high school in fall 1979 in southwestern San Juan County, will leave roughly 300 vacancies in San Juan High School. Blanding's two elementary schools are currently 120 students below capacity; therefore, the influx of additional students during the construction period should not present a problem. However, the influx of 200 to 300 new elementary students during the operations period will necessitate operating at 80 to 180 students over capacity. The school district is prepared to provide new facilities as the need arises (San Juan County School District, personal communication, August 18, 1978).

Monticello

Existing solid waste disposal and recreation facilities appear adequate to accommodate the projected population influx, as does the local system of streets. Improvements in public safety and health care facilities are likely to be required. To supply future needs, the community is currently attempting to expand the city-run electricity transmission system.

The existing sewage treatment plant is currently operating at its design capacity; the growth associated with mill construction and operations would cause overloading. Improvements are being planned to allow service for 3000 residents, but completion is not anticipated until at least mid-1980. The city's share of the associated expenses will amount to roughly one-quarter million

dollars and is likely to be financed through general obligation bonds. The remainder of the required funds will come from the Federal government. Monticello's water supply system is currently operating near capacity. However, improvements to the existing system are scheduled to be completed by August 1979. Until that time, lack of water is a limitation to growth. Afterward, the system will be able to accommodate nearly 800 new people. The city's share of project expenditures will be approximately $600,000, financed by general obligation and revenue bonds (Monticello City Manager, personal communication, July 11, 1978).

Because both the elementary and the high school are operating at approximately two-thirds capacity, with room for over 300 students between them, the addition of 140 to 180 n students during the operations period should not present a problem.[35]

Bluff

Most existing public services in the town of Bluff are currently adequate to handle the limited growth anticipated. The local water system is capable of accommodating a 79% increase in usage. Sewage disposal is currently handled by individual septic tanks. Public safety, recreation, and health facilities may all require incremental improvements to keep up with rising population. Educational facilities are also more than adequate for the expected in-migration. Growth beyond that shown in Table 4.11, however, may strain existing public services and call for improvements not considered here.

4.8.2.3 Culture

A large proportion of the population of San Juan County is comprised of Mormons and Navajo Indians. Changes in the relative numbers of these two groups could alter the social climate in the area of the proposed mill.

In addition to potentially changing the racial and religious composition of the community, a substantial population influx could also create tensions between established "old-timers" and "newcomers." As area population grows, long-time residents may feel a loss of intimacy, and value conflicts may arise between those who favor a more "urban" lifestyle and those who wish to preserve a small town atmosphere.[36] However, because the greatest growth will occur during the operations period, when in-migrants are much more likely to settle permanently than during construction, it is expected that eventually a mutual accommodation of "old" and "new" values will occur.

4.8.3 Political organization

Changes in the political as well as the cultural characteristics of an area frequently accompany rapid growth. Expansion and "professionalization" of local government often occur in response to the changing size and characteristics of the population. This trend is evident in the area of the proposed White Mesa mill where the city of Blanding has recently hired a full-time city engineer in response to the accelerating growth rate (Blanding City Manager, personal communication, August 14, 1978), and Monticello anticipates the eventual need for more public employees to handle future in-migration (Monticello City Manager, personal communication, July 11, 1978).

The local power structure can also be altered by the growth associated with a project such as the White Mesa Uranium Mill. Political control may pass from the hands of established residents to those of newcomers associated directly and indirectly with mill operations.[36] As in the cultural arena, a balance is likely to be reached over time between divergent political interests.

4.8.4 Economic organization

4.8.4.1 Employment

Peak employment during the construction of the White Mesa mill is expected to be about 350; of these workers, approximately 150 are expected to come from the immediate area. During operations, between 939 and 1017 new jobs are expected to be created directly and indirectly by the mill. Roughly 300 to 500 of these jobs should be filled by area residents. At 8.?%, the

unemployment rate in San Juan County is significantly higher than the state average of 5.3% (Sect. 2.4.2.2), and it is highly probable that mill-induced employment will result in a loweri g of this figure.

4.8.4.2 Income

Of the additional 350 needed during construction, 250 will be construction workers whose wages are substantially higher than the local mean. The remaining 100 will be employed in lower-paying jobs in the nonbasic sector. During operations, nearly 40% of all new workers will be highly paid miners or mill personnel. According to the Utah State Department of Employment Security, the average monthly salary for a miner in this state is $1500 to $1833 and for a miller, $1000 to $1500.[36]

These high-paying new jobs will elevate average per capita income in San Juan County and increase the amount of money spent in the local communities. These increased expenditures may lead to the availability of a wider range of goods and services. Competition from the new, high-wage industries may also have the effect of raising salaries for other jobs.[36]

4.8.4.3 Tax revenues

During the construction period, San Juan County will continue to collect property taxes on the unimproved value of the White Mesa site (Sect. 2.4.2.2). Sales tax will also be paid on materials purchased in connection with this project. The communities of Blanding, Monticello, and Bluff each have this local option tax; outside of their boundaries the local tax goes to the county (Utah State Tax Commission representative, personal communication, August 23, 1978).

The applicant estimates that of the $18 million to be spent on equipment and supplies during construction, $432,000 in sales tax will accrue to the State, and $81,000 to the locales in which purchases are made. Of the local share, $13,500 will end up in the southeastern counties. The ore buying stations operated by Energy Fuels Nuclear, Inc., will also pay property taxes during this period.

Area mines selling ore to the applicant's ore-buying stations will be subject to as many as four different taxes. Property tax will be levied at the normal county rate on twice the value of average net proceeds plus the value of the land, if patented, and the personal property and improvements onsite (Utah State Tax Commission representative, personal communication, July 14, 1978). A 1% mine occupation tax is levied on the gross value of all ore sold, less a standard exemption. These revenues go to the State general fund. Sales tax will be paid on all purchases, and a State corporate franchise tax of 4% on net taxable income will supply monies to the State's Uniform School Fund.

Workers will be subject to Federal and State income taxes; the applicant estimates that roughly $1.3 million will go to the Federal and State governments from construction worker incomes (ER, p. 4-23). Taxes on the salaries of nonbasic employees will contribute additional income tax revenues. Workers will also pay sales tax on all purchases and ad valorem taxes on any property owned in the area. Assuming nationwide expenditure patterns, 38.3% of family income (ER, p. 5-31), $2.82 million for construction workers alone (ER, p. 4-24), will be spent locally on personal consumption expenditures.[36] Sales tax on this will amount to $112,800 for the State and $21,150 for the jurisdictions in which the purchases are made.

During operations, the mill will pay property taxes of approximately $456,000 to San Juan County (ER, p. 5-28). Two-thirds of this amount goes to the school district. Sales tax will be paid on most equipment and materials purchased but not on the raw ore to be processed (Utah State Tax Commission representative, personal communication, August 23, 1978). Finally, the Federal and State governments will levy corporate franchise and income taxes.

If mining activity increases in the area the tax base of San Juan and neighboring counties will increase, as will the revenues received by the State. Corporate-owned property would be subject to the State franchise and Federal income taxes. The ore-buying stations and independently owned mining operations would continue to pay taxes as outlined above.

San Juan County and the communities of Blanding, Monticello, and Bluff are also expected to benefit from increased property taxes due to the construction of new commercial and residential buildings and rising property values. Sales tax will be paid on roughly $4.5 million in personal consumption expenditures in the area.[36] Around $180,000 will go into the State treasury and $35,000 will be returned to the county or municipality where purchases are made.

During both construction and operations, the State of Utah receives a substantial portion of the tax revenues generated by the White Mesa mill and related activites. The State receives the entire mine occupation and corporate franchise taxes and splits personal income taxes with the Federal government. Sales tax revenues are split with local governments, with the majority of the funds being routed to the State government (Table 4.13).

Table 4.13 Taxes related to the White Mesa Uranium Project

Tax	Construction period		Operations period	
	Entity taxed	Recipient of tax	Entity taxed	Recipient of tax
Property tax	Unimproved mill site	San Juan County	White Mesa Mill	San Juan County
	Ore buying stations	San Juan and Wayne counties	Ore buying stations	San Juan and Wayne counties
	Uranium mines	San Juan and neighboring counties	Uranium mines	San Juan and neighboring counties
	Property-owning workers	San Juan County, Blanding, Monticello, and Bluff	Property-owning workers	San Juan County, Blanding, Monticello, and Bluff
Sales tax	Mill materials	Utah, San Juan County, Blanding, and Monticello	Mill supplies	Utah, San Juan County, Blanding, and Monticello
	Mine supplies	Utah, San Juan County, Blanding, and Monticello	Mine supplies	Utah, San Juan County, Blanding, and Monticello
	Worker purchases	Utah, San Juan County, Blanding, and Monticello	Worker purchases	Utah, San Juan County, Blanding, and Monticello
Mine occupation tax	Uranium mines	Utah	Uranium mines	Utah
Corporate franchise tax	Some uranium mines	Utah	Some uranium mines and White Mesa mill	Utah
Personal income tax	All workers	Utah, United States	All workers	Utah, United States

Both San Juan County and its municipalities will receive property and sales tax revenues from the mill and related activities (Table 4.13). Most purchases are likely to take place in Blanding and Monticello, which will receive the local option sales tax. During the operations period, these two communities may share as much as $35,000 annually from personal expenditures, which is relatively minor compared to the $456,000 in property taxes which San Juan County will receive from the mill itself. The ad valorem taxes paid to the county by area mines could also be substantial when mining activity is at its peak. Increased property tax revenues will accrue to the cities of Blanding, Monticello, and Bluff from new houses and businesses, but these added revenues will be significantly less than the amounts received by San Juan County.

4.8.4.4 Public expenditures

Financing improvements in public services needed as a result of rapid population growth can place a strain on local governments. Estimates of the required capital investment range from $1000 (ER, p. 5-27) to $5000 for each additional resident.[37] For the 1500 to 2000 in-movers expected as a result of operating the White Mesa mill, this amount would be approximately $1.5 and $10 million. As much as another $1000 per person should be expected for operating costs,[37] adding an extra $1.5 to $2 million annually to the expenditures of local governments in the vicinity of the proposed mill. The capital and operating expenses listed above would be shared by San Juan County and the communities of Blanding, Monticello, and Bluff.

Blanding and Monticello are expected to need improvements in their water and sewage systems as well as in their health and public safety services. Blanding will probably require additional education facilities, and Monticello will need an expanded electricity distribution system. The majority of the costs associated with these services will be borne by the impacted municipalities themselves.

Although the largest share of the new tax revenues generated by the White Mesa project will accrue to San Juan County, the communities of Blanding, Monticello, and Bluff will receive some of these monies. In addition, other sources are expected to provide funds for needed public service improvements. Capital outlays for water and sewage system expansion are expected to include Federal and State funds (Sect. 4.8.2.2), and tap fees will aid in repaying local water and sewer improvement bonds.[39] It is the judgment of the staff that, given all the revenue sources available, the impacted communities will be able to provide services for the expected population influx without long-range fiscal difficulties.

4.8.5 Transportation

Both heavy truck and automobile traffic will increase in the area as a result of the proposed White Mesa Uranium Project; therefore, traffic congestion, road wear, road noise, and traffic accidents will also increase.

During the peak construction period, 250 workers are expected to drive to and from the mill site each day. Because most workers are expected to live north of the site in the cities of Blanding and Monticello, traffic will increase substantially on U.S. Route 163. The 100 additional nonbasic workers expected during this time will also add to traffic on area roads, although a large portion of these employees are likely to live and work in the same community. Non-work trips will also increase on area roads, as will traffic within the communities of Blanding, Monticello, and Bluff.

During the operations period, the number of automobile trips between Blanding and the mill site will decrease, but auto traffic in the surrounding area will rise. About 85 hourly mill employees plus 20 salaried staff and 10 buying station employees will travel to the White Mesa mill daily along U.S. Highway 163. In addition, approximately 220-250 new miners will be employed in the area and their trips between home and work will considerably increase traffic volumes. Finally, about 600 new workers in the nonbasic sector will add to local traffic, even though many will reside in their community of employment.

Heavy truck traffic will also increase substantially in the project area. During the operations period, when area mining is at expected peak levels, approximately 53 round trips per day will be made between area mines and the Blanding buying station. Another 17 round trips between other mines and the Hanksville station and an additional 15 round trips between the Hanksville and Blanding stations will occur each day (ER, p. 5-34).

The heaviest truck traffic will take place on U.S. Route 163 and Utah Route 95, but U.S. Route 666 and Utah routes 262, 276, 263, and 24 will also be affected. In addition to these paved roads, secondary roads are also expected to handle up to 15% of total truck traffic (ER, p. 5-34).

4.8.6 Impact mitigation

Energy Fuels Nuclear, Inc., has expressed concern about maintaining a stable work force and has instituted programs to mitigate potential negative impacts on the project area. The applicant has cooperated with a Denver-based developer to provide additional housing for expected in-migrants in Blanding. Preliminary plan approval was received in August 1978 for a 117-space mobile home park and a 242-unit single family subdivision (Sect. 4.8.2.1) on land that was purchased by Energy Fuels Nuclear for resale to the developer (Vice-President for Operations, Energy Fuels Nuclear, Inc., personal communication, June 27, 1978). These dwelling units will satisfy a large portion of the total mill-induced housing need. Company benefits, such as an annual cash bonus and profit-sharing plan, encourage job stability.

Public action is also being planned to mitigate prospective social impacts at the area of the proposed mill. Section 4.8.2.2 details the steps being taken by local governments to provide additional public services to meet expected population increases.

Additional actions can be taken to further mitigate potential mill-induced impacts. Hiring unemployed area residents can keep the total population influx down and simultaneously reduce local unemployment. Negative impacts can be diminished by ensuring that planned improvements to public services are made before anticipated growth occurs. Early solicitation of Federal and

State aid and early issuance of local bonds can provide funds for needed expansions before existing services become inadequate.

Both San Juan County and its municipalities have the fiscal responsibility of providing needed services for new residents. Neither these costs nor the tax revenues generated by the White Mesa mill and related activities, however, are evenly distributed. The communities of Blanding and Monticello face substantial capital and operating costs for providing for new residents. A fraction of the additional taxes accruing to San Juan County and the State of Utah could be distributed by means of a revenue-sharing arrangement based on the distribution of the costs of new required services.

Although it is certain that residential and commercial growth will occur in the communities of Blanding, Monticello, and Bluff, the form of this growth is difficult to predict. Advance land-use planning should ensure that the spatial structure of eventual growth is compatible with community goals.

4.8.7 Conclusions

Both positive and negative socioeconomic impacts are probable as a result of the proposed White Mesa Uranium Project. The reduced unemployment, higher per capita income, increased tax base, and greater availability of goods and services, all of which are likely to accompany the mill and its related activities, could be considered benefits for the project area. On the negative side, public service expenditures will rise, existing cultural and political balances may be changed, and road traffic and associated impacts will increase as a result of increased road use. Although most project-related socioeconomic impacts can be mitigated, the distribution of impacts and responsibility for mitigation of the impacts may not coincide. The importance of a coordinated, joint planning effort by incoming industrial developers and local and state governments should be emphasized in order to mitigate some of the adverse impacts of the rapid population change expected in the Blanding area. The staff has concluded that the potential benefits of the proposed project outweigh the asscciated costs.

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5. ENVIRONMENTAL EFFECTS OF ACCIDENTS

The occurrence of accidents related to operation of the White Mesa mill will be minimized through the proper design, manufacture, and operation of the 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, Energy Fuels Nuclear, Inc., 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, have been 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 postulated accidents involving radioactive materials 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 to 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 products.* The quantities of materials handled, on the other hand, are relatively large: 773 metric tons (MT) of yellow cake per year, representing $\approx$472 Ci of radioactivity. To be of concern, these very low specific activities require the release of exceedingly large quantities of materials; driving forces for such releases will not exist at the proposed White Mesa mill.

Guidelines have not been published for the consideration of accidents at 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).

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*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 include failure of the air cleaning system serving the concentrate drying and packaging area, a fire or explosion in the solvent extraction circuit, and an explosion in the yellow cake dryer. Large releases include a major tornado.

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 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 operation, 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 of the occurrence of similar accidents 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 offsite release of contamination and that 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

The following accidents, due to human error or equipment failure, would not result in the release of radioactive materials 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 uranium (in the liquid phase) 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 75.3 MT (83.3 tons) of solids per hour and approximately 76.1 m^3 [75.95 MT (84.02 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 tailing retention area.

5.1.2 Small releases

The following accidents, due to human 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 safeguard designs, this type of accident is unlikely to occur or go undetected. loss of water pressure to the scrubber or the failure of the fan drive would sound an alarm. In the event of electrical or mechanical failure, however, it was estimated that approximately 14.83 kg (27.97 lb) of U_3O_8 would be lost from the stack over an 8-hr shift. 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 [4.8 km (3 miles) from the point of release] were as follows: total-body, 0.0009 millirem; bone, 0.026 millirem; lung, 0.32 millirem; and kidney, 0.008 millirem. The maximum dose commitments to the potential nearest resident [1.6 km (1 mile) from point of release] were as follows: total-body, 0.009 millirem; bone, 0.25 millirem; lung, 3.0 millirems; and kidney, 0.072 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 metric 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 6×10^{-3} per year.

In the event of a major fire, it is conservatively assumed from previous estimates that 1% of the maximum uranium inventory, or approximately 4.5 kg (10 lb), would be released into the environment.[5,6] 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 [4.8 km (3 miles) from point of release] were total-body, 0.0004 millirem; bone, 0.01 millirem; lung, 0.122 millirem; and kidney, 0.003 millirem. The maximum dose commitments to the potential nearest resident [1.6 km (1 mile) from point of release] were total-body, 0.005 millirem; bone, 0.15 millirem; lung, 1.8 millirem; and kidney, 0.04 millirem.

5.1.3 Large releases

Incidents that might release large quantities of radioactive materials to the environment compared with annual releases from normal operations are considered in this section. 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 in the 1° square in which the White Mesa mill is located is negligible. Using closest available data, the probability is approximately 8×10^{-5} per year.[7] The area is categorized as region 3 in relative tornado intensity[8] [i.e., for a "typical" tornado, the wind speed is 385 km/hr (239 mph/hr) of which 305 km/hr (190 mph/hr) is rotational and 79 km/hr (49 mph/hr) 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 could be done 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 45 MT of product may be accumulated prior to shipment, it is assumed that the tornado lifts 4550 kg (10,031 lb) of yellow cake.

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 it disperses through an arc of 45°. Due to 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 1.1×10^{-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 lungs.

5.1.3.2 <u>Tailings dam failure</u>

Because of the multiple cell design (Sect. 3.2.4.7; Fig. 3.4), the short period of cell use and the low head [<9 m (30 ft)], a large release of tailings and tailings fluid is not credible. Small releases would be retained by downstream catchment ponds.

5.2 NONRADIOLOGICAL ACCIDENTS

The potential for environmental effects from accidents involving nonradioactive materials at the White Mesa mill 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. Because the vapors are ultimately discharged to the atmosphere in any case, such a failure would have no effect on the environment.

A number of chemical reagents used in the process will be stored in relatively large quantities on the site. Minor leaks and spillage of reagents will be captured in sumps and returned to the mill circuit. Major spills could flow across the mill site and enter the drainage diversion ditch protecting the tailings impoundment. The staff recommends either the construction of dikes around storage tanks or the construction of a catchment basin below the mill for any major spills. Spillage in the mill will be washed down and pumped back into the mill circuit.

The only chemical that might seriously affect the environment is ammonia. A break in the external piping of the anhydrous ammonia tank would not result in a release, because, upon a drop in pressure, an excess flow valve would automatically close, thus preventing any loss. The line carrying ammonia to the storage tank from the tank truck possibly could be ruptured, in which case the release rate would be limited to 100 g/sec of the vapor.[10] Beyond a distance of 10 km (6 miles), the resulting concentration would be below the 600 $\mu g/m^3$ short-term air quality standard derived from State of Colorado regulations, the most restrictive current regulation.[11] 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 would not be noticeable by offsite residents; these concentrations would pose no health risk because they would be less than the 69,000-$\mu g/m^3$ limit for prolonged human exposure.[12] Thus, the released ammonia would not be noticed by offsite residents and would pose no health risk to the environment.

The solvent extraction and dryer units in the vanadium circuit will be similar to the corresponding units in the uranium circuit with respect to fire and explosion potential (Sect. 5.1). Vanadium pentoxide (V_2O_5) and/or organic complexes of vanadium would be released as would very minor amounts of thorium-230 and uranium, which may also be present in the organic solvent. Thorough washing of contaminated areas would minimize the risk to mill employees. The general public should receive no significant health effects from accidents in the vanadium circuit.

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 conceptualized 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 White Mesa mill capacity of 618,200 MT (680,000 tons) of ore annually and a yellow cake yield of 773 MT (850 tons), an average of approximately 48 such shipments are required annually.

From published accident statistics,[13,14] 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 event. 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 or 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 0.13.

The ability of the materials and structures in the shipping package to resist the combined physical forces arising from impact, puncture, crushing, vibration, and fire depends on the magnitude of the forces. 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 classified accidents into eight categories, depending upon the combined stresses of impact, puncture, crushing, and fire.[15] 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 5.1. To assess the risk of a transportation accident, the fraction of radioactive material released in an accident of a given severity must be known. Two models are postulated for this analysis, and the fractional releases for each model are shown in Columns 3 and 4 of Table 5.1. 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.

Table 5.1. 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).

Model I and Model II estimate the quantity of yellow cake released to the atmosphere in the event of a truck accident 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 several years of actual laboratory and field measurements have been developed.[14] 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 m/sec,

t = the duration of the release, in hours.

In this expression, the first term represents the initial "puff" immediately airborne when the container is 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,[16] 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 have been 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. The consequence for the accident area, where the population density is estimated to be 2.13 people per square mile, would be a 50-year dose commitment of 0.146 man-rem, which can be compared to a 50-year integrated lung dose of 19 man-rems from the natural background.

The applicant will submit 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

Hanksville and Blanding are ore buying stations servicing small- and intermediate-sized mines throughout southeastern Utah and southwestern Colorado. Because of the small sizes of the mines, shipments of ore will be sporadic; therefore, the average shipping distance for the ore will vary throughout the life of the project. The applicant estimates the radii of the Hanksville and Blanding buying station service areas to be 160 km (100 miles) and 201 km (125 miles) respectively. Ore collected at the Hanksville station will be shipped an additional 262 km (163 miles) to the mill at Blanding. Based on projected capacities of the two ore buying stations, approximately 25% of the total ore requirements would be supplied by the Hanksville station. On this basis the ore will be shipped an average of 258 km (160 miles). This value is an upper limit because most of the mines will be well within the service areas. To deliver 618,200 MT (680,000 tons) of ore in trucks with a 30-ton capacity would require 22,670 trips per year, or a total of 5.84×10^6 vehicle-km (3.63×10^6 vehicle-miles). For the accident probability cited in the previous section, 1.0×10^{-6} to 1.6×10^{-6} accidents per kilometer (1.6×10^{-6} to 2.6×10^{-6} per mile), accidents involving ore trucks would occur at the rate of 7.6 per year. However, because of the low specific activity of the ore and the ease with which the contaminant can be removed, the radiological impact is considered to be insignificant.

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. Approximately 17 shipments of anhydrous ammonia will be made annually in 18 MT (20-ton) loads from a supplier located approximately 300 km (200 miles) from the mill.

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

The annual U.S. production of anhydrous ammonia shipped in that form is approximately 6.9×10^6 MT (7.6×10^6 tons). About 26% of the shipments are made by truck (the remainder by rail, pipeline, and barge). If the average truck shipment is 19 MT (21 tons), the 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)], occurred in 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 near the White Mesa mill because of the relatively low population density. Nevertheless, if this estimate is used, the likelihood of an injury to the general public resulting from shipments of ammonia to the mill is predicted to be roughly 1.6×10^{-3} per year.

REFERENCES FOR SECTION 5

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15. U.S. Nuclear Regulatory Commission, *Final Environmental Statement on Transportation of Radioactive Materials by Air and Other Modes*, Report NUREG-0170, February 1977 (draft).

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

6. MONITORING PROGRAMS

6.1 AIR QUALITY

Particulate matter, measured by dustfall samplers, and sulfation rates, measured by lead dioxide plates, were monitored at four locations on the project site for one year beginning in March 1977. Beginning in October 1977, total suspended particulates were measured for five months at one location by a high-volume air sampler. The ore buying station located on the project site (Fig. 2.10) began operation in May 1977.

An estimate of SO_2 concentrations (ppm) was obtained by multiplying sulfation plate data (milligrams per 100 cm^2 per day) by 0.03.[2] In addition to the onsite monitoring, the Utah Bureau of Air Quality operates a monitoring station for suspended particulates and sulfur dioxide approximately 106 km (66 miles) to the southwest, at Bull Frog Marina. The applicant will be required to conduct a monitoring program to collect onsite meteorological data, e.g., wind speed and direction at one hour intervals, the results of which will aid in the determination of compliance with 40 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 recommend 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 published reports (ER, Sect. 13), discussions with personnel of various Federal, State, and local offices, and onsite visits. The staff would 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 Archeological Resources

The existing condition of the site was determined as described in Sect. 2.5.2. Additional monitoring, will be performed as described in Sect. 4.2.2.

6.2.2 Reclamation

Reclamation plans are in accordance with the regulations of the Utah Division of Oil, Gas and mining.[1,2] The vegetation on reclaimed areas will be monitored and maintained until stand establishment and perpetuation is assured.[2] In accordance with the State of Utah Division of Oil, Gas, and Mining (Reclamation Regulation, Rule M-10), the 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.[3]

In addition, the applicant states that aerial photographs will be taken every third year to monitor the progress of reclamation efforts.[2]

The staff feels that the applicant's revegetation procedures and monitoring programs are adequate to ensure successful reclamation. Sufficient records must be maintained by the applicant to furnish evidence of compliance with all monitoring. The applicant will file a performance bond with the State of Utah to ensure performance of land reclamation.[4]

6.3 WATER

6.3.1 Surface water

Quarterly monitoring of surface-water quality will continue throughout the life of the project. Sample locations are described in Table 2.21 and Fig. 2.5, and the chemical and physical parameters to be measured are given in Table 2.20. Because of the temporary nature of many of the watercourses in the site vicinity, it is recommended that the applicant take advantage of seasonal rainfall and snowmelt in scheduling the collection of water samples.

6.3.2 Groundwater

The applicant has supplied chemical constituent data for one sample from each of two abandoned stock wells on the project site. Water from these wells (G6R and G7R on Fig. 2.5), completed in the Dakota Sandstone, is of poor quality. Total dissolved solids are in excess of 2000 ppm, which would have adverse effects on many crops. Total sulfate is in excess of 1300 ppm compared with an acceptable value of 250 ppm; dissolved iron is in excess of 3 ppm compared with an acceptable value of 0.05 ppm; and lead is in excess of 0.12 ppm compared with an acceptable value of 0.05 ppm.[5]

Because the available groundwater data cannot be presumed to represent background conditions, additional sampling in accordance with Table 6.1 will be required. The applicant will be required to monitor the groundwater from wells installed on the sides of each tailings cell and from a well installed centrally on each tailings cell embankment to detect potential groundwater contamination (as discussed in Sect. 4.3.2.2) until reclamation is completed. The applicant is also required to submit a plan to mitigate such contamination if observed.

6.4 SOILS

During September 1977, an existing soil survey of the site was field-verified by Lowell Woodward of Provo, Utah (retired USDA Soil Conservation Service scientist), and a soil scientist for the applicant's consultant (ER, Sect. 6.1.4.1). At least one soil profile for each mapping unit was located and sampled. Soil analyses for potential uses in reclamation operations included contents and characteristics such as texture, water-holding capacity, saturation percentage, pH, lime percentage, gypsum, electrical conductivity, exchangeable sodium percentage, sodium adsorption ratio, organic carbon, cation exchange capacity, boron, selenium and available phosphates, potassium, and nitrate/nitrogen (ER, Sect. 6.1.4.1).

6.5 BIOTA

6.5.1 Terrestrial

Plant communities at the project site were mapped by aerial photographs and field verification (ER, Sect. 6.1.4.3). Vegetation on the site was surveyed during the spring and summer of 1977 (Fig. 6.1). Five 1.0-m^2 quadrats were placed every 10 m along 100-m transects. The number of transects varied depending upon the size and homogeneity of the community. The larger and more diverse communities had the greatest number of transects. Species collected were tentatively identified in the field and later verified at the Rocky Mountain Herbarium of the University of Wyoming. The density of each species was determined by counting the number of individual plants in each quadrat. The percentage of cover for each community was estimated visually within each quadrat, and all quadrats were then summed and divided by the total number of quadrats to reach a mean percentage of cover for the entire community. Production studies were also conducted during the 1977 growing season (April through September) and expressed as kilograms per hectare (pounds per acre). The number of 1.0-m^2 samples taken in each community on the site to measure production varied from 5 to 40, depending upon the size and homogeneity of the community.

A census of birds was taken in February, May, late June, and October by roadside counts (ER, Plate 2.8-3) and a walked-transect count (Fig. 6.1). For the roadside count, all birds were tallied within a 0.4-km (1/4-mile) radius every 0.8 km (1/2 mile) along the transect. The roadside count is an adequate method for determining the composition and abundance of birds. The walked-transect counts, described by Emlen,[6] are useful for estimating densities in specific habitats. Raptor nests were investigated by visting possible nesting sites.

Data on big game were based on signs (scat, tracks, etc), direct observations, and information supplied by the Utah Division of Wildlife Resources (ER, Sect. 6.1.4.3). Livestock information was obtained from the U.S. Bureau of Land Management. Rabbits and hares were counted along two roadside transects on two consecutive evenings each season (ER, Plate 2.8-3). A census of small mammals was taken at three trap grids placed on the site for each of three consecutive nights in August and October 1977. Each grid consisted of 12 rows and 12 columns of traps spaced 15 m (49 ft) apart for a total of 144 traps. Sherman live traps were used in the study and all traps were checked each morning and night. The captured animals were eartagged and released to estimate the population through a standard capture/recapture method.[7] However, not enough animals were captured to make a meaningful population estimate (ER, Sect. 6.1.4.3). In addition to the grids, two traps lines consisting of 20 to 26 traps each were placed in pinyon-juniper and tramarisk-salix habitats to determine relative abundance, diversity and distribution of small mammals (Fig. 6.1).

Although potentially harmful amounts of radionuclides and other contaminants in the tailings impoundment are not expected to result in any significant impacts to wildlife, the actual extent of this impact cannot be quantified (Sect. 4.6.1). Therefore, the staff recommends that the applicant monitor the use of the impoundment by wildlife. Because surface water is limited in the area, daily monitoring would be especially important during the fall and spring migration periods of waterfowl and shorebirds. 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 additional monitoring.

6.5.2 Aquatic

Because of the lack of aquatic habitat (Sect. 2.6.1.1), subsequent paucity of aquatic biota (Sect. 2.9.2), and the low probability that the aquatic habitat could be significantly impacted by mill construction and/or operation (Sect. 4.6.2), an extensive, long-term aquatic biota monitoring program is not considered necessary by the staff. However, because the local, ephemeral streams (Corral Creek, Westwater Creek, and Cottonwood Wash) have not been sampled for aquatic biota during times of water flow, the staff is requiring the applicant to undertake a biotic survey of these environments under appropriate conditions to characterize the temporal aquatic biota. Such data as baseline information will be necessary in evaluating possible construction and operational impacts.

6.6 RADIOLOGICAL

6.6.1 Preoperational program

A preoperational, radiological monitoring program is being developed at the proposed White Mesa mill site to establish the baseline radiation levels and concentrations of radioactive materials occurring in air, biota, and soil, as well as in regional surface water and local groundwater. The sampling program, begun in July 1977, is ongoing, and results are incomplete. The preoperational monitoring program will conform to that recommended by the 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 recommended by NRC will consist of measurements of radioactivity in the air, surface water and groundwater, soil, and biota and is shown in Table 6.2.

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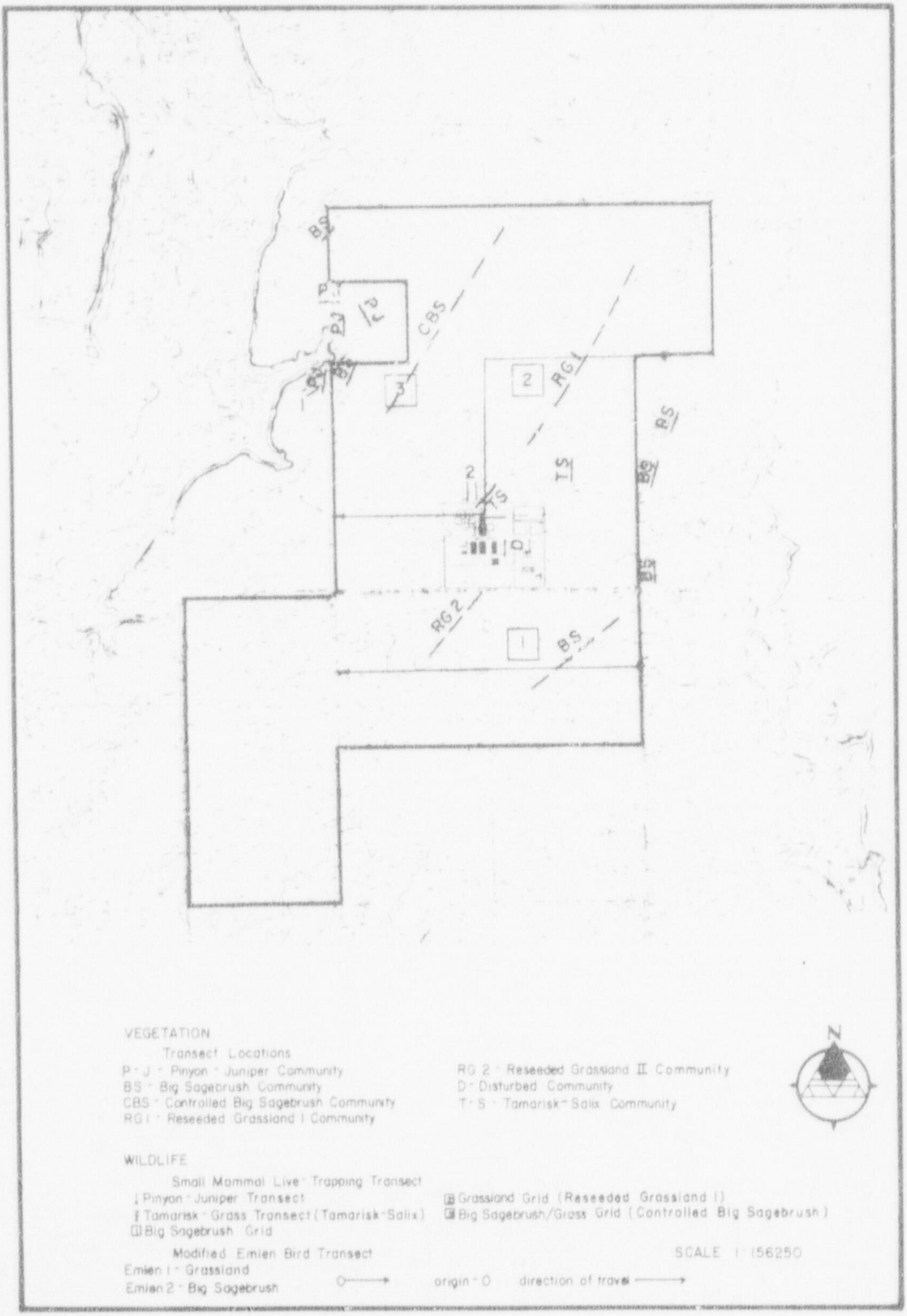

Fig. 6.1. Sampling locations for terrestrial ecological characteristics in the vicinity of the White Mesa project. Source: ER, Plate 2.8-1.

Table 6.1. Preoperational monitoring program

Type of sample	Sample collection: Number	Sample collection: Location	Sample collection: Type and frequency	Sample measurement: Test frequency	Sample measurement: 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 (emphasis on down gradient)	Grab; quarterly	Quarterly	Dissolved natural uranium, Ra-226, Th-230 and chemicals[a]
				Semiannually	Dissolved Pb-210 and Po-210
	1 (from each well)	Wells within 2 km of tailings disposal areas (could be used for potable water or irrigation)	Grab; quarterly	Quarterly	Total and dissolved natural uranium, Ra-226, Th-230 and chemicals[a]
				Semiannually	Total and dissolved Pb-210 and Po-210
	1	Well located up gradient from disposal area for background	Grab; quarterly	Quarterly	Dissolved natural uranium, Ra-226, Th-230 and chemicals
				Semiannually	Dissolved Pb-210 and Po-210
Surface water	1 (from each body of water)	Onsite or offsite streams (Westwater Creek, Corral Creek, Cottonwood 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

[a] Non-radiological chemical parameters listed in Table 2.25

Table 6.1. (continued)

Type of sample	Sample collection			Sample measurement	
	Number	Location	Type and frequency	Test frequency	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

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	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	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[a] 48-hr sample	Rn-222
Particulates	1	Ore crusher stack	Isokinetic and representative[b] 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[b] monthly stack sample and either (1) semiannual stack sample or (2) semiannual product (yellow cake) sample	Monthly	Natural uranium, flow rate
				Semiannual,[a] 1 or 2	(1) Ra-226 and Th-230 or (2) natural uranium, Ra-226, and Th-230
				Semiannual for first year,[a] 1 or 2	Pb-210

Table 6.2. (continued)

Type of sample	Sample collection			Sample measurement	
	Number	Location	Method and frequency	Test frequency	Type of measurement
Water					
Groundwater	3	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[c] and TDS[d]
	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[a]	Grab; quarterly	Quarterly	Total natural uranium, Ra-226, Th-230, Pb-210, and Po-210; chemicals and TDS
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 thermoluminescence dosimers 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] If a large number of wells are located within 2 km, only those wells nearest tailings impoundment need be sampled.

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

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

[d] TDS = total dissolved solids.

REFERENCES FOR SECTION 6

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

2. Energy Fuels Nuclear, Inc., "Responses to Comments from the U.S. Nuclear Regulatory Commission, June 7, 1978, White Mesa Uranium Project Environmental Report," Denver, June 28, 1978.

3. State of Utah, Division of Oil, Gas, and Mining, "Changes and Adoptions to the General Rules and Regulations," adopted by the Board of Oil, Gas, and Mining on March 22, 1978; effective June 1, 1978.

4. Energy Fuels Nuclear, Inc., "Responses to Comments Telecopied from NRC to Energy Fuels Nuclear, Sept. 25, 1978," Oct. 4, 1978.

5. Office of Water and Hazardous Materials, USEPA, *Quality Criteria for Water*, Washington, D.C., 1976.

6. J. T. Emlen, "Population Densities of Birds Derived from Transects Counts," *Auk* 88: 323-342 (1971).

7. R. L. Smith, *Ecology and Field Biology*, 2d ed., Harper and Row, New York, 1974.

7. UNAVOIDABLE ENVIRONMENTAL IMPACTS

7.1 AIR QUALITY

An unavoidable impact of construction and operation of the mill facility would be a slight increase in particulate matter and ambient concentrations of gaseous emissions. Because the concentration of these pollutants would be below the Federal and State air quality standards, the staff feels that they will not significantly contribute 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 which would result from increased traffic on the highways.

7.2.1.2 Agricultural

Construction and operation of the mill would result in an unavoidable loss of nearly 360 ha (900 acres) of potential grazing land. Following project termination, about 50% of this total area would be occupied by the tailings disposal system and would be unavailable for grazing until it had been released from its status as a restricted area. The remaining land would be reclaimed to permit unrestricted use.

7.2.2 Historical and archaeological resources

The nature of the archaeological resources on the site is such that their value is expected to lie primarily in the information they contain, not in their existing location. Therefore, if the program of mitigation outlined in Section 4.2.2 is followed (avoidance of sites when possible, full excavation of those which cannot be avoided, and protection of potential or currently unidentified sites), 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 to surface waters are expected.

7.3.2 Groundwater

Operation of the proposed mill would result in the use of about $5.9 \times 10^5 m^3$ (480 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 unexpected groundwater contamination is observed.

7.4 SOILS

Construction and operation of the mill facility would disturb about 360 ha (885 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 to the soil are not expected to be significant.

7.5 BIOTA

7.5.1 Terrestrial

The proposed project would result in a temporary unavoidable loss of about 360 ha (885 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.

7.5.2 Aquatic

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

7.6 RADIOLOGICAL

Radioactive emissions from transportation, storage, and milling of the ore would increase the level of radioactivity in the surface environment.

7.7 SOCIOECONOMIC

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

The present consumer prices for goods and services in the area of the site would 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 in the area of the White Mesa Uranium Project but that these effects cannot be avoided.

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 land on which the mill is located could be returned to its present state and capacity by reclamation activities. The tailings area, however, under present regulations may be unavailable for further productive use.

While 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 prior to the initial surface disturbance.

8.1.3 Water

Because water for milling operations will be drawn from a deep and lightly used aquifer, no changes in the water-use patterns of the area will occur as a result of mill operation.

8.1.4 Mineral resources

No mineral resources are known to exist on the site. Reworking of tailings for extraction of other minerals could occur if economics warrant.

8.1.5 Soils

The applicant's reclamation program is designed to return the soils to a condition of productivity that is consistent with their present and historic usage — that is, the production of forage and habitat for livestock and wildlife. The program will begin as soon as practicable and will continue throughout the life of the project. As a result, about half the disturbed soils should be back in production by the time mill operation ceases.

8.1.6 Biota

8.1.6.1 Vegetation

Revegetation of disturbed areas will begin as soon as practicable and will continue throughout the life of the project. A satisfactory vegetative cover is expected to be established in two or three years. About half the disturbed area will be revegetated by the time mill operations cease, and the remainder will be revegetated shortly thereafter.

8.1.6.2 Wildlife

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.

8.1.7 Radiological

The tailings will be impounded in lined pits. Such enclosures would be overlain with cover material to meet radon release standards, and then reclaimed. The reclaimed tailings area will constitute a source of radon emission of about twice the natural background flux.

8.2 SOCIETY

No significant long-term impacts on the socioeconomic character of local communities can presently be attributed to the project with certainty. 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 White Mesa mill 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.

A loss of long-term productivity may result from disturbance of archaeological sites. However, the mitigating actions that would be taken should result in preservation of archaeological materials that might otherwise have been destroyed. This is consistent with the opinion of the Utah State Historic Preservation Officer who has advised as follows[1]:

> The work to identify significant sites and sites that will be adversely effected is nearly complete and while certain sites within the property may be significant under the federal criteria, as more fully explained in the State Archaeologist's report, you should be aware that the significance of these sites lies not with their becoming public attractions or monuments, but rather with the information they have yielded about certain prehistoric cultures. Sites of this nature are plentiful throughout the southeastern part of Utah, but have not been tested. It is only the opportunity presented by the desire of Energy Fuels to build a uranium mill in this area that permitted us to devote the time and energy to a thorough study of such sites. In essence, Energy Fuels project will permit the recovery of archaeological data that without the project probably never would have been recovered.

REFERENCES FOR SECTION 8

1. Utah State Historic Preservation Officer, letter to NRC, dated December 5, 1978.

9. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

9.1 LAND AND MINERAL

9.1.1 Land

The land occupied by the reclaimed tailings cells may not be available for further productive use. This would be considered an irreversible commitment of resources.

Work to reclaim archaeological sites may result in an incomplete recovery of archaeological data or resources, or in an inadvertent destruction of a portion of those resources.

9.1.2 Mineral

No major irreversible or irretrievable commitments of mineral resources are anticipated other than (1) the uranium and vanadium that will be recovered; (2) the 23,000 MT (25,000 tons) of coal that will be burned each year; and (3) the yearly consumption of 6.6 MT (7.3 tons) of kerosene and 95 m^3 (25,000 gal) of fuel oil in processing operations.

9.2 WATER AND AIR

9.2.1 Water

Ground and surface waters are not expected to be impacted by the proposed project. Because of the large volume of groundwater available, use of that water during mill operations is not considered an irreversible or irretrievable commitment of resources.

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

Although a total of about 360 ha (885 acres) of soils and associated vegetation will be temporarily disturbed or lost for the life of the project, the land and wildlife habitat can be restored in time to acceptable levels as a result of approved reclamation efforts (Sect. 3.3.2). Current regulations, however, require the tailings disposal area (about 180 ha (450 acres)) to remain fenced until it is released from its status as a restricted area. Wildlife will undoubtedly use this area after it is fully reclaimed. This restriction is not considered an irreversible commitment of resources.

9.3.2 Aquatic

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

9.4 MATERIAL RESOURCES

Major irretrievable and irreversible commitments of material resources* incurred per year of White Mesa mill operation are 6.04 MT (6.66 tons) of sulfuric acid; 4.8 x 10^3 MT (5.3 x 10^3 tons) of manganese dioxide, 2.47 x 10^3 MT (2.72 x 10^3 tons) of sodium chlorate; 1.92 x 10^3 MT (2.12 x 10^3 tons) of soda ash; 4.39 x 10^2 MT (4.84 x 10^2 tons) of ammonium sulfate; 2.93 x 10^2 MT (3.23 x 10^2 tons) of anhydrous ammonia; and 0.91 x 10^2 MT (1.0 x 10^2 tons) of flocculent. In addition small amounts of Isadecanol, Amine, and various laboratory chemicals will be consumed.

These materials are not in short supply and are common to many industrial processes.

*Assuming 25% of the ore is processed for vanadium.

10. ALTERNATIVES

10.1 ALTERNATIVE SITES

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

1. availability of suitable land; 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 natural tailings impoundment liner materials (5) adequate quantity and quality of materials available for reclaiming the tailings disposal area and other disturbed surface areas, and (6) suitable drainage and flood characteristics;

4. topographical factors such as (1) surface suitability for construction of facilities with minimum alteration of terrain, and (2) minimal 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;

7. availability of industrially important services such as transportation, power, and communications.

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

10.1.1 Alternative Mill and Tailings Disposal Sites

The applicant's Hanksville and Blanding ore-buying stations were located to collect uranium ore from small producing mines in southeast Utah. The majority of the ore for the mill will not be coming from company-owned mines located in close proximity in a specific geographical area but will be collected thru ore-buying from widely scattered mining operations in the Four Corners region. There are, theoretically, a multitude of potential sites in the Blanding - Hanksville region.

As was the case with the existing ore-buying stations, alternate sites for the mill would be optimally located with respect to the ore to be processed to minimize hauling distances, i.e., transportation impacts.

In addition to the alternative sites discussed below, the following alternatives were evaluated:

1. The alternative of storing the mill wastes in the mines from which the ore was extracted. This alternative is not feasible for a central milling operation that will be processing ore from approximately 100 small, widely distributed mines with diverse ownerships. Adequate control of the transportation, handling, and storage of the tailings would be difficult, and accessing and monitoring the effects of the tailings on the scattered, site-specific environments would be both difficult and expensive.

2. The alternative of milling the ore purchased at the buying stations at existing uranium mills (see Section 10.4 for discussion).

The applicant evaluated two basic siting options: (1) locating the mill and tailings impoundment in the Hanksville area, and (2) siting the processing and waste disposal facilities in the vicinity of Blanding.

The option of locating the mill and tailings disposal facilities in the Hanksville area was considered unacceptable by the staff for the following reasons:

1. Socioeconomic limitations (Section 2.4.2). These limitations include (1) limited capacity of Hanksville to absorb growth (excess housing is nonexistent); and (2) limited availability of power, communications, and transportation (air and rail) services. Hanksville (population 160) could not support the population increase that would be necessary to implement this project. The population change would be similar to that projected for Blanding (Section 4.8.1); however, the impacts would be significantly greater.

2. Increased ore haulage distances. Approximately 75% of the known uranium ore deposits available for processing are located near Blanding (ER. p. 10-2).

Based on a consideration of socioeconomic and transportation impacts, the staff has concluded that other potential alternative sites in the southeastern Utah region would be no better than those located in the vicinity of Blanding, Utah. Four alternative mill and waste disposal sites in the Blanding area were evaluated by the applicant (Fig. 10.1): (1) Zekes Hole (Area I), (2) Mesa (Area II), (3) Calvin Black property (Area III), and (A) White Mesa (Area IV). Zekes Hole is publicly-owned land located approximately 8 km (5 miles) southwest of Blanding, adjacent to and on the south side of State Highway 95. The Mesa site alternative is located approximately 6.4 km (4 miles) southwest of Blanding, adjacent to and on the south side of State Highway 95 and consists of two sections of public land. The Calvin Black property encompasses approximately 290 ha (720 acres) of privately owned land and is located approximately 3.2 km (2 miles) south of Blanding along the north side of State Highway 95. The White Mesa site is composed of 600 ha (1480 acres) of privately owned land and is located approximately 10 km (6 miles) south of Blanding on the west side of Highway 163 and is crossed by the Black Mesa Road and an existing power line. (The site is owned by Energy Fuels Nuclear).

These sites were evaluated primarily with respect to the availability of suitable land, hydrological and topographical considerations, and accessibility of services:

1. Availability of Suitable Land. A drawback for the Calvin Black property is that it is 3.2 km (2 miles) from Blanding and there are private residences within a 0.4-km (0.25-mile) radius of the site. The White Mesa site, 10 km (6 miles) south of Blanding, on the other hand, is bounded on east, west, and south sides by publicly-owned land and the nearest potential residence is 1.6 km (1 mile) north (the nearest current resident is approximately 3 miles north).

2. Hydrological and Topographical Considerations. Cottonwood Wash drains through the middle of the Zekes Hole site and the drainage at this location is greater than 500 km^2 (193 square miles). The Calvin Black property lies directly in the Westwater Creek drainage. The Mesa and White Mesa sites are both located on gently sloping lands and are not crossed by major drainages.

3. Accessibility of Services. There is limited accessibility to commercial power at the Zekes Hole and Mesa sites; power is available at the Calvin Black property and White Mesa sites. The applicant claims that the water supplies at the Mesa site and at the Calvin Black property might be inadequate to support the proposed mill. Access to roads is not a problem at any of these sites.

Based on a comparison of the four areas with respect to the characteristics listed above the staff concluded that the mill site area chosen by the applicant (White Mesa) was as environmentally suitable (or was better) than any of the other three.

10.1.2 Alternative Tailings Disposal Sites in the White Mesa Area

The applicant evaluated four potential sites for mill tailings disposal in the White Mesa area (see Fig. 10.2). At two of the sites (East and West), the tailings would be stored in canyons; and dams of considerable height would be required as part of the impoundments. At the North and South sites, tailings impoundments would cover larger surface areas and would be shallow, requiring the construction of dikes of low height.

The West site is located in Westwater Creek Canyon. The terrain in the area is steep, and a 15-year impoundment would require a dam approximately 70.1 m (230 ft) high. A single-cell, above-grade impoundment, sized to hold 15 years of tailings, would cover a small area [approximately 28 ha (68 acres)], and the drainage area would be about 340 ha (850 acres). The applicant rejected this tailings disposal site alternative for the following reasons (ER, Appendix H, p. 5):

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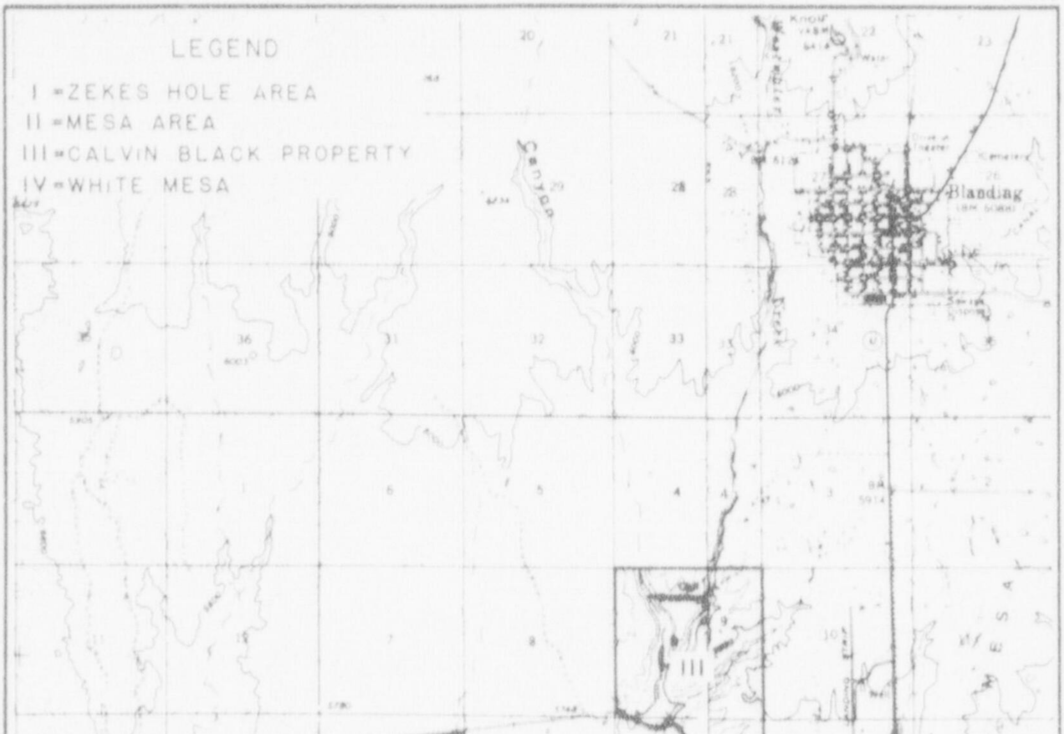

Fig. 10.1. Alternative areas near Blanding Studied by applicant for the White Mesa Uranium Project
Source: ER, Plate 10.2-1.

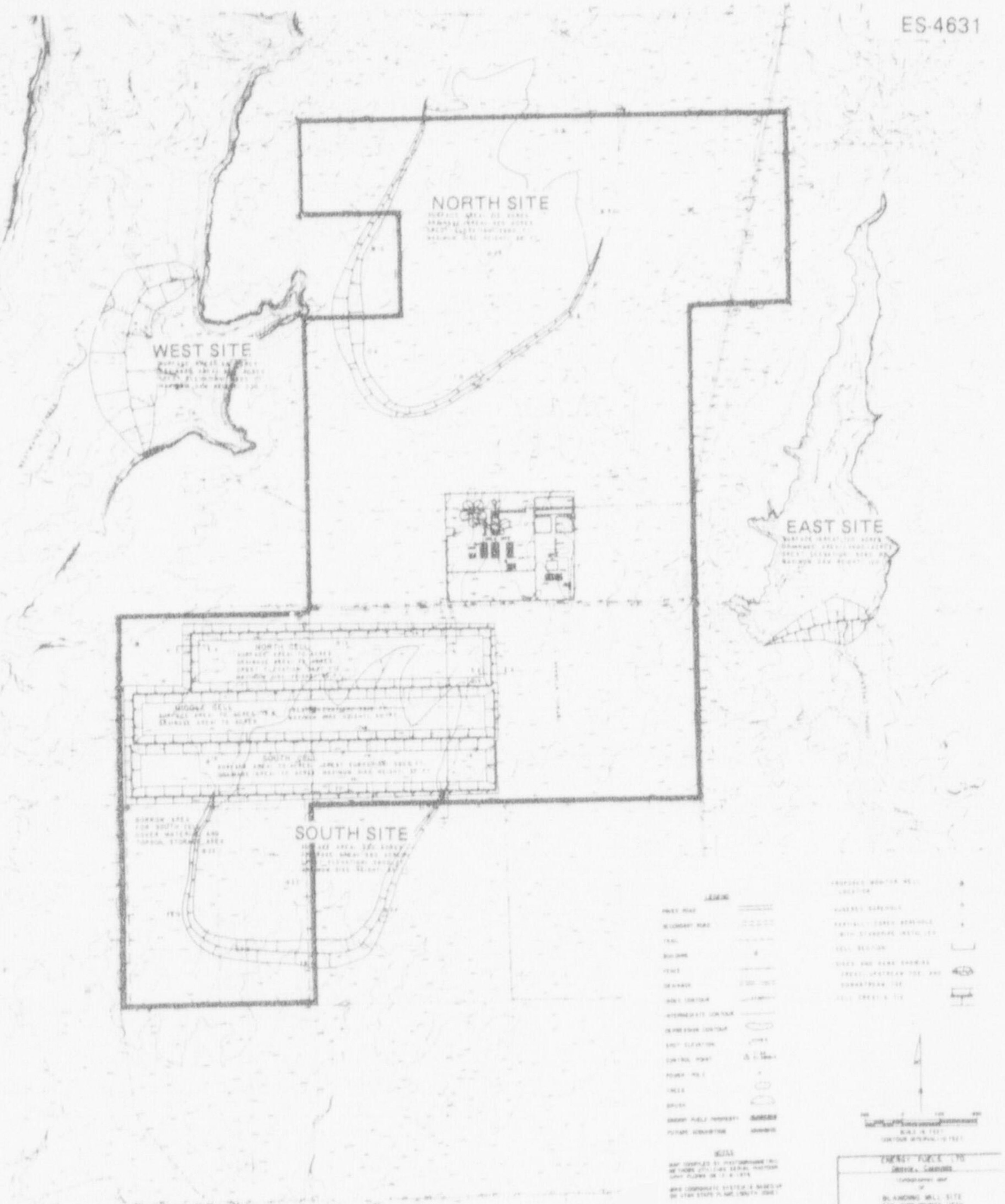

Fig. 10.2. Alternative tailings disposal sites in the White Mesa area. Source: ER, Appendix H, Plate 2.

1. Because the dam would have to be quite high to provide the required storage capacity and the toe of the dam would be in the flood plain of Westwater Creek, the long-term stability of the impoundment would be questionable.

2. Prevention of excessive seepage into the nearby vertical sandstone canyon walls would be difficult.

The East site is located in Corral Creek Canyon. A conventional, above-grade tailings impoundment, designed to hold 15 years of mill tailings, would cover approximately 49 ha (120 acres), would require a dam approximately 36.6 m (120 ft) high, and would have a drainage area of about 1400 ha (3400 acres). This tailings disposal site alternative was rejected by the applicant for the following reasons (ER, Appendix H, p. 6):

1. Although the reservoir surface area would be small, which is beneficial for reclamation purposes, the drainage area is large; and water erosion over the long term is potentially severe.

2. Prevention of excessive seepage into the steep, mostly sandstone canyon walls would be difficult.

The South site, which was picked by the applicant as the optimum site, is downgradient from the proposed mill site. The area is gently sloping, disturbed rangeland containing a slight swale in the general area where the tailings impoundment would be placed. The applicant initially proposed a single-cell, above-grade, 15-year impoundment would cover approximately 100 ha (250 acres), would require a dam approximately 19.8 m (65 ft) high, and would have a drainage area of about 240 ha (590 acres). The proposed impoundment at the South site, which is part of the tailings management system proposed by the applicant is discussed in detail in Sects. 3 and 10.3.2 (Alternative 1).

The North site is located on gently sloping land upgradient from the proposed mill site. If a conventional, above-grade, dam/pond disposal facility, sized to hold 15 years of mill wastes, were to be constructed in the area, the applicant estimates that the impoundment would cover 87 ha (215 acres), would require a dam approximately 24.4 m (80 ft) high, and would have a drainage area of approximately 170 ha (420 acres). With the exception that the tailings would ~~have~~ to be pumped uphill for a slightly greater distance, there are no significant differences between this site and the South site.

Assuming that the mill would be located at White Mesa and utilizing the following criteria to screen feasible site alternatives from a multitude of potential sites in the Blanding area, the staff located and evaluated three additional alternative tailings disposal sites:

1. To minimize long-term wind and water erosion problems, the areas chosen for further study contained naturally excavated basins which 1) are almost completely enclosed by substantial rock barriers (such as cliffs) and would require a dam with a small length, and 2) which would have minimal drainage areas above the tailings impoundment.

2. Only basins that could be impounded to contain at least 15 years of mill tailings and which could be readily accessed by road or by slurry pipeline were considered.

The three additional alternative tailings disposal sites evaluated by the staff were 1) Recapture Creek, 2) Brown Canyon, and 3) Alkali Canyon. The Recapture Creek site is located in Section 26, T37S, R22E, east of the Corral Canyon tailings disposal site ("East site") investigated by the applicant, and east of the White Mesa site boundary. The Brown Canyon site is located northeast of the White Mesa mill site in sections 13, 14, and 23, T37S, R22E (the majority of the tailings impoundment would be in section 14). The Alkali Canyon site is located east-northeast of the White Mesa mill site in sections 10, 11, 14 and 15, R23E, T37S.

A tailings impoundment at the Recapture Creek site would cover approximately 37 ha (90 acres) and would require a dam approximately 48.8m (160 ft) high. At the Brown Canyon site an impoundment would cover approximately 84 ha (205 acres) and would require a dam approximately 30.5m (100 ft) high. A tailings retention area at the Alkali Canyon site would cover approximately 66 ha (161 acres); the dam required would be about 54.9m (180 ft) high. All sites are accessible by road; the haulage distances would be approximately 5.3 km (3.3 mi) to Recapture Creek, 8.5 km (5.3 mi) to Brown Canyon, and 19.5 km (12.2 mi) to Alkali Canyon.

The tailings retention areas at these sites would be smaller than the proposed impoundment at White Mesa, and the local topographies offer excellent protection from wind and water erosion. However, the dam heights would be greater, and the canyon walls are steep and consist of highly permeable and fractured sandstone; the prevention of seepage from the tailings retention areas would be difficult, and the long-term stability of the dams would be questionable. The staff concluded that no appreciable additional environmental benefits could be gained by storing the tailings at these sites.

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 site proposed by the applicant (White Mesa); i.e., the site proposed for the projected facilities is better, from a environmental standpoint, or at least as suitable as other potential locations. It must be emphasized that this conclusion is only possible because a similar conclusion can be made concerning the acceptability of the proposed tailings management system (Section 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 are conventional 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 solution, (5) precipitation of the uranium from the leach 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.

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.[1] Conventional crushing equipment usually reduces the size of the ore particles to approximately minus 1.9 cm (3/4 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.[1] At the White Mesa mill the ore [which has already been crushed to less than 3.8-cm (1.5-in.) size at the ore buying stations] will be fed by a front-end loader through a primary grizzly to a secondary grizzly and then fed by conveyor belt to a semiautogenous wet grinding mill. The mill will operate in closed circuit with screens, with the minus 28 mesh output (underflow from the screens) being pumped to three mechanically agitated, wet-slurry storage tanks.

The leaching method chosen for removal of 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. Some processes add acid in "stages" to minimize excessive initial frothing and to monitor acid content (pH control). The applicant evaluated the effectiveness of acid and alkaline leaching processes on ores purchased by the ore buying stations (ER, p. 10-6). Although some of the ore could be successfully treated by alkaline leaching, acid leaching usually resulted in higher recovery rates; therefore, a conventional sulfuric acid leach process was chosen by the applicant. The leaching circuit at the White Mesa mill will be designed for the extraction of vanadium as well as uranium. The ore will be leached in two stages utilizing sulfuric acid, manganese dioxide (depending on availability and delivery, an equivalent oxidant such as sodium chlorate might be used), and steam. The overall uranium recovery rate is expected to be about 95%.

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 counter-current decantation in thickeners for liquid-solid separation.[2] The applicant has also chosen to achieve liquid-solid separation by counter-current decantation washing and thickening methods. (The belt filtration alternative is described in Sect. 10.2.2.) Either conventional, multistage, counter-current thickeners or Enviro-Clear type thickeners will be

employed. To reduce freshwater requirements, barren raffinate will be added to the final thickner for washing the leached residue. Polymeric flocculants will be used to increase separation efficiency, and the waste solids (underflow slurry from the last thickener containing 50% water) will be pumped to the tailings impoundment area.

Concentration and purification of the uranium from the pregnant leach solution is necessary for the production of a high-grade uranium product. Uranium extraction is usually performed by either solvent extraction or by ion exchange processes. The applicant has decided to utilize a solvent extraction method where the decanted, aqueous uranium-bearing leach solution will be contacted with an organic solution consisting of an amine-type compound dissolved in a kerosene diluent. The dissolved uranyl ions are more soluble in (and transfer into) the organic solution. Resin-based processes, such as resin-in-pulp and resin ion exchange in clarified solution, were evaluated by the applicant and rejected for economic reasons, primarily because of relatively higher operating costs. The solvent extraction process will be carried out in a series of mixer and settling vessels, with the organic and aqueous solutions being mechanically agitated and separated into organic and aqueous phases in the settling tanks. This separation operation would be performed in four stages using a counter-flow principle where the organic flow is introduced to the preceding stage and the aqueous flow feeds the following stage. The depleted aqueous phase (raffinate) will be recycled to the counter-current decantation stage or processed for the recovery of vanadium (Sect. 3.2). The uranium-loaded extract (organic solution) will be washed and stripped of uranium by contact with an acidified sodium chloride solution; the resulting barren organic solution will be returned to 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.[2] The precipitate is then dewatered, dried, and packaged. At the White Mesa mill, the uranium-rich solution from the stripping operation will be treated with ammonia to neutralize the solution, precipitating ammonium diuranate, or yellow cake. The precipitate will then be thickened, dewatered by centrifuge, dried in a multiple-hearth, oil-fired dryer (calciner), crushed to minus 0.6-cm (0.25-in.) size in a hammer mill, and then packaged in 55-gal drums for shipment. 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 wet scrubbing) airborne U_3O_8 particles. As an alternative to the drying, crushing, and packaging operations, yellow cake slurry can now be shipped directly to a UF_6 conversion facility. The applicant investigated this alternative processing option but rejected it because of uncertainties concerning the long-range availability of sufficient capacity at this type of conversion facility.

10.2.2 <u>Uranium Milling Processes which Produce Low-moisture Tailings</u>

There are several alternative uranium milling processes currently in use in other countries which utilize leach cycles similar to the conventional procedures described in Sect. 10.2.1. These milling methods produce low-moisture tailings, which 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 and 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 50% water by weight; the rate of discharge will be approximately 1800 MT (2000 tons) of tailings and 1800 MT (2000 tons) of water per day. If the Pechiney milling technique, which uses a belt filter, were to be implemented, the "cake" would be counter-currently washed in two stages, with the barren tailings being dewatered to a moisture content of approximately 22%. The tailings can be neutralized before or on the belt filter. The tailings would then be belt-conveyor or truck transported 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 ore to be processed at the White Mesa mill will have a wide range of physical and chemical characteristics.

The applicant evaluated the effectiveness of utilizing a belt filter or disk filter system to reduce the moisture content of the mill tailings. The filtration circuit evaluated, however, would not replace the proposed "thickener" liquid-solid separation process but would accept the tailings from the thickener circuit and segregate the slimes and sands for separate disposal. This alternative tailings disposal method is discussed in greater detail in Sect. 10.3.2 (Alternative 3).

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 the disposition of the tailings and waste leach solutions following removal of the uranium values. Engineering techniques to control pollutants from tailings storage, both during operational and post-operational 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. The staff has examined alternatives considered by the applicant,[3-5] as well as alternatives considered for other mills in preparing this section.[6-10] Alternatives presently available or feasible (i.e., potentially available with existing technology within legal constraints 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 viable with existing technology is presented in Sect. 10.3.4.

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.

Post reclamation

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: Partially below-grade tailings disposal in impoundments built, filled, and reclaimed in stages

This alternative involves the construction of a partially below-grade, six-cell impoundment system in a swale (shallow natural basin) immediately to the west and south of the proposed mill site. As proposed by the applicant, the total tailings disposal area would be sized to contain 1800 metric tons (MT; 2000 tons) per day of tailings produced during 15 years of mill operation (see Fig. 3.4). The proposed tailings system involves simultaneous construction, operation, and reclamation of individual cells. As one cell is being used for tailing disposal, the previously used cell will be drying and next cell downgradient will serve as an emergency catchment basin (Sect. 3.2.4.7). An individual cell would be sized to hold approximately 2.5-years production of tailings and would cover approximately 28 ha (70 acres) of surface area. Cells would be constructed by excavating the bottom of the impoundment and by building successive embankments across the open (southern) end of the swale to contain the tailings. Except for cell 1, which should have a sufficiently large surface area to make the cutting of bedrock unnecessary, the excavation of a limited amount of bedrock material (0.3 to 0.9 m (1 to 3 ft) deep), in addition to overburden soil, would be necessary. Because a high degree of weathering is anticipated at these depths, excavation would be accomplished by ripping; no blasting would be used for excavation of the rock (except for localized lenses of unweathered rock). The dikes would be homogeneous, compacted, earth-filled embankments constructed from soils present in the overburden at the tailings disposal site. The embankments would vary in height from approximately 4.6 m (15 ft) for cell 1 to 8.5 m (28 ft) for cell 6, where the dikes cross the lowest part of the swale. Each dike would be 6.1 m (20 ft) thick at the crest to allow for an access road and would have side slopes no steeper than 3:1 (horizontal to vertical) (Fig. 3.6). Overflow structures 1.5 m (5 ft) deep would be built into the dikes between the individual cells to maintain a freeboard allowance of at least 1.5 m (5 ft). The downstream slope of the final, southernmost dike (cell 6) is the only dike that would ultimately have an exposed face (after final reclamation), therefore, to reduce the potential for excessive erosion of this embankment after cessation of mill operations, a 6:1 sloped layer of rock fill would be used in the construction of the downstream segment of this dike (Fig. 3.7). Additionally, to minimize water and wind erosion during operations, excavated rock would be used to protect drainage channels and storm retention ponds and to cover the exterior slopes on the perimeter of the impoundment. The entire tailings retention system would cover approximately 180 ha (450 acres) of surface area if the mill were to operate at 1800 MT per day for 15 years; the total affected acreage (includes land needed for stockpiling and borrow areas) would be approximately 338 ha (835 acres).

To prevent seepage of liquid wastes from the impoundment facilities, the applicant would line all interior surfaces of each cell with a state-of-the-art synthetic liner such as Hypalon reinforced with a nylon scrim (the final liner and liner system specifications will be reviewed by the staff prior to approval for use). To prevent puncturing of the synthetic liner, a smooth (projection free) subliner of locally obtained clayey-silt soil would be placed over the excavated rock surfaces of each cell floor. The entire synthetic liner surface (including the liner on the upstream portion of the dikes) would be overlain with 30.5 cm (12 in) of clayey-silt soil to minimize liner deterioration caused by winds, sunlight, and the tailings materials and also for protection from operating equipment. Since: 1) the cell floors would be flat (2% slopes, or less), 2) the cells would be shallow impoundments, and 3) dense, relatively incompressible materials (Mancos Shale and Dakota Sandstone) would underly the liner, differential settlement should not be of sufficient severity to compromise the liner integrity.

The expected net evaporation rate at the site is 1.56 m (5.13 ft) per year, and the total liquid transported with the tailings would be 5.84 x 10^5 m^3 (474 acre-ft) per year. On the slightly sloping impoundment surfaces, the staff expects the tailings to drain and settle to a void fraction approaching .34, which would contain pore water at 50% of saturation. This quantity would be effectively bound by capillary forces at 0.17 m^3 (0.17 ft^3) of water for each cubic meter (foot) of settled tailings or about 7.0 x 10^4 m^3 (57 acre-ft) per year. With no seepage, equilibrium between input and evaporation would be achieved with about 33 ha (81 acres) of ponded liquid. Because the surface areas of some of the proposed cells would be less than 33 ha, the staff has concluded that corrective measures, such as pumping tailings solutions from one cell to another to increase the liquid surface area, may have to be instituted to satisfy water balance requirements.

During operations, retention ponds and interceptor ditches would be constructed to divert surface drainage away from the impoundment area. These retention ponds would be placed north of the mill site, with the discharges from these ponds being directed eastward, away from the tailings cells. Interceptor ditches, sized to pass the probable maximum flood, would be constructed north, east, and west of the tailings retention area. Riprap, consisting of excavated rock, would be placed in the ditches to aid in preventing erosion. Over the long term, the interceptor ditches and the retention ponds would fill with silt and become revegetated. The small drainage area upgradient from the reclaimed tailings impoundment (upgradient drainage area is 0.065 sq. km. (0.025 sq. mi.)) obviates concerns over dispersion of the cover from flooding.

Reclamation would be implemented sequentially for the six tailings cells as each cell is inactivated and as soon as an individual cell has dried sufficiently to allow the movement of equipment over the pile. To reduce radon gas emanation and gamma radiation from the tailings to acceptable levels, the applicant proposes to cover the tailings with a 0.6-m (2-ft) layer of compacted Mancos Shale obtained from offsite deposits, 3.0 m (10 ft) of onsite clayey-silt material, and 23 cm (9 in.) of topsoil.* The compacted shale would be designed and constructed to prevent damage by differential settlement. To revegetate the tailings area, the applicant has proposed to seed the tailings cover with a mixture of grasses, forbs, and shrubs.

Because the cap would be almost 4 m (13 ft) thick, the staff has concluded that root penetration into the tailings is not likely, reducing the possiblity of adverse impacts associated with the upward migration of radionuclides and toxic elements through plant root systems. Although the disposal area would be located in a relatively arid region, the proposed cover is not expected to develop significant shrinkage cracks because the clay content of the soils to be utilized is low (except for the imported, remolded Mancos Shale).

The reduction of the gamma radiation that results from capping a tailings pile is dependent on the degree of compaction and mass stopping power of the cover material. As shown in Appendix G, the 3 m (10 ft) of clayey-silt liner alone, excluding the shale cover, was calculated by the staff to reduce the gamma radiation from the tailings to approximately 1×10^{-7} milliroentgens per year, thus meeting the performance objective for reduction of gamma radiation.

The radon flux at the surface of uncovered tailings was calculated by the staff to be approximately 439 $pCi/m^2 \cdot sec$. The covering scheme proposed by the applicant [0.6 m (2 ft) of Mancos Shale, overlain with 3 m (10 ft) of clayey-silt material and 23 m (9 in.) of topsoil] was estimated by the staff to reduce the radon emanation rate from the reclaimed tailings area to approximately 1.16 pCi/m^2 sec and meets the intent of the performance objective for reduction of radon exhalation. (See Appendix F for calculations and assumptions utilized to derive the above figures.)

Discounting and deflating the expected costs to 1978 dollars (10% discount rate and 8% rate of of inflation per annum), the total estimated costs for this alternative is approximately $24.7 million. (The costs for the synthetic liner and the Mancos Shale component of the cover are estimated at $6.51 and $2.73 million, respectively.)

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

1. The tailings would be stored in a trough below the normal surface contours of the area. Although the tailings cover is only partially below grade (at least 5 feet below grade), the slight grade (<2%) on the cover should provide a high degree of protection from wind and water erosion. The entire area would be revegetated; and a layer of riprap would be placed on all exposed slopes around the impoundment, further minimizing potential erosion problems. Although the downstream side of the last dike (on cell 6) has an exposed face, it will have a 6:1 slope and will be constructed of rock overburden.

2. The cellular design allows staged reclamation, minimizing the quantity of tailings exposed at any one time. Overburden storage and handling requirements are also reduced, i.e., overburden removed during excavation of later cells can be transported directly to cells being reclaimed.

3. The low dikes and the shallow depth of the cells increases dike stability.

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*Energy Fuels Nuclear, letter to NRC, dated October 16, 1978.

Alternative 2: Below-grade burial in a specially excavated pit

This alternative involves the excavation of a basin of sufficient size and depth to store all of the tailings and tailings cover completely below grade. The impoundment would be lined with a synthetic liner to minimize seepage from the disposal area. 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 compacted Mancos Shale, locally obtained soil, and topsoil in the same configuration as proposed for Alternative 1 [0.6 m (2 ft) of Mancos Shale, 3 m (10 ft) of soil, and 23 cm (9 in.) of topsoil]. Therefore, the radon gas and gamma attenuation estimates would be the same as for Alternative 1.

In the version of this alternative proposed by the applicant, the tailings would be stored below grade, but the tailings cover would protrude above grade. However, a true below-grade disposal system would have to include the cover below grade, which would require modifications in the applicant's proposed plan. Further excavation downward would significantly increase costs and would require extensive blasting to remove unweathered Dakota Sandstone. Implementing either version of this alternative would be advantageous as no retention embankment would be required; thus the probability of release and dispersion of tailings would be minimized.

The estimated cost of Alternative 2 is $32.6 million (discounted to 1978 dollars). This does not include the cost of the additional excavation of bedrock that would be required to make the system "below grade". The benefits that this alternative might have over Alternative 1 do not justify the additional costs.

Alternative 3: Filtered tailings disposal

This alternative features partially below-grade burial of dewatered tailings in unlined basins or trenches. Dewatering would be accomplished by either horizontal belt-type or disc-type vacuum filters. The filtration circuits would not replace the proposed "thickener" liquid-solid separation process but would accept the tailings from the thickener circuit and segregate the liquids and solids for separate disposal (see Fig. 10.3). The dewatered tailings would be transported to the disposal area either by truck or by a portable conveyor system. The liquid filtrate would be discharged to three 28-ha (70-acre) lined evaporation ponds. After completion of milling operations, the ponds would dry out. Soluble residue and contaminated clays and underlying materials would be removed from the pond areas and buried in the tailings disposal area. The evaporation ponds would be constructed above grade, would vary from 1.8 m (6 ft) to 2.4 m (8 ft) in depth, and would be lined with a clayey-silt material available onsite.

The total volume of tailings produced over the 15 years of project operation would approach 6.88×10^6 m^3. This volume would cover an area of 160 ha (400 acres), 4.6 m (15 ft) deep. To balance excavation quantity (4.74×10^6 m^3) and cover requirements, the applicant proposes to construct a 160-ha (400-acre) impoundment, 3 m (10 ft) deep. This design would result in a tailings projecting 1.5 m (5 ft) above grade and the tailings cover completely above grade. The cover scheme proposed in Alternative 1 would be utilized (0.6 m (2 ft) of Mancos Shale, 3 m (10 ft) of clayey-silt material, and 23 cm (9 in) of topsoil).

The major disadvantages associated with the implementation of this alternative are as follows:

1. The tailings would be partially above grade, and the long-term stability of the reclaimed tailings impoundment would be questionable.

2. The absence of an impermeable liner under the evaporation pond increases the possibility of long-term leaching of toxic elements from the tailings. (The impermeability of the compacted clayey-silt material has not been proven.)

3. The reliability of the filter system would be questionable due to the wide variety of ores to be processed by the proposed mill.

The total cost of this alternative is a function of the dewatering system and tailings transport system chosen. With haulage of dewatered tailings by truck or by conveyor belt and filtration by horizontal belt or disc filters, the costs range from approximately $24.7 to $25.0 million. (The cost of Mancos Shale cap would be approximately $2.4 million.)

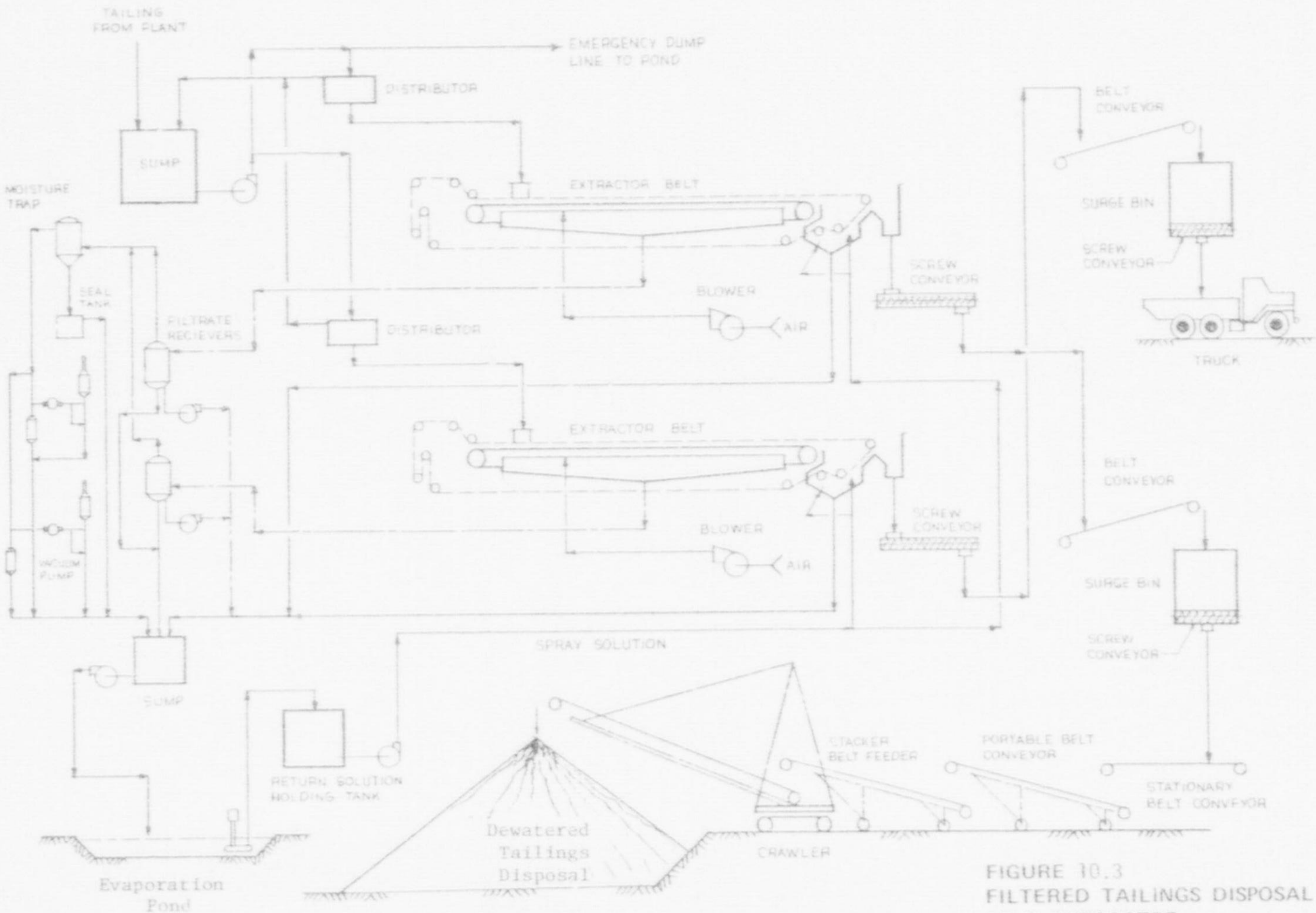

FIGURE 10.3
FILTERED TAILINGS DISPOSAL
BELT EXTRACTOR
FLOW DIAGRAM

Source: Adapted from Ref. 5

Alternative 4: Solidification of tailings utilizing cement, asphalt, or other chemical fixants

In 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 would be reclaimed by covering the material with layers of overburden and topsoil and revegetating it to minimize water and wind erosion.

Portland cement could be utilized to fix either the entire tailings solids 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 increase as the ratio of cement to tailings increases (ref. 11, p. 43). The 1:20 cement to tailings mixture could be pumped, if necessary, via a 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% slimes solids (ref. 11, p. 42). When first mixed, the product would be fluid and could be shipped via a pipeline to a disposal site. The major advantages of solidifying tailings in asphalt are (1) leaching resistance is high and (2) radon exhalation is reduced because asphalt is an effective radon diffusion barrier.

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 resultant mixture pumped to a licensed impoundment where solidification would occur within a few days to a few weeks. The waste material would either be entirely entrapped or the pollutants (primarily heavy metals) would be chemically bound in insoluble complexes.[4]

Although theoretically feasible and environmentally desirable, solidification of tailings is expensive. The applicant investigated the costs of utilizing chemical fixants to solidify the tailings, finding the costs to range from $7 to $36 per ton of treated tailings.[4] If a nominal cost of $10 per ton of tailings is assumed, chemically fixing the waste material produced by 15 years of mill operation would cost approximately $91.3 million (discounted to 1978 dollars). The staff estimates that the costs of asphalt or cement fixation would range from $90 million to $105 million.

Alternative 5: Conventional above-grade tailings disposal using an engineered embankment to retain the tailings

This alternative consists of creating a tailings impoundment by constructing a dike to enclose the lower end of the natural basin south of the proposed mill site (Fig. 10.4). A full-height engineered embankment constructed of borrow material would be used to retain 15 years of mill tailings. Because the basin created by the embankment would be filled with tailings by distribution from the top of the dam, construction of the embankment would have to be completed before the system could be used. The downstream segment of the embankment would be constructed of permeable sand. To minimize seepage, the upstream section would be constructed of compacted clayey-silt and silty-sand and would be tied into the soil liner on the bottom of the impoundment. The dam would be approximately 20.7 m (68 ft) high, with a freeboard allowance of about 1.5 m (5 ft) for wave protection. The tailings reservoir would cover approximately 103 ha (250 acres). To prevent erosion of the downstream dam slope, 15 cm (6 in) of gravel, overlain with 30.4 cm (1 ft) of riprap or a 10 cm-thick (4 in-thick) concrete cap reinforced with wire mesh, would be placed over the downstream segment. The floor of the impoundment would be lined with 0.6 m (2 ft) of compacted, locally obtained clayey-silt material to limit seepage from the impoundment.

After the completion of mill 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 Mancos Shale, clayey-silt material, and topsoil of the same configuration as proposed for Alternative 1 [0.6 m (2 ft) of compacted Mancos Shale, 3 m (10 ft) of locally obtained soil, and 23 cm (9 in.) of topsoil] and the area would be revegetated with appropriate plant species.

The total estimated cost for this alternative is $9.6 million (discounted to 1978 dollars) if riprap is used for slope protection. The cost of the Mancos Shale cap is roughly $1.5 million.

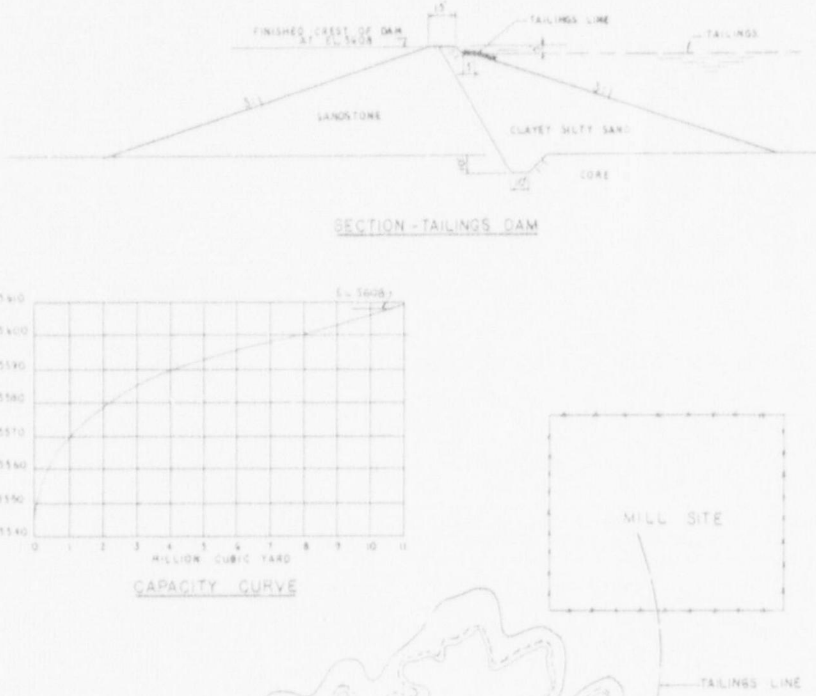

FIGURE 10.4
CONVENTIONAL DISPOSAL
ENGINEERED EMBANKMENT - FULL HEIGHT
Source: Ref. 5

The applicant also investigated the construction of an engineered embankment in stages, with each stage being sized to retain the tailings from five years of mill operation. With the exception that the dam would be exposed to erosion during the operational period (because no riprap could be adequately placed until the final stage is completed), the impacts of staged dam construction would be about the same as would occur if a full-height engineered embankment were to be used. The cost would be approximately $9.4 million (discounted to 1978 dollars). This estimate does not include the cost described above for the Mancos Shale cap.

Alternative 6: Conventional above-grade tailings disposal utilizing an evaporation pond for storage of liquid wastes

This alternative consists of discharging the tailings slurry into a segmented settling pond, with liquid wastes being decanted into an evaporation pond. The settling basin and the evaporation pond would be enclosed by engineered embankments (Fig. 10.5). The evaporation pond would be 1200 m (4000 ft) by 165 m (540 ft), or 20.3 ha (49.5 acres). The main basin would cover approximately 103.7 ha (253 acres). The maximum height of the settling pond embankments would be 12 m (40 ft); the dam around the evaporation pond would be about 9 m (30 ft) high. Small embankments constructed of tailings sands would be constructed in the main basin to create five segments. Tailings would be delivered to the tops of these dikes, with the excess liquids being decanted into the pond area outside the tailings impoundment. As each divided segment is filled to design capacity, it would be allowed to dry and then covered with a layer of compacted Mancos Shale, soil material, and topsoil of the same configuration as proposed for Alternative 1. The main basin and the evaporation ponds would be lined to limit seepage with a 0.6 m (2 ft) liner of clayey-silt materials. The lengths of the embankments required to surround the impoundments would be approximately 4180 m (13,700 ft) for the settling basin and approximately 1550 m (5080 ft) for the evaporation pond. The total cost of this alternative would be approximately $10.7 million (discounted to 1978 dollars). The cost of Mancos Shale cap is $1.8 million.

Alternative 7: Segregated disposal

In this alternative, tailings sands would be separated from slimes and liquids. The dewatered sands would be placed in unlined trenches, and the slimes and liquids would be discharged to clay- or synthetic-lined evaporation ponds (Figure 10.6).

The sands disposal area would cover approximately 126 ha (310 acres) and would consist of a series of parallel, unlined trenches. The total excavation requirements for the area would approach 4.18×10^6 m^3. Sands would be placed in the trenches by a "Mobile Disposal Unit," which would (1) receive the total slurry, (2) remove the sands from the slurry by means of either standard hydrometallurgical cyclones (hydrocyclones) with or without a dewatering screen, and (3) would deposit the moist sands (20 to 25% moisture) in the unlined trenches. The deposited sands would drain to 15 to 20% moisture, and all drainage would be recycled to the mill. Use of the hydrocyclone-dewatering screen option would result in drier sands being deposited, thus minimizing the seepage from the trenches. Each individual trench would be reclaimed after it is filled. The sands would be leveled to the natural grade and a 2.7-m (9-ft) layer of compacted clayey-silt material would be placed over the sands to limit radon emanation and to protect the sands against erosion.

Slimes and liquids would be directed to a 36-ha (90-acre) evaporation pond. The applicant has examined four alternate pond configurations: two above grade (lined with onsite soils), one partially below grade (synthetic-lined), and one below grade (synthetic-lined). Engineered embankments would be constructed for the above-grade and partially above-grade options, and the below-grade option would not require embankments.

The major differences in the costs of the alternative configurations are related to the amount of excavation necessary in construction of the ponds. Dike construction for the above-grade option would require 1.13×10^6 m^3 of fill materials from onsite borrow areas. The partially above-grade option would result in the excavation of 1.53×10^6 m^3, with 305,800 m^3 being used in embankment construction. The below-grade option would result in the excavation of 5.35×10^6 m^3 of material, of which 2.78×10^6 m^3 would be solid rock.

Reclamation would be achieved by covering the area with a suitable radon diffusion barrier over the dry slimes. Given the high radium content of the slimes, the staff feels that the cover configuration proposed in Alternative 1 could be inadequate for the slimes area.

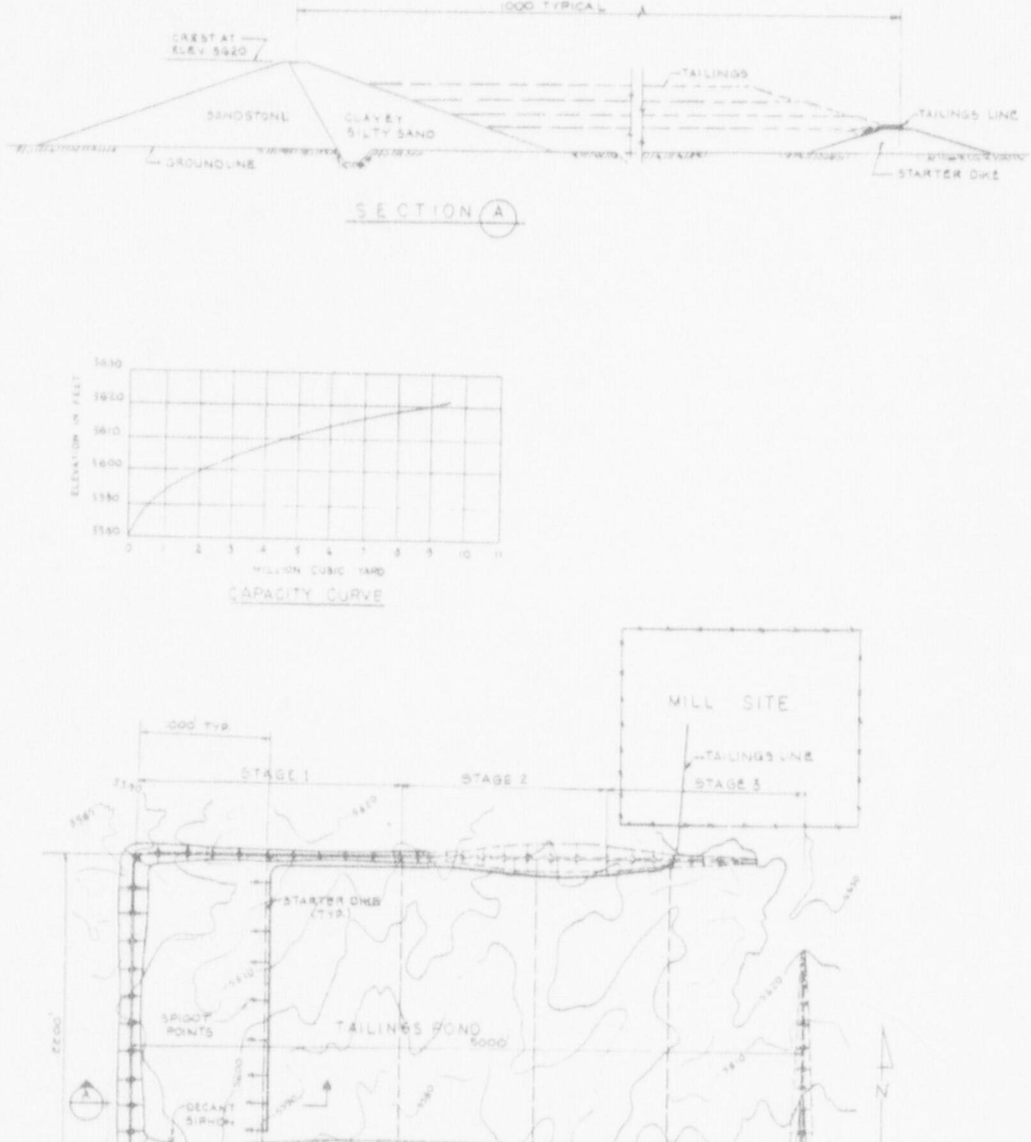

FIGURE 10.5
CONVENTIONAL DISPOSAL
SEGMENTED SETTLING POND AND EVAPORATION POND
SOURCE: Ref. 5

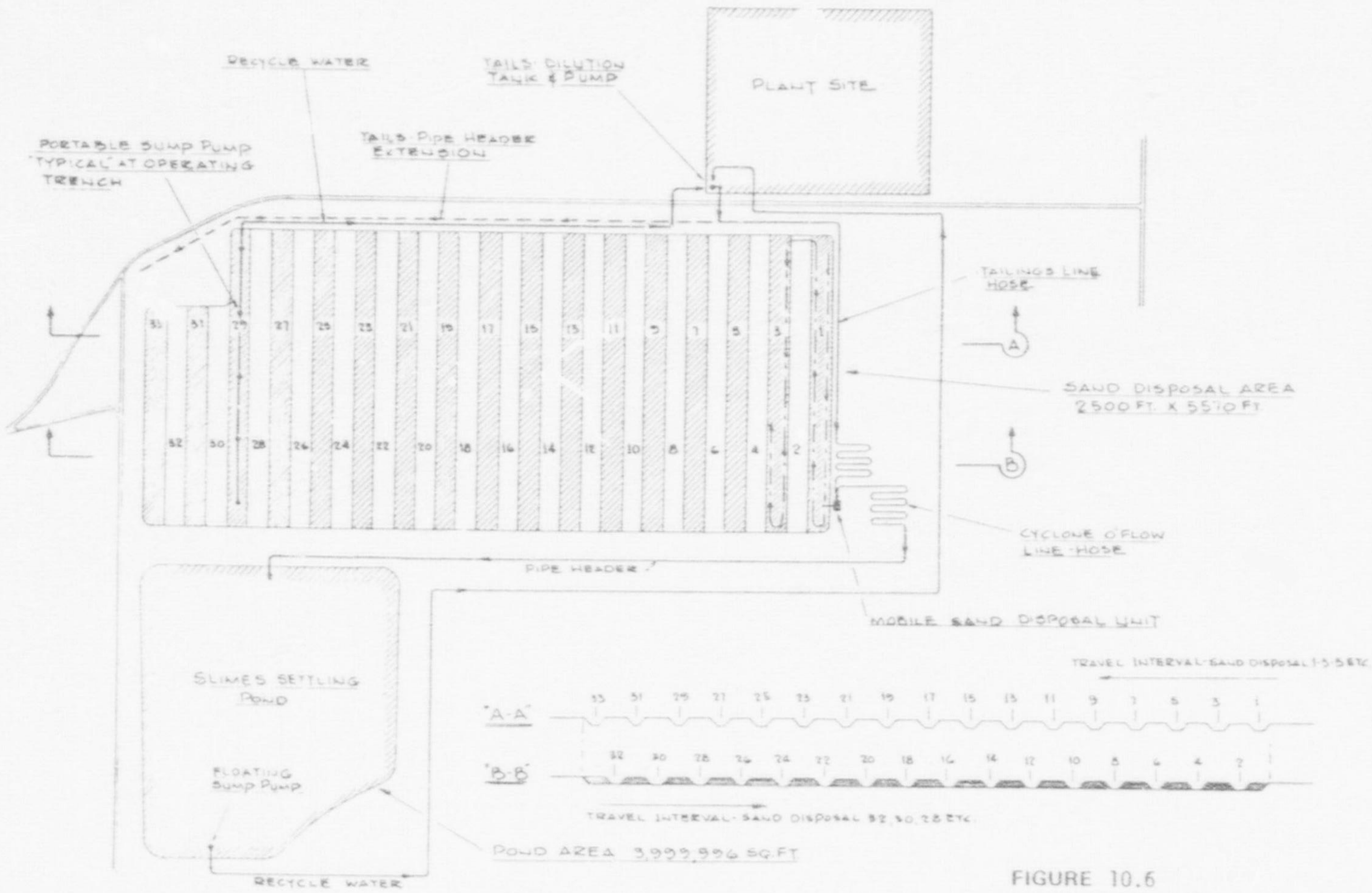

FIGURE 10.6
SEGREGATED DISPOSAL AREA
GENERAL LAYOUT

Source: Ref. 5

The cost of this alternative as estimated by the applicant is a function of the slime-sand separation method and of the slime pond configuration chosen (the increase in costs due to increases in cover material thickness over the dried slimes is not included):

Hydrocyclones only	Hydrocyclones and dewatering screens	Evaporation pond
\$16,720,000	\$16,924,000	Above-grade slimes
\$25,147,000	\$25,350,000	Partially below-grade slimes
\$31,368,000	\$31,571,000	Below-grade slimes
\$16,720,000	\$16,924,000	Above-grade disposal with several small ponds

Alternative 8: Neutralization of tailings

This alternative consists of treating the acidic tailings with various bases to yield a neutral solution. According to ref. 11, pp. 132 and 133, neutralization ". . . causes the precipitation of 90% of the radium, almost all the thorium, and much of the iron, copper, cobalt, arsenic, uranium, vanadium, and other heavy metal ions as insoluble oxides or hydroxides. . . Seepage from neturalized, compacted tailings covered by a pond, or runoff from neutralized tailings, carries very little radium, in contrast to seepage or runoff from unneutralized tailings which may carry dissolved radium."

In Canada, liquid wastes from acid-leach uranium mills are routinely neutralized prior to discharge to natural waterways. Neutralization reportedly requires about 7.3 kg (16 lb) of limestone ($CaCO_3$) and 4.5 to 22 kg (10 to 48 lb) of lime ($Ca[OH]_2$) per ton of ore.[14] A theoretical value of 15.6 MT (34.4 tons) per day of lime for an 1800 MT (2000 tons) per day mill has been reported.[11] The White Mesa Uranium Project would be processing approximately 1800 MT (2000 tons) of ore per day for 340 days per year; therefore, neutralization could require approximately 11,000 MT (12,000 tons) per year of lime [assuming 32 MT (35 tons) per day].

The applicant investigated the possibility of introducing milk of lime into the tailings stream to neutralize the tailings effluent. Neutralization could be applied to any of the tailings disposal alternatives discussed in this section. For alternatives 1, 2, and 6, the applicant estimated that neutralization of the tailings would precipitate about 91 kg (200 lb) of salts (including water of hydration) per ton of tailings. The precipitate would be gelatinous and of low density, and the total volume of tailings would increase slightly. The total capital and operating costs for neutralizing 15 years of mill tailings was estimated to be approximately \$18.55 million (discounted to 1978 dollars) for these alternatives.

The applicant also evaluated the consequences of neutralizing the slimes portion of the tailings produced by segregating the slimes and sands (see Alternative 7). The applicant estimated that approximately 82 kg (180 lb) of salts would be precipitated per ton of tailings, increasing the weight of the slimes and reducing the resulting mixture to approximately 40% solids. The applicant also estimated that to maintain an adequate evaporative rate, the evaporation pond would have to be doubled in size to approximately 73 ha (180 acres). (About 36 ha (90 acres) would be needed for unneutralized slimes.) The total capital and operating costs for neutralization of only the slimes portion of the tailings were estimated to be \$16.34 million, assuming 15 years of mill operation and discounted to 1978 dollars.

10.3.3 Evaluation of alternatives

Alternative 1 is the preferred alternative of the applicant and the staff. The tailings would be stored completely below grade; and although the cover is only partially below grade (approximately 5 of the 12.75 ft of cover are below grade), the final grade on the reclaimed impoundment is slight (<2%), and revegetation of the area and the placement of containment material (riprap or concrete) on all downstream slopes would minimize wind and water erosion. In addition, the small drainage area above the reclaimed tailings area obviates concerns over dispersion of cover from flooding which can be a severe problem over the long term. Therefore, 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 segmented impoundment design, which allows for staged reclamation, would minimize tailings exposure during operations. The liner on cell interiors would essentially eliminate seepage.

Storing the tailings below grade (Alternative 2) in a specially dug pit would minimize seepage over long-term wind and water erosion of the reclaimed pile. In addition, the proposed cover (same as for Alternative 1) would meet the radon exhalation and gamma radiation criteria. However, to provide sufficient pit capacity to contain both the tailings and cover completely below grade, significant amounts of bedrock would have to be excavated by blasting, which could fracture the bedrock increasing its permeability substantially. Because the water table is only 15 to 23 m (50 to 75 ft) below the surface and the pit would be deep (7.6 to 9.2 m (25 to 30 ft)), any failure of a liner could result in liquid wastes reaching the water table through these fractures. In addition, the cost of this excavation could be prohibitive.

Alternative 3 involves dewatering the tailings. The major disadvantages for this dewatering alternative as proposed by the applicant are that the tailings themselves would be partially above grade and susceptible to long-term wind and water erosion following reclamation and that the success of filtration, which depends greatly upon the amenability of the ores to the method chosen for filtration, would be questionable because of the variability of the ores. Also, the clayey-silt liner proposed for the evaporation pond has not been shown to be capable of reducing seepage to the maximum extent reasonably achievable.

Alternative 4 involves solidification of tailings. Although this could be environmentally attractive, the technology is not well established, and at present, the costs far outweigh any benefits that might accrue.

Alternative 5 consists of conventional above-grade dam and pond systems. The reclaimed impoundment area would be highly susceptible to wind and water erosion and would not eliminate the need for ongoing monitoring and maintenance over the long term. In addition, the proposed clayey-silt liner has not been shown to be capable of reducing seepage to the maximum extent reasonably achievable.

Alternative 6 consists of discharging the tailings slurry into a segmented, above-grade settling pond and transferring the tailings liquids to an enclosed, above-grade evaporation pond. The reclaimed impoundment would be susceptible to erosion over the long term. Also the proposed liner has not been shown to be capable of reducing seepage to the maximum extent reasonably achievable.

Alternative 7 involves the segregation of tailings sands from the slimes and liquids and disposal of the sands in unlined trenches and storage of the slimes/liquids in clay- or synthetic-lined impoundments. The slimes ponds would be either above grade, partially below grade, or below grade. The proposed alternative would result in above-grade systems that would be highly susceptible to erosion. Also, the cover over the slimes might not reduce radon exhalation to two times background.

Neutralization of the entire tailings (Alternative 8) might eliminate the need for a liner which is needed to prevent seepage. Neutralization of the slimes produced after segregation of sands from slimes (Alternative 7) or neutralization of dewatered tailings (Alternatives 3 or 6) would be the most effective programs. However, the supplemental costs for neutralization would be high, and are not considered to be justified at the present time by the benefits gained at the White Mesa site.

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 White Mesa 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 White Mesa 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 Alternative considered and rejected

Table 10.1 lists some of the additional alternatives considered and rejected.

Table 10.1. Alternatives considered and rejected

Alternative	Reason for rejection
Precipitate radioactive and toxic elements to bottom of the tailings pond and consider top of tailings as cover	Technology is not developed (would require a selectively permeable bottom liner)
Install drains below pond to collect and discharge 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
Offsite disposal in mines	Control of transportation, unloading, storage, and placement of the wastes in the many small mines as well as monitoring and control of radon gas emissions, particulate emissions, groundwater contamination, and other detrimental impacts would be very difficult (Sect. 10.1.1)
Covering of the tailings with a synthetic liner material such as concrete, asphalt, 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 impoundments	The environmental hazards and the costs of mitigating the adverse impacts associated with tailings disposal would only be shifted from the Blanding 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 nearest currently operating uranium ore processing facilities (in relationship to the applicant's Hanksville and Blanding ore buying stations) are located in Moab, Utah; La Sal, Utah; and Uravan, Colorado. The approximate highway distances of these mills from the Hanksville and Blanding stations are, respectively, Moab, 189 km (118 miles) and 134 km (84 miles); La Sal, 243 km (152 miles) and 74 km (46 miles); and Uravan, 339 km (212 miles) and 170 km (106 miles).

Although the mill located in La Sal (Humeca) is reasonably close to the Blanding ore buying station, it would have drawbacks as an ore processing alternative for the following reasons:

1. The Humeca mill utilizes an alkaline leach process. Although tests conducted by the applicant indicated that some of the ores bought by its ore buying stations could be successfully treated by alkaline leaching, higher recovery rates could be obtained with acid for the majority of the ores. Because most of the ores are low grade (about 0.125%), any significant lowering of recovery rates would decrease the economic feasibility of ore shipment from the scattered, small mining operations.

2. Currently, only ore from a company-owned and company-operated mine is being processed; therefore, it is questionable whether the mill has the capacity, processing capability or the willingness to accept additional ore.

The mills at Moab and Uravan utilize acid leaching (the Moab mill also has an alkaline leach circuit); therefore, with process adjustments, acceptable recovery rates could be obtained. However, primarily because of high haulage costs and the limited capabilities of the mills to process additional ore, the staff has concluded that processing the ores at either or at both of these mills is not feasible. Assuming that (1) transportation costs are 10¢ per ton-mile[6] and (2) the average grade of the ore bought at the applicant's Hanksville and Blanding ore-buying stations will be 0.125%, the staff estimates that, if the ore is shipped to these currently operating 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 incremental cost for toll milling):

1. Moab mill - $3.20 per pound.

2. Humeca mill (La Sal) - $3.04 per pound.

3. Uravan mill - $7.84 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 Blanding 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. If no mills (or expansions) are constructed, a substantial economic base for the Hanksville-Blanding area will be removed because many of the small independent mines would not be economically viable.

10.5 ALTERNATIVE ENERGY SOURCES

10.5.1 Fossil and Nuclear Fuels

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 unit 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, since availability will be the key factor in the choice of fuel to be used.

Table 10.2 shows the disparity between availability and usage of energy resources in the U. S. Although these data are for 1974 (more up-to-date figures are not yet available), estimates from 1974 through 1977 indicate little difference. Gas usage in 1976 decreased slightly (~ 1%), and this decrease is continuing; oil, coal, and nuclear usage increased slightly.[14,15]

Table 10.2. Reserves and Current Consumption of Energy Sources[14]

	Percent of Proven U.S. Energy Reserves Economically Recoverable with Existing Technology 1974	Percent of Total U.S. Energy Consumption Contributed by Each Energy Resource, 1974
Coal	90	18
Oil	3	46
Gas	4	30
Nuclear	3	2
Other	0	4

For a given thermal content, transport facility requirements (trains, trucks, etc.) for U_3O_8 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-MWe nuclear plant operating at a plant factor of 80%. Annual coal requirements for an equivalent 1000-MWe coal plant would be more than three million tons, or the full capacity of at least one unit-train (100 cars of 100 tons each) per day of plant operation.

The evidence available at this time indicates that, of the resources currently used in electric power generating stations (coal, uranium, oil, gas, and hydro), only coal and uranium have the potential for long-range reliability in increasing domestic energy production. Because of the time lag between initial extraction and the consumption of the resource for energy production (3-5 years from mine to generation plant for uranium and coal, 5-7 years for construction of a coal-fired generating plant, and 7-10 years for construction of a nuclear generating plant), the exploitation of both coal and uranium resources must be integrated with contemporary energy needs. Neither the coal- nor uranium-producing industries are considered capable of singly supporting the electrical energy requirements projected for the next few decades; major expansion of both industries will be required to fill projected needs.[15]

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.[17] 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.

10.5.2 Solar, Geothermal, and Synthetic Fuels

Estimates reported in the "National Energy Outlook"[14] indicate that solar and geothermal sources will each supply about one percent of U. S. energy requirements by 1985 and about two percent by 1990. Supplies of synthetic gas and oil derived from coal will probably not exceed one percent 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 government incentives. A maximum of six percent of projected 1990 energy requirements is expected to be derived from solar, geothermal, and synthetic fuel resources combined. 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.

In 1975, the U. S. consumed about 71 q of energy (1 q = 10^{15} Btu); of this total, 20 q consisted of electric energy. By the end of 1977 an estimated 12% of this 20 q electric energy was

being generated using nuclear fuels; within ten years, the percentage is expected to increase to 20%[14,15]

Coal was used to produce 50% of the electric energy generated by the combustion of fossil fuels in 1975. Relative changes in resources used for electricity generation, as estimated in "Project Independence,"[16] are shown in Table 10.3. The National Energy Plan [15] confirms these views of resource dependence. All information available to date indicates that coal and uranium must be used to generate an increasing share of future U. S. energy needs because of decreasing supplies of oil and gas available for electric power generation. The U. S. does not have sufficient oil and gas reserves to ensure a long-term supply, but coal and uranium resources are adequate for foreseeable needs. Currently, rising prices for oil and gas are a reflection of increasing competition for these two resources, which both may be severely depleted in the next few decades.

Coal production must be increased to meet projected requirements for the next decade (the total requirement is seen as 1040 million tons in 1985 vs. 640 million tons in 1977).[14-16] The major expansion of coal production will likely be in the West (from 92 million tons in 1974 to 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 U. S. will be increased. Since the major markets for the coal produced are located hundreds of miles from the mines, transportation costs will be high, as will the environmental impacts associated with transportation systems. Transportation costs for bringing western coal to the eastern U. S. currently account for the major portion of the delivered market price.

Table 10.3. Estimated Relative Changes in Resources to be Used for Electricity Generation through 1985[16]

	Percent of Thermal Energy Required in Year				
Fuel Resource	Used	1970[a]	1974[b]	1980[b]	1985
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 q's of energy[e] required	15.6	20	25.5	34	

[a]Actual.

[b]Estimated.[18]

[c]Coal usage must increase (from 640×10^6 tons/yr to 1.04×10^9 tons/yr) by 1985 to attain this level.

[d]Uranium-fueled reactors furnished 9.9% of the total U. S. production in January 1976, and 12% in January 1977.

[e]$1\ q = 10^{15}$ Btu.

10.5.3 Byproduct Uranium

Uranium recoverable as a byproduct of phosphate fertilizer and copper production have increased from 90,000 tons (U_3O_8) in 1974 to 140,000 tons in 1977. These resources are in addition to the 808,000 tons ($50 forward cost) available from conventional mining and milling sources.

A report by the National Academy of Sciences states:[18]

> "Like all byproducts commodities, byproduct 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. Byproduct 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 short tons of 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 thought that other porphyry copper deposits might also be possible sources of byproduct uranium.

The staff has studied available data on the potential of uranium production from phosphate fertilizer production[19] 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.[19,20] 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 byproduct 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.[20]

10.5.4 Energy Conservation

The cornerstone of the National Energy Plan (NEP) 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.
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 U. S. 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 RELICENSING 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 Energy Fuels 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 thus 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. Alternate (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 yellowcake produced by the White Mesa 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 White Mesa mill were 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.

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11. NRC BENEFIT-COST SUMMARY FOR THE WHITE MESA 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 which includes a review of the availability of uranium resources. The uranium to be produced by the White Mesa 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 White Mesa mill.

11.2 QUANTIFIABLE ECONOMIC IMPACTS

Section 4 of this Environmental Statement treats the quantifiable economic impacts for the White Mesa 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 White Mesa 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 White Mesa 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 White Mesa 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 would reduce to acceptable levels the short- and long-term adverse environmental impacts and costs associated with the project.

The White Mesa Uranium Project, along with other energy-related projects in the area, will create a short-term stress on the political and social systems (including housing and schools) of the area. The quantity of total tax money appears to the staff to be adequate but the distribution may not be (see Sect. 11.2). This aspect of the project is currently receiving attention by the institutions directly concerned, and mitigation appears possible.

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 White Mesa Uranium Project is favorable, and the indicated action is that of licensing.

This assessment is subject, however, to reevaluation in the light of additional information regarding archaeological resources and the comments of the Advisory Council on Historic Preservation.

APPENDIX A

RESERVED FOR COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

APPENDIX B. BASIS FOR NRC EVALUATION OF THE WHITE MESA MILL PROPOSAL

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 (U-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 (U-235, U-238, Pu) from fission products (waste), with concurrent separation of uranium from plutonium.

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 LWR fuel has also been deferred. These policy statements enter into the staff's evaluation of the need for licensing the White Mesa project 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 White Mesa mill and the related uranium mines.

This cycle, as defined by current policy, is portrayed in Figure B.1.

Nuclear reactor operation converts about 75% of the fissionable isotope (U-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.

USE OF NUCLEAR FUEL IN REACTORS

Two types of reactors are currently used to generate essentially all of the nuclear energy sold in the U.S.: 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

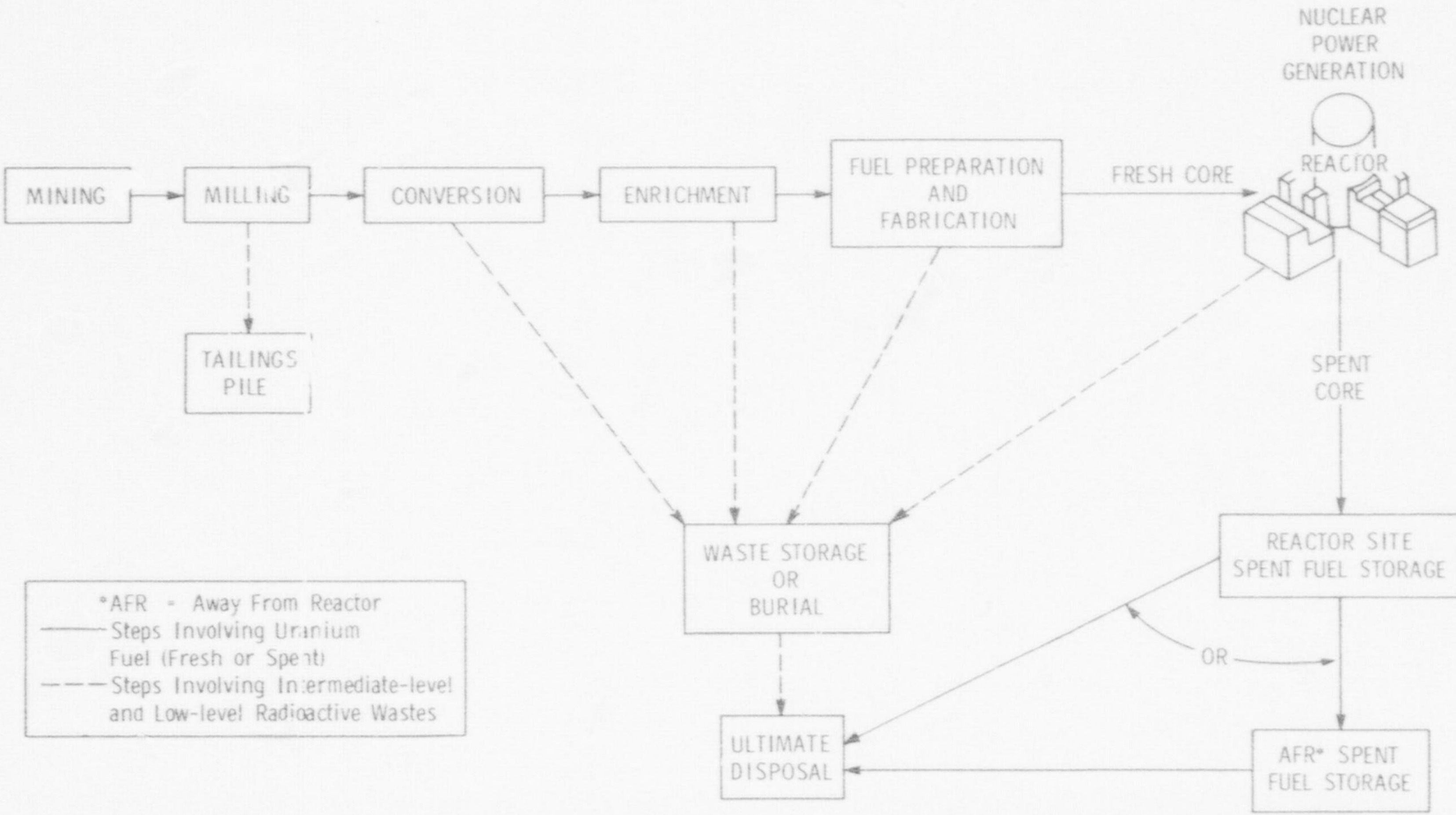

Fig. B.1. The LWR Fuel Cycle.

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 $\sim$ 22 MT of uranium fuel per year at a plant factor of 0.6 and $\sim$ 30 MT 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 MT 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]

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, $\times 10^3$ MT
1976	43	9,500	9.35
1977	49	10,000	19.1
1978	53	10,000	29.1
1979	57	11,000	40.2
1980	61	11,[illegible]00	52.0
1981	74	17,500	69.4
1982	87	18,000	87.6
1983	100	20,500	108
1984	112	22,500	130
1985	127	26,500	157
1986	141	28,000	185
1987	154	30,000	215
1988	167	32,500	248
1989	181	35,500	283
1990	195	38,000	321
1991	210	41,000	362
1992	225	43,500	406
1993	240	46,500	452
1994	260	51,500	504
1995	280	54,500	558
1996	300	58,000	616
1997	320	61,500	678
1998	340	65,500	743
1999	360	68,500	811
2000	380	71,500	883

[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] Minimum	Total Generating Capacity, GWe[a] Maximum	Nuclear Generating Capacity, GWe: 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.

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] i.e., the sum of reserves and probable resources is approximately equal to the lifetime requirements of the 380 GWe installed by 2000.

Table B.3. Comparison of U. S. Reactor Requirements and Domestic Resource Availability (in MT U_3O_8 as of January 1978)[a,b]

Time Period	Reactor Demand	Resource Availability @ \$30/lb[c]	Resource Availability @ \$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. Dept. 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 byproduct of phosphate fertilizer and copper production.

In 1977, 23 mills produced about 12,000 MT (14,000 tons) of U_3O_8 while handling 32,000 MT (35,000 tons) of ore per day. These mills operated at 80 to 85% of capacity. The U_3O_8 content of the ore was less than 3 lb/ton (< 0.15%).[4] Ores processed by the White Mesa mill will have a U_3O_8 content approximating this national average.

As can also be seen from 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). The White Mesa project would produce in 1980 6% of the national capacity for tons 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 forecasted for the nuclear power industry.

REFERENCES FOR APPENDIX B

1. National Energy Plan, Office of the President, April 1977.
2. Brown and Williamson, "Domestic Uranium Requirements, Policy and Evaluation," U. S. Department of Energy, paper presented at the Uranium Seminar, Grand Junction, Colorado, 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, CO., October 1977.

APPENDIX C

STATEMENTS OF GENERAL FUND REVENUES AND EXPENDITURES

FOR SAN JUAN COUNTY,

BLANDING AND MONTICELLO

SAN JUAN COUNTY
GENERAL FUND
STATEMENT OF REVENUES, EXPENDITURES, AND COMPARISON WITH BUDGET
FOR THE YEAR ENDED DECEMBER 31, 1977

EXPENDITURES	BUDGET	1977 TOTAL ACTUAL	OVER (UNDER) BUDGET	1976 ACTUAL PRIOR YEAR
GENERAL GOVERNMENT:				
Commission	$ 31,950	$ 31,434	$ (516)	$ 28,785
District court	3,150	2,994	(156)	3,252
City and precinct courts	15,000	22,364	7,364	15,818
Other judicial	6,500	1,907	(4,593)	922
Clerk and auditor	40,250	34,284	(5,966)	35,005
Recorder	36,980	39,877	2,897	34,648
Attorney	24,100	22,974	(1,126)	21,781
Treasurer	16,380	15,094	(1,286)	13,978
Assessor	23,825	26,336	2,511	26,086
Surveyor	39,970	37,706	(2,264)	40,340
Planning commission	1,000	727	(273)	
Non-departmental	185,500	222,525	37,025	192,005
Buildings	18,150	21,143	2,993	18,258
Advertising and community promotion	68,070	31,820	(36,250)	37,662
Total general government	$ 510,825	$ 511,185	$ 360	$ 468,540
PUBLIC SAFETY:				
Sheriff	$ 155,820	$ 144,320	$(11,500)	$ 145,648
Fire department	5,835	5,787	(48)	4,273
Corrections (jail)	36,100	36,156	56	31,021
Other protection	12,600	11,859	(741)	11,272
Total public safety	$ 210,355	$ 198,122	$(12,233)	$ 192,214
PUBLIC HEALTH:				
Health services	$ 326,315	$ 250,157	$(76,158)	$ 155,538
HIGHWAY AND PUBLIC IMPROVEMENT:				
Highways	$ 653,500	$ 750,896	$ 97,396	$ 767,420
Class "B" roads	550,000	310,992	(239,008)	328,004
Collector roads	580,000	96,583	(483,417)	203,713
Miscellaneous	119,800	17,899	(101,901)	11,939
Total highway and public improvement	$1,903,300	$1,176,370	($726,930)	$1,311,076

SAN JUAN COUNTY
GENERAL FUND
STATEMENT OF REVENUES, EXPENDITURES, AND COMPARISON WITH BUDGET
FOR THE YEAR ENDED DECEMBER 31, 1977

EXPENDITURES	BUDGET	1977 TOTAL ACTUAL	OVER (UNDER) BUDGET	1976 ACTUAL PRIOR YEAR
PARKS, RECREATION AND PUBLIC PROPERTY:				
Parks and recreation	$ 71,293	$ 71,602	$ 309	$ 63,823
Television	9,600	17,436	7,836	18,702
Total parks, recreation and public property	$ 80,893	$ 89,038	$ 8,145	$ 82,525
CONSERVATION AND ECONOMIC DEVELOPMENT:				
Agriculture and extension service	$ 13,875	$ 16,073	$ 2,198	$ 13,346
Total conservation and economic development	$ 13,875	$ 16,073	$ 2,198	$ 13,346
TOTAL EXPENDITURES - GENERAL FUND	$3,045,563	$2,240,945	$(804,618)	$2,223,239
EXCESS REVENUES (EXPENDITURES)	$ (537,428)	$ 444,977	$ 982,405	$ 310,766

Source: San Juan County Audit for 1977.

SAN JUAN COUNTY
GENERAL FUND
STATEMENT OF REVENUES, EXPENDITURES, AND COMPARISON WITH BUDGET
FOR THE YEAR ENDED DECEMBER 31, 1977

REVENUES	BUDGET	1977 TOTAL ACTUAL	OVER (UNDER) BUDGET	1976 ACTUAL PRIOR YEAR
TAXES:				
General property taxes		$ 891,085		$ 846,129
Delinquent prior years' taxes		8,918		13,714
General sales and use taxes		87,496		74,374
Penalties and interest on taxes		6,020		5,174
Total taxes (Note 2)	$ 891,085	$ 993,519	$ 102,434	$ 939,391
LICENSES AND PERMITS:				
Business licenses and permits		$ 3,150		$ 3,250
Non-business licenses and permits		816		463
Total licenses and permits	$ ...	$ 3,966	$ 3,966	$ 3,713
INTERGOVERNMENTAL REVENUES:				
Federal grants	$	$ 11,655	$ 11,655	$ 11,892
Federal shared revenue		119,029	119,029	186,671
Federal payments in lieu of taxes	445,000	292,902	(152,098)	
State grants	14,000	36,392	22,392	9,453
State shared revenues	550,000	539,838	(10,162)	525,572
Grants from other units	134,000	114,712	(19,288)	92,331
Total intergovernmental revenues	$1,143,000	$1,114,528	$(28,472)	$ 825,919
CHARGES FOR SERVICES:				
General government	$ 11[illegible]350	$ 81,055	$(38,795)	$ 74,934
Public safety	7,[illegible]	5,8[illegible]4	(1,686)	10,591
Streets and public improvements	142,000	155,144	13,144	305,882
Health		3,120	3,120	4,160
Parks and public property	24,000	12,755	(11,245)	24,283
Miscellaneous services	19,700	32,834	13,134	29,528
Total charges for services	$ 313,050	$ 290,722	$(22,328)	$ 449,378
FINES AND FORFEITURES:				
Fines	$ 61,000	$ 91,697	$ 30,697	$ 72,202
MISCELLANEOUS REVENUES:				
Interest earnings		$ 79,409		$ 61,114
Rents and concessions		38,909		119,276
Sale of materials and supplies		73,172		63,012
Total miscellaneous revenues	$ 100,000	$ 19[illegible],490	$ 91,490	$ 243,402
TOTAL REVENUES - GENERAL FUND	$2,508,135	$2,685,922	$ 177,787	$2,534,005

CITY OF BLANDING
Blanding City, Utah

SCHEDULE: "E"

STATEMENT OF GENERAL FUND REVENUES and EXPENDITURES - FISCAL YEARS ENDED JUNE 30, 1976 - 1977

	June 30, 1976		June 30, 1977	
REVENUE RECEIPTS:				
Current Year Property Taxes	$ 37,959.53		$ 44,393.96	
Redemption - Prior Years Taxes	3,488.70		1,691.72	
Sales and Use Taxes	43,336.72		55,313.55	
Business Licenses	489.00		450.00	
Building and Construction Permits	645.80		1,387.60	
Bicycle Permits	7.00		6.00	
Other Licenses and Permits	85.00		245.00	
Grants From Federal Government	5,937.30		770.00	
Federal Revenue Sharing	14,087.00		18,227.00	
State Liquor Fund Allotment	4,248.20		4,248.20	
Class "C" Road Fund Allotment	6,940.83		14,278.44	
Other Governmental Grants	2,056.46		5,626.70	
Airport Revenue	1,782.33		1,351.87	
Cemetery Lot Sales	700.00		280.00	
Court Fines and Penalties	7,879.00		6,718.50	
Waste Collection and Disposal Fees	17,451.37		18,462.50	
Waste Collection and Disposal Penalties	80.61		102.61	
Earned Interest - Class "C" Road Fund	907.56		480.26	
Earned Interest - Revenue Sharing Fund	1,335.16		760.33	
Earned Interest - Airport Construction Fund	70.12		98.79	
Proceeds From Sale of G. O. Bonds	-- --		225,000.00	
Earned Interest - G. O. Bond Funds	577.42		3,389.71	
Miscellaneous Revenues	318.52		1,193.31	
Total Receipts		$150,383.63		$404,476.05
Cash Accountability Adjustments -				
Add:				
Cash Contribution - Electric, Water and Sewer Fund, Account Current		7,770.05		-- --
Deduct:				
Discounts Allowed - Waste Collection and Disposal		(134.65)		(87.73)
Balance - Cash Receipts		$158,019.03		$404,388.32
Add:				
Non-Cash Revenues:				
Service Fees (Waste Collection and Disposal)-				
Representative of Uncollectible Accounts Charged	127.25		180.00	
Electric, Water and Sewer Utility Fund-				
Account Current Credits	11,525.33		9,672.01	
Employee Payroll Taxes, Retirement Funds, and				
Insurance Premiums Withheld	8,219.98		9,845.59	
Elected Officials and Firemen Employee Benefits				
Allowed; Insurance Premiums	-- --		1,522.94	
Total Revenue Adjustments		$ 19,872.56		$ 21,220.54
TOTAL GROSS REVENUES		$177,891.59		$425,608.86

CITY OF BLANDING

Blanding City, Utah

SCHEDULE: "E" STATEMENT OF GENERAL FUND REVENUES AND EXPENDITURES - FISCAL YEARS ENDED JUNE 30, 1976 - 1977 . . . . CONTINUATION . . . .

EXPENDITURE CHARGES:				
Operating Expenditures:				
Administrative	$ 6,044.01		$ 5,606.53	
Municipal Court	2,742.42		3,536.93	
Election Expense	388.14		1,086.75	
Audit Expense	589.50		589.50	
Police Department Expense	47,288.56		46,929.58	
Fire Department Expense	2,396.21		4,744.42	
Inspection Department Expense	60.00		60.00	
Street Department Expense	17,969.27		26,960.59	
Debt Service Redemptions:				
Water Bonds - Series 11-1-47	1,105.00		1,075.00	
Sewer Bonds - Series 12-1-54	1,532.20		1,498.50	
Light Bonds - Series 5-1-57	6,522.50		6,275.00	
Water Bonds - Series 5-1-74	18,887.50		18,188.40	
Waste Collection and Disposal Expense	12,725.04		14,666.88	
Airport Expense	3,352.04		4,824.35	
Class "C" Road Fund Expense	2,180.06		-- --	
Parks and Recreation Expense	75.13		105.34	
Total Operating Expenditures		$123,857.98		$136,147.77
Other Expenditures:				
Surplus Invested In Fixed Assets	7,480.83		11,396.36	
Remittance - Employees' Withheld Taxes and Insurance Premiums	8,332.04		10,686.07	
Contribution - Electric, Water and Sewer, Account Current	154,330.36		48,344.32	
Refunds - Waste Collection and Disposal	4.00		-- --	
Total Other Expenditures		170,147.23		70,427.80
TOTAL EXPENDITURES		$294,005.21		$206,575.57
EXCESS (DEFICIT): Revenue Receipts Over Expenditures		($116,113.62)		$219,033.29
Adjustments:				
Incremental Increase in Unappropriated Surplus -				
Employees' Insurance Premiums Advanced, Increase		(11.72)		(1,032.76)
Waste Collection and Disposal Accounts Receivable, Increase		21.38		28.37
Payroll Taxes Payable, Increase		123.78		142.98
Electric, Water and Sewer - Account Current, Increase		135,034.98		38,672.31
Net Increase In Unappropriated Surplus		$19,054.80		$256,844.19

MONTICELLO

GENERAL FUND

	1977-1978 Adjusted Budget
Revenues	
Property taxes	$ 37,536
Sales tax	79,908
Court fines	16,422
Class "C" Road Fund	4,950
State Liquor Allotment	2,702
Business licenses	1,602
Other licenses and permits	2,066
Other revenues	2,450
Total Revenues	$147,636
Disbursements	
Administration	$ 54,800
Court	3,700
Police	49,400
Fire	1,700
Streets	10,200
Parks	2,000
Total Disbursements	$121,800
Transfer to Bond Redemption & Interest Fund	19,500
	$141,300
Excess of Revenues over Disbursements and Transfers	$ 6,336

APPENDIX D. DETAILED RADIOLOGICAL ASSESSMENT

Supplemental information is provided below which describes the models, data, and assumptions utilized by the staff in performing its radiological impact assessment of the White Mesa 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 (Ref. 1).

D.1 ANNUAL RADIOACTIVE MATERIAL RELEASES

Estimated annual activity releases for the White Mesa site are provided in Table 3.3. They are based on the data and assumptions given in Table 3.2 and described elsewhere in Section 3 and in Appendix F, with the exception of the annual average dusting rate for exposed tailings sands. This dusting rate is calculated in accordance with the following equation:

$$M = \frac{3.156 \times 10^7}{0.5} \sum_s R_s F_s \qquad \text{(D-1)}$$

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 $\leq$ 20 μm diameter, g/m²-sec;
M is the annual dust loss per unit area, g/m²-yr;
3.156×10^7 is the number of seconds per year; and
0.5 is the fraction of the total dust loss constituted by particles $\leq$ 20 μm diameter, dimensionless (Ref. 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 555 g/m²-yr. Annual curie releases from the tailings piles are then given by the following relationship:

$$S = MA\,(1-f_c)\,f_t\,(423)(2.5)(1\times10^{-12}) \qquad \text{(D-2)}$$

where A is the assumed beach area of the pile, m²;
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/yr;
423 is the assumed raw ore activity, pCi/g;
2.5 is the dust to tails activity ratio; and
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/m²-sec[a]	Frequency of Occurrence(F_s)[b]
0-3	1.5	0	--
4-6	5.5	0	--
7-10	10.0	3.92×10^{-7}	0.2836
11-16	15.5	9.68×10^{-6}	0.1736
17-21	21.5	5.71×10^{-5}	0.0395
>21	28.0	2.08×10^{-4}	0.0229

(a) Dusting rate as a function of wind speed is computed by the UDAD code (Ref. 1).
(b) Wind speed frequencies obtained from annual joint frequency data presented in Table D.2.

HOADR, MODIX

METSET BLANDING, UTAH

JOINT FREQUENCY DATA IN PERCENT

MPH	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
STABILITY CLASS 1																	
1.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0387	0.0000	0.0000	0.0000	0.0000	0.0000	.0387
5.5	0.0000	0.0000	0.0000	0.0000	.0387	0.0000	.0387	0.0000	.1550	.0387	.1162	.0387	.0387	0.0000	0.0000	0.0000	.4647
10.0	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
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	0.0000	0.0000	0.0000	0.0000	.0387	0.0000	.0387	0.0000	.1550	.0387	.1549	.0387	.0387	0.0000	0.0000	0.0000	.5034
STABILITY CLASS 2																	
1.5	.0775	.0387	.0775	.0387	0.0000	.0775	.0775	.0387	.1550	.0775	.1937	.1162	.0387	0.0000	.1550	.0387	1.2009
5.5	.1162	.0775	.1162	.0775	.2325	.1937	.9812	.7361	1.2011	.4262	.5812	.2712	.2712	.1550	.1162	.0775	5.6305
10.0	0.0000	0.0000	.0775	.0775	.0387	.1162	.6199	.7361	1.3581	.2325	.4262	.1550	.3487	.0387	.0387	0.0000	4.2638
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	.1937	.1162	.2712	.1937	.2712	.3874	1.6786	1.5109	2.7142	.7362	1.2011	.5424	.6586	.1937	.3099	.1162	11.0952
STABILITY CLASS 3																	
1.5	0.0000	.0387	.0387	0.0000	.0387	0.0000	.0387	.0387	0.0000	0.0000	.1162	.0387	.0775	0.0000	0.0000	.0387	.4646
5.5	.1937	.2325	.5087	.3487	.5812	.2325	.6587	.3874	.6082	.3910	.5317	.1937	.1550	.0775	.2712	.1162	5.0879
10.0	.1550	.0775	.0775	.0387	.0775	.1550	.2712	.2325	.9686	.8136	.6974	.1937	.1162	.1162	.3487	.0775	4.4168
15.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.2325	.1937	.2325	.3874	.5812	.1162	.1162	.0775	.1162	.0387	2.0921
21.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0775	0.0000	0.0000	.0387	0.0000	0.0000	0.0000	0.0000	.1162
28.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0387	0.0000	.0387	0.0000	0.0000	0.0000	0.0000	.0774
ALL	.3487	.3487	.6249	.3874	.6974	.3875	1.2011	.8523	1.8868	1.6307	1.9265	.6197	.4645	.2712	.7361	.2711	12.6550
STABILITY CLASS 4																	
1.5	.1550	.1162	.1162	.1937	.2325	.3487	.1162	.2325	.2325	.1162	.0387	.1162	.0387	.1550	.0387	.1550	2.4020
5.5	.3100	.5037	1.0171	.9395	.9395	.9782	.7749	.5424	.3874	.2712	.4649	.1550	.2712	.3100	.1550	.2325	8.2525
10.0	.1550	.5812	.6974	.2325	.1162	.1937	.4262	.4262	.6974	.5424	.3874	.1937	.1937	.3487	.4649	.2325	5.8891
15.5	.6199	1.0074	.6974	.1162	.1162	.4649	.4649	.4262	1.5498	1.9330	1.4723	.8911	1.0849	.5037	1.4723	.7361	13.0569
21.5	.2325	.0775	.0775	0.0000	0.0000	.1162	.0387	0.0000	.1937	.6974	.5037	.5037	.4262	.1550	.4649	.3487	3.8357
28.0	.0387	0.0000	0.0000	0.0000	0.0000	.0387	.0775	0.0000	.0775	.4262	.3487	.1550	.1550	.1937	.5424	.1550	2.2084
ALL	1.5111	2.2860	2.6056	1.4819	1.4044	2.1404	1.8980	1.6273	3.1383	3.4870	3.2157	2.0147	2.1697	1.6661	3.1382	1.8598	35.6446
STABILITY CLASS 5																	
1.5	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
5.5	.3874	.5812	.8138	.4649	.1550	.1550	.1937	.1937	.3487	.1550	.2712	.1162	.0387	.1937	.3874	.4649	4.9205
10.0	1.1236	1.3173	1.8985	.1937	.0775	0.0000	.1162	.0775	.3487	.6974	.4649	.1550	.3487	.2712	1.5110	1.2011	9.8023
15.5	.1162	.2325	.3100	0.0000	.0775	.0387	0.0000	.0775	0.0000	.0775	.1550	.1162	.1937	0.0000	.5037	.3100	2.2085
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	1.6272	2.1310	3.0223	.6586	.3100	.1937	.3099	.3487	.6974	.9299	.8911	.3874	.5811	.4649	2.0021	1.9760	16.9313
STABILITY CLASS 6																	
1.5	.3566	.1627	.2402	.1550	.3487	.1162	.1162	.3100	.1550	.0775	.1550	.1162	.1937	.2712	.3178	.2403	3.3321
5.5	1.4491	1.7590	1.8752	1.0849	.4649	.5037	.4262	.4262	.6587	.8911	.7749	.3874	.8911	.8136	2.1852	1.6628	16.2340
10.0	.4339	.5501	.4339	.2325	0.0000	.0387	.0387	.0387	.1937	.1162	.1937	.0387	.0387	.2712	.3565	1.0152	3.9904
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	2.2398	2.4718	2.5493	1.4724	.8136	.6586	.5811	.7749	1.0074	1.0848	1.1236	.5423	1.1235	1.3560	2.8595	2.8983	23.5565
ALL	5.9201	7.3537	9.0733	4.1940	3.5353	3.7070	5.7078	5.1141	9.5991	7.9073	8.5129	4.1452	5.0365	3.9519	9.4058	7.1214	100.3860

Table D.2 White Mesa Joint Frequency Meteorological Data

For the White Mesa site, it was assumed that two 100-acre cells would be available for dusting while drying prior to reclamation. Required mitigating actions to reduce dusting were assumed to reduce dust losses by 80 percent for these cells. It was also assumed that half of a third 100-acre cell being filled would be beach area and available for dusting. No control was assumed for the exposed beach area of the operational cell.

Dust losses from the six-acre ore storage pile were estimated by assuming they would be about one percent of those from an equivalent area of tailings beach.

D.2 ATMOSPHERIC TRANSPORT

The staff analysis of off site air concentrations of radioactive materials released at the White Mesa mill site has been based on a full year of meteorological data collected on site over the period 3/1/77 through 2/28/78 (Ref. 2). The collected meteorological data is 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 (Ref. 1). Ground level, sector-average concentrations are computed using this model and are corrected for decay and ingrowth in transit (for Rn-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 which depends on the age of the deposited material and its particle size (Ref. 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.

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
Yellowcake Dusts	1.0	8.9	1.0	2.98
Tailings, Ore Pile	5.0 (30%)	2.4	1.0	7.75
Dusts	35.0 (70%)	2.4	8.8	54.2
In-grown Rn Daughters	--	1.0	0.3	0.3

[a]Aerodynamic equivalent diameter, used in calculating inhalation doses (Ref. 1).

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 White Mesa 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 U-238, Th-230, Ra-226, Rn-222 (air only), and Pb-210. Concentrations of Th-234, Pa-234, and U-234 are assumed to be equal to that of U-238. Concentrations of Bi-210 and Po-210 are assumed to be equal to that of Pb-210.

D.3.1 Air Concentrations

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). In order 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:

$$C_{aip}(t) = C_{aipd} + C_{aipr}(t) \qquad \text{(D-3)}$$

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; and

$C_{aipr}(t)$ 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

$$R_p(t) = (1/V_p)10^{-5}\ e^{-\lambda_R t} \quad (\text{for } t \le 1.82 \text{ yrs}) \qquad \text{(D-4a)}$$

$$R_p(t) = (1/V_p)10^{-9} \quad (\text{for } t > 1.82 \text{ yrs}) \qquad \text{(D-4b)}$$

where $R_p(t)$ is the ratio of the resuspended air concentration to the ground concentration, for a ground concentration of age t yrs, 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 halflife), 5.06 yr;

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}; and

1.82 is the time required to reach the terminal resuspension factor, yrs.

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 (Ref. 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

$$C_{aipr}(t) = 0.01\ C_{aipd} \left[10^{-5} \left\{ \frac{1 - \exp\left[-(\lambda_i^* + \lambda_R)\ 1.82\right]}{(\lambda_i^* + \lambda_R)} \right\} + 10^{-9} \left\{ \frac{\exp(-1.82\lambda_i^*) - \exp(-\lambda_i^* t)}{\lambda_i^*} \right\} \right] \qquad \text{(D-5)}$$

where λ_i^* is the effective decay constant for isotope i on soil (see Equation D-7), yr^{-1}; and 0.01 is m/cm.

Total air concentrations are computed using Equations D-5 and D-3 for all particulate effluents. Radon daughters which 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

$$C_{gip}(t) = 0.01\ C_{aipd}\ V_p \left[\frac{1 - \exp(-\lambda_i^* t)}{\lambda_i^*} \right] \qquad \text{(D-6)}$$

where $C_{gip}(t)$ is the ground concentration of isotope i, particle size p, at time t, pCi/m²; and

λ_i^* is the effective decay constant for isotope i on or in soil, yr^{-1};

and where $\lambda_i^* = \lambda_i + \lambda^*$ (D-7)

where λ_i is the radiological decay constant, yr^{-1}; and

λ^* is the assumed environmental loss constant for activity in soil (equivalent to a 50-yr halflife), 1.39×10^{-2}/yr.

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 Pb-210 from Ra-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

$$C_{vip} = 0.01\ V_p\ C_{aip}\ F_r\ E_v \left[\frac{1 - \exp(-\lambda_w t_v)}{Y_v \lambda_w} \right] + C_{gip} \frac{B_{vi}}{P} \qquad \text{(D-8)}$$

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}/sec; and

0.01 is m/cm.

The value of E_v is assumed to be 1.0 for all above grounnd vegetation, and 0.1 for all below ground vegetables (Ref. 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 Enviro[illegible] cients

	[illegible]	Ra	Pb
I. Plant/Soil (B_{vi}'s)			
a) Edible Above Ground:	[illegible]	[illegible] 10^{-2}	4.2×10^{-3}
b) Potatoes:	[illegible]	[illegible] 10^{-3}	4.2×10^{-3}
c) Other Below Ground:	[illegible]	[illegible] $\times 10^{-2}$	4.2×10^{-3}
d) Pasture Grass:	[illegible]	[illegible] $\times 10^{-2}$	7.8×10^{-2}
e) Stored Feed (Hay):	[illegible]	[illegible].6 $\times 10^{-2}$	7.8×10^{-2}
II. Beef/Feed (F_{bi}'s)			
pCi/kg per pCi/day:	[illegible]	[illegible]0 $\times 10^{-3}$	2.9×10^{-4}

D.3.4 Meat Concentrations

Radioactive materials can be deposited on grasses, hay, or sila[illegible] which are eaten by meat animals, which are in turn eaten by man. For the White Mesa site, it has been assumed that meat animals obtain their entire feed requirement by grazing, 6 months per year, and by eating locally grown stored feed the remainder of the year. The equation used to estimate meat concentrations is

$$C_{mi} = Q F_{bi} (0.5 C_{pgi} + 0.5 C_{hi}) \quad \text{(D-9)}$$

where C_{pgi} is the concentration of isotope i in pasture grass, pCi/kg;

C_{hi} is the concentration of isotope i in hay (or other stored feed), 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; and

0.5 is the fraction of the total annual feed requirement assumed to be satisfied by pasture grass or locally grown stored feed.

D.4 DOSES TO INDIVIDUALS

Doses to individuals have been calculated for inhalation, external exposure to air and ground concentrations, and ingestion of v getables and meat. Internal doses are calculated by the staff using dose conversion factors which yield the 50-yr dose commitment, i.e., the entire dose insult received over a period of 50 years following either inhalation or ingestion. Annual doses given are the 50-yr dose commitments resulting from a one-year exposure period. The one-year expos period was taken to be the final year of mill oper ion when environmental concentrations resulting from plant operations are expected to be a eir highest level.

D.4.1 Inhalation Doses

Inhalation doses have been computed using air concentrations obtained by Equation D-3 (resuspended air concentrations are included) for particulate materials, and the dose conversion factors presented in Table D. . These dose conversion factors have been computed by Argonne National Laboratory's UDAD code (Ref. 1) in accordance with the Task Ground Lung Model of the International Commission on Radiological Protection (Ref. 5).

Doses to the bronchial epithelium from Rn-222 and short-lived daughters were computed based on the assumption of indoor exposure at 100% occupancy. It was assumed that indoor radon daughter concentrations would be approximately 50% of the outdoor Rn-222 concentration. The dose conversion factor for bronchial epithelium exposure from RN-222 derives as follows

1) 1 pCi/m^3 Rn-222 = 5×10^{-6} Working level (WL).*

2) Continuous exposure WL = 25 cumulative working level months (WLM) per year.

3) 1 WLM = 5000 mrem (Ref. 6)

Therefore:

$$1\ pCi/m^3\ \text{Rn-222} \times (5 \times 10^{-6} \frac{WL}{pCi/m^3}) \times (25 \frac{WLM}{WL}) \times (5000 \frac{mrem}{WLM}) = 0.625\ mrem$$

and the Rn-222 bronchial epithelium dose conversion factor is taken to be 0.625 mrem/yr per pCi/m^3.

D.4.2 External Doses

External doses from air and ground concentrations are computed using the dose convers factors provided in Table D.6 (Ref. 1). Doses were computed based on 100% occupany at the particular location. Indoor exposure was assumed to occur 14 hrs/day at a dose rate of 70% of the outdoor dose rate.

D.4.3 Ingestion Doses

Ingestion doses have been computed for vegetables and meat (beef and lamb). Ingestion doses reported are based on concentrations obtained using Equations D-8 and D-9, ingestion rates given

*One WL concentration is defined as any combination of short-lived radioactive decay products of Rn-222 in one liter of air that will release 1.3×10^5 MeV of alpha particle energy during their radioactive decay to Pb-210.

Table D.5 Inhalation Dose Conversion Factors (mrem/year/pCi/m^3)

Particle Size = 0.3 Microns	PB210	PO210
Whole Body	7.46E+00	1.29E+00
Bone	2.32E+02	5.24E+00
Kidney	1.93E+02	3.87E+01
Liver	5.91E+01	1.15E+01
Mass Average Lung	6.27E+01	2.[illegible]6E+02

Particle Size = 1.0 Microns Density = 8.9 g/cm^3	U238	U234	TH230	RA226	PB210	PO210
Whole Body	1.44E+00	1.64E+00	1.37E+02	3.97E+01	9.42E+00	1.77E+00
Bone	2.42E+01	2.64E+01	4.90E+03	3.97E+02	2.87E+02	7.22E+00
Kidney	5.53E+00	6.30E+00	1.37E+03	1.40E+00	2.39E+02	5.33E+01
Liver	0.	0.	2.82E+02	4.94E-02	7.32E+01	1.59E+01
Mass Average Lung	2.13E+03	2.42E+03	2.37E+03	3.04E+02	2.49E+01	1.12E+02

Particle Size = 1.0 Microns Density = 2.4 g/cm^3	U238	U234	TH230	RA226	PB210	PO210
Whole Body	1.65E+00	1.87E+00	1.66E+02	3.40E+01	8.24E+00	1.54E+00
Bone	2.78E+01	3.03E+01	5.95E+03	3.40E+02	2.56E+02	6.29E+00
Kidney	6.33E+00	7.22E+00	1.67E+03	1.20E+00	2.13E+02	4.64E+01
Liver	0.	0.	3.43E+02	4.22E-02	6.53E+01	1.38E+01
Mass Average Lung	2.88E+03	3.28E+03	3.22E+03	4.04E+02	3.38E+01	1.48E+02

Particle Size = 5.0 Microns	U238	U234	TH230	RA226	PB210	PO210
Whole Body	1.16E+00	1.32E+00	1.01E+02	4.47E+01	1.00E+01	1.96E+00
Bone	1.96E+01	2.14E+01	3.60E+03	4.47E+02	3.11E+02	7.99E+00
Kidney	4.47E+00	5.10E+00	1.00E+03	1.57E+00	2.59E+02	5.89E+01
Liver	0.	0.	2.07E+02	5.55E-02	7.93E+01	1.76E+01
Mass Average Lung	1.24E+03	1.42E+03	1.38E+03	1.87E+02	1.45E+01	7.01E+01

Particle Size = 35.0 Microns	U238	U234	TH230	RA226	PB210	PO210
Whole Body	7.92E-01	9.02E-01	5.77E+01	4.40E+01	9.66E+00	1.93E+00
Bone	1.34E+01	1.46E+01	2.07E+03	4.40E+02	3.00E+02	7.84E+00
Kidney	3.05E+00	3.47E+00	5.73E+02	1.55E+00	2.50E+02	5.79E+01
Liver	0.	0.	1.19E+02	5.47E-02	7.65E+01	1.73E+01
Mass Average Lung	3.30E+02	3.80E+02	3.71E+02	6.38E+01	3.91E+00	2.58E+01

Table D.6 Dose Conversion Factors for External Exposure

Dose Factors for Doses from Air Concentrations, mrem/yr per pCi/m^3

ISOTOPE	SKIN	WHOLE BODY
U238	1.05E-05	1.57E-06
TH234	6.63E-05	5.24E-05
PAM234	8.57E-05	6.64E-05
U234	1.36E-05	2.49E-06
TH230	1.29E-09	3.59E-06
RA226	6.00E-05	4.90E-05
RN222	3.46E-10	2.83E-06
PO218	8.18E-07	6.34E-07
PB214	2.06E-03	1.67E-03
BI214	1.36E-02	1.16E-02
PO214	9.89E-07	7.66E-07
PB210	4.17E-05	1.43E-05

Table D.6 Cont'd

Dose Factors for Doses from Ground Concentrations, mrem/yr per pCi/m^2

ISOTOPE	SKIN	WHOLE BODY
U238	2.13E-06	3.17E-07
TH234	2.10E-06	1.66E-06
PAM234	1.60E-06	1.24E-06
U234	2.60E-06	4.78E-07
TH230	2.20E-06	6.12E-07
RA226	1.16E-05	9.47E-07
RN222	6.15E-08	5.03E-08
PO218	1.42E-08	1.10E-08
PB214	3.89E-05	3.16E-05
BI214	2.18E-04	1.85E-04
PO214	1.72E-08	1.33E-08
PB210	6.65E-06	2.27E-06

in Table D-7, and dose conversion factors given in Table D-8 (Ref. 1 and Ref. 7). Vegetable ingestion doses were computed assuming an average 50% activity reduction due to food preparation (Ref. 4). Ingestion doses to children and teenagers were computed but found to be equivalent to or less than doses to adults.

Table D.7 Assumed Food Ingestion Rates,[a] kg/yr

	Child	Teen	Adult
I. Vegetables (Total):	48	76	105
a) Edible Above Ground:	16	29	42
b) Potatoes	27	42	60
c) Other Below Ground:	5	5	3
II. Meat (Beef and Lamb):	28	45	78

a All data taken from Reference 4. Ingestion rates are averages for typical rural farm households. No allowance is credited for portions of year when locally or home grown food may not be available.

Table D.8 Ingestion Dose Conversion Factors (mrem/pCi ingested)

Age Group	Organ	238U	234U	234TH	230TH	226RA	210PB	210BI	210PO
Infant	Wh. Bod	3.33E-04	3.80E-04	2.00E-08	1.06E-04	1.07E-02	2.38E-03	3.58E-07	7.41E-04
	Bone	4.47E-03	4.88E-03	6.92E-07	3.80E-03	9.44E-02	5.28E-02	4.16E-06	3.10E-03
	Liver	0.	0.	3.77E-08	1.90E-04	4.76E-05	1.42E-02	2.68E-05	5.93E-03
	Kidney	9.28E-04	1.06E-03	1.39E-07	9.12E-04	8.71E-04	4.33E-02	2.08E-04	1.26E-02
Child	Wh. Bod	1.94E-04	2.21E-04	9.88E-09	9.91E-05	9.87E-03	2.09E-03	1.69E-07	3.67E-04
	Bone	3.27E-03	3.57E-03	3.42E-07	3.55E-03	8.76E-02	4.75E-02	1.97E-06	1.52E-03
	Liver	0.	0.	1.51E-08	1.78E-04	1.84E-05	1.22E-02	1.02E-05	2.43E-03
	Kidney	5.24E-04	5.98E-04	8.01E-08	8.67E-04	4.88E-04	3.67E-02	1.15E-04	7.56E-03
Teenager	Wh. Bod	6.49E-05	7.39E-05	3.31E-09	6.00E-05	5.00E-03	7.01E-04	5.66E-08	1.23E-04
	Bone	1.09E-03	1.19E-03	1.14E-07	2.16E-03	4.09E-02	1.81E-02	6.59E-07	5.09E-04
	Liver	0.	0.	6.68E-09	1.23E-04	8.13E-06	5.44E-03	4.51E-06	1.07E-03
	Kidney	2.50E-04	2.85E-04	3.81E-08	5.99E-04	2.32E-04	1.72E-02	5.48E-05	3.60E-03
Adult	Wh. Bod	4.54E-05	5.17E-05	2.13E-09	5.70E-05	4.60E-03	5.44E-04	3.96E-08	8.59E-05
	Bone	7.67E-04	8.36E-04	8.01E-08	2.06E-03	4.60E-02	1.53E-02	4.61E-07	3.56E-04
	Liver	0.	0.	4.71E-09	1.17E-04	5.74E-06	4.37E-03	3.18E-06	7.56E-04
	Kidney	1.75E-04	1.99E-04	2.67E-08	5.65E-04	1.63E-04	1.23E-02	3.83E-05	2.52E-03

REFERENCES FOR APPENDIX D

1. M. Momeni et al., "Uranium Dispersion and Dosimetry (UDAD) Code", Argonne National Laboratory Report, in preparation.

2. Personal communication (letter), D. J. Markley, Environmental Coordinator, Energy Fuels Nuclear, Inc., to E. A. Trager, U.S. NRC, November 8, 1978.

3. Generic Environmental Impact Statement on Uranium Milling, U.S. NRC, 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", Hanford Engineering Development Laboratory, HEDL-TME-71-168, December 1971.

5. ICRP Task Group on Lung Dynamics, "Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract", Health Physics 12:181, 1966.

6. 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), U.S. Government Printing Office, 1972.

7. G. R. Hoenes and J. K. Soldat, "Age - Specific Radiation Dose Conversion Factors for a One-Year Chronic Intake," Battelle Pacific Northwest Laboratories, U.S.NRC Report NUREG-0172, November 1977.

APPENDIX E

RESERVED FOR LETTER FROM THE UTAH STATE HISTORIC PRESERVATION OFFICER

APPENDIX F. RADON RELEASE DURING MILLING OPERATIONS

F.1 ORE PADS

The radon-222 release from the ore pad can be estimated by the following data and assumptions:

Area of the ore pads (A)	2.43×10^8 cm^2 (6 acres)
Thickness of ore piles (t)	670 cm (22 ft) — maximum case; and 305 cm (10 ft) — equilibrium case
Radium-226 concentration (C_{Ra})	423 pCi per gram of ore
Density of ore (ρ)	1.6 g/cm^3
Decay constant of radon-222 (λ)	2.1×10^{-6} sec^{-1}
D_e/v (diffusion coefficient/void fraction)	2.5×10^{-2} cm^2/sec
Radon emanation coefficient (generic value given, actual ore from numerous mines may vary widely) (E).	0.2

The radon-222 flux (J) at the surface of an area with a finite depth of uniform material may be estimated:

$$J = C_{Ra}\rho E\ \sqrt{\lambda(D_e/v)}\ \tanh\left[\ \sqrt{\lambda/(D_e/v)}\,t\right]\ ,$$

where the symbols are as defined above.

The hyperbolic tangent factor corrects the infinite thickness radon flux for the thickness of the pile. Substituting into this correction factor for a 670-cm (22-ft) pile and a 305-cm (10-ft) pile reveal that the radon release is reduced by 9×10^{-6}% and 0.75% respectively. This reduction is negligible so the piles may be considered infinitely thick.

The radon flux (J) for an infinitely thick pile is given by

$$J = C_{Ra}\rho E\ \sqrt{\lambda(D_e/v)}\ .$$

Substitution of the above values gives

$$J = (423\ \text{pCi/g})(1.6\ \text{g/cm}^3)(0.2)\sqrt{(2.1 \times 10^{-6}\ \text{sec}^{-1})(2.5 \times 10^{-2}\ \text{cm}^2/\text{sec})} = 0.031\ \text{pCi/cm}^2\cdot\text{sec}\ .$$

Multiplication by the area gives the release rate:

JA = (0.031 pCi/cm^2·sec)(2.43 x 10^8 cm^2) = 7.54 x 10^6 pCi/sec = 7.54 μCi/sec = 240 Ci/year .

This value applied to both the maximum and equilibrium stockpiles, as the flux is a function of area rather than thickness.

F.2 TAILINGS IMPOUNDMENT

For fill operations and prereclamation conditions the impoundment is assumed to have areas of saturated tailings, areas of moist tailings, and areas of relatively dry tailings. The following data and assumptions were used to determine radon-222 release rates from the different areas.

Radium concentration (C_{Ra}) of solids	423 pCi/g
Density	1.6 g/cm^3
Emanation factor	0.2
D_e/v for dry tailings (8% moisture)	5 x 10^{-2} cm^2/sec (ref. 1, Table 9.29)
D_e/v for moist tailings (15% moisture)	1 x 10^{-2} cm^2/sec (ref. 1, Table 9.29)
D_e/v for saturated tailings (37% moisture)	5.7 x 10^{-6} cm^2/sec (ref. 1, Table 9.29)

The "infinite thickness" flux is calculated by the expression

$$J_\infty = C_{Ra}\rho E \sqrt{\lambda(D_e/v)}$$

Substitution of the above values gives

J_∞, dry tails = 439 pCi/m^2-sec;

J_∞, moist tails = 196 pCi/m^2-sec; and

J_∞, saturated tails = 4.7 pCi/m^2-sec.

Based on the conservative assumptions of 40 ha (100 acres) dry tails, 40 ha (100 acres) moist tails, and 20 ha (50 acres) saturated tails, the annual radon-222 release from the tailings impoundment system is calculated to be 8064 Ci. Radon releases from ponded areas are negligible. Radon-222 releases from dry, moist, and saturated tails are 5552 Ci/yr, 2482 Ci/yr, and 30 Ci/yr, respectively.

F.3 TAILINGS COVER REQUIREMENTS

The following formula was used in calculating the reduction in radon flux produced by the proposed cover system:

$$J = J_o \exp\left[-\sum_{i=1}^{n}\sqrt{\lambda/(D_e/v)_i}\, x_i\right],$$

where

i = the ith layer of a multicomponent cover (n is the number of components) ,

λ = decay constant for radon-222 (2.1×10^{-6} sec^{-1}) ,

x = thickness of cover layer (cm) ,

J = resulting radon flux after attenuation through cover ($pCi/m^2 \cdot sec$) ,

J_o = radon flux at the surface of the tailings ($pCi/m^2 \cdot sec$) .

Th cover proposed by the applicant consists of 61 cm (2 ft) of compacted Mancos Shale overlain by 305 cm (10 ft) of silt-sand soil and 23 cm (9 in.) of topsoil. The estimated D_e/v for these materials are 1.2×10^{-3} cm^2/sec, 2.2×10^{-2} cm^2/sec and 2.2×10^{-2} cm^2/sec respectively.[2] The dry tailings (8% moisture) infinite thickness flux of 439 $pCi/m^2 \cdot sec$ is assumed to model the long term conditions for the system. Substitution of these values into the equation yields

$$J = (439\ pCi/m^2 \cdot sec)\exp\left\{-\sqrt{(2.1 \times 10^{-6})/(2.2 \times 10^{-2})}(328) - \sqrt{(2.1 \times 10^{-6})/(1.2 \times 10^{-3})}(61)\right\}$$

$$= (439\ pCi/m^2 \cdot sec)(3.16 \times 10^{-3})$$

$$= 1.4\ pCi/m^2 \cdot sec\ .$$

As reported in the Supplemental Environmental Report[3] the average background flux is 0.64 $pCi/m^2 \cdot sec$. Because of its thickness, the silt-sand material is expected to contribute backround flux, so the total radon flux would be essentially twice background. The proposed cover is adequate for areas where there is no significant accumulation of slimes. The applicant's proposed operating plan should prevent excessive sand-slimes segregation.

REFERENCES FOR APPENDIX F

1. R. E. Blanco et al., *Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents*, vol. 1, Report ORNL/TM-4903, Oak Ridge National Laboratory, Oak Ridge, Tenn., May 1975, Table 9.29.

2. Energy Fuels Nuclear, Inc., *Supplement to the Proposed Tailings Disposal System, White Mesa Uranium Project*, Oct. 16, 1978.

3. Energy Fuels Nuclear, Inc., *Supplemental Report, Baseline Radiology Environmental Report, White Mesa Uranium Project, San Juan County, Utah*, Sept. 26, 1978, p. 15.

APPENDIX G

CALCULATIONS OF TAILINGS PILE GAMMA RADIATION ATTENUATION

Assuming soil to be composed mainly of SiO_2, the mass attenuation coefficient for 1-2 MeV gamma ray is 0.0518 cm^2/g.[1] (Most of the dose rate from a typical natural emitter is in this range.[2]) Assuming the gamma radiation from the uncovered tailings pile to be approximately 12 R/year (same as for Bear Creek project) and the bulk density of the soil to be 1.5 g/cm^3, the effect of the 3.28 m (10.75 ft) of soil materials proposed (excluding the shale layer) would reduce the gamma radiation to approximately 10.3 pR year.

$$I/I_o = \exp[-(\mu en/\rho)\rho x] = \exp[-(0.0518\ cm^2/g)(1.5\ g/cm^3)(328\ cm)] = 8.5 \times 10^{-12} ;$$

$$I = (8.5 \times 10^{-12})(12\ R/year) = 10.3\ pR/year .$$

The background radiation dose as measured by the applicant[3] is 77.7 mR/year. 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," Chap. 29 in *The Natural Radiation Environment*, J. A. S. Adams and W. M. Lowder, Eds., University of Chicago Press, Chicago, 1964.

3. Energy Fuels Nuclear, Inc., *Supplemental Report, Baseline Radiology Environmental Report, White Mesa Uranium Project*, Sept. 26, 1978, p. 27.

APPENDIX H

ATMOSPHERIC DISPERSION COEFFICIENTS

Tables H.1 through H.4 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.[2]

Table H.1. Annual average χ/Q (sec/m^3) at various distances for the 16 compass directions, release height 1 m

Wind	Distance from effluent (m)						
Toward	335	790	940	1095	1400	1720	2400
N	7.13E-6	1.23E-6	8.55E-7	6.35E-7	3.96E-7	2.66E-7	1.39E-7
NNW	5.19E-6	9.05E-7	6.34E-7	4.72E-7	2.96E-7	2.00E-7	1.05E-7
NW	6.65E-6	1.16E-6	8.09E-7	6.01E-7	3.76E-7	2.54E-7	1.33E-7
WNW	3.94E-6	6.88E-7	4.82E-7	3.59E-7	2.25E-7	1.52E-7	7.99E-8
W	3.00E-6	5.03E-7	3.49E-7	2.58E-7	1.60E-7	[illegible]	5.58E-8
WSW	2.54E-6	4.32E-7	3.01E-7	2.23E-7	1.39E-7	[illegible]	4.91E-8
SW	6.34E-6	1.06E-6	7.33E-7	5.42E-7	3.38E-7	2.27E-7	1.19E-7
SSW	1.04E-5	1.69E-6	1.17E-6	8.59E-7	5.34E-7	3.57E-7	1.85E-7
S	5.31E-5	8.24E-6	5.62E-6	4.09E-6	2.51E-6	1.66E-6	8.36E-7
SSE	2.88E-5	[illegible]	3.11E-6	2.27E-6	1.40E-6	9.28E-7	4.72E-7
SE	2.54E-5	3.98E-6	2.72E-6	1.98E-6	1.22E-6	8.09E-7	4.11E-7
ESE	9.82E-6	1.57E-6	1.08E-6	7.93E-7	4.91E-7	3.27E-7	1.68E-7
E	8.40E-6	1.37E-6	9.46E-7	6.96E-7	4.32E-7	2.89E-7	1.49E-7
ENE	6.09E-6	1.03E-6	7.20E-7	5.33E-7	3.34E-7	2.25E-7	1.18E-7
NE	1.27E-5	2.16E-6	1.51E-6	1.12E-6	6.99E-7	4.71E-7	2.47E-7
NNE	1.00E-5	1.73E-6	1.21E-6	9.01E-7	5.65E-7	3.82E-7	2.01E-7

Table H.2. Annual average χ/Q (sec/m^3) at various distances for the 16 compass directions, release height 6 m

Wind	Distance from effluent (m)						
Toward	335	790	940	1095	1400	1720	2400
N	7.10E-6	1.54E-6	1.09E-6	8.13E-7	5.10E-7	3.43E-7	1.79E-7
NNW	5.10E-6	1.11E-6	7.93E-7	5.93E-7	3.74E-7	2.53E-7	1.33E-7
NW	6.61E-6	1.43E-6	1.02E-6	7.60E-7	4.78E-7	3.23E-7	1.69E-7
WNW	3.91E-6	8.42E-7	5.99E-7	4.48E-7	2.82E-7	1.91E-7	1.00E-7
W	2.94E-6	6.70E-7	4.75E-7	3.53E-7	2.21E-7	1.48E-7	7.67E-8
WSW	2.34E-6	5.53E-7	3.95E-7	2.95E-7	1.87E-7	1.27E-7	6.64E-8
SW	6.05E-6	1.44E-6	1.02E-6	7.60E-7	4.77E-7	3.21E-7	1.66E-7
SSW	9.24E-6	2.34E-6	1.67E-6	1.24E-6	7.85E-7	5.28E-7	2.74E-7
S	4.59E-5	1.22E-5	8.63E-6	6.42E-6	4.02E-6	2.69E-6	1.37E-6
SSE	2.42E-5	6.49E-6	4.63E-6	3.45E-6	2.17E-6	1.46E-6	7.50E-7
SE	2.18E-5	5.78E-6	4.11E-6	3.06E-6	1.92E-6	1.28E-6	6.57E-7
ESE	8.61E-6	2.22E-6	1.58E-6	1.18E-6	7.41E-7	4.97E-7	2.56E-7
E	7.52E-6	1.88E-6	1.34E-6	9.97E-7	6.28E-7	4.22E-7	2.19E-7
ENE	5.57E-6	1.34E-6	9.58E-7	7.17E-7	4.54E-7	3.07E-7	1.61E-7
NE	1.20E-5	2.77E-6	1.97E-6	1.47E-6	9.30E-7	6.27E-7	3.28E-7
NNE	9.58E-6	2.17E-6	1.54E-6	1.16E-6	7.30E-7	4.94E-7	2.59E-7

Table H.3. Annual average χ/Q (sec/m^3) at various distances for the 16 compass directions, release height 13.7 m

Wind	Distance from effluent (m)						
Toward	335	790	940	1095	1400	1720	2400
N	3.92E-6	1.19E-6	9.31E-7	7.43E-7	5.06E-7	3.61E-7	2.02E-7
NNW	2.81E-6	8.78E-7	6.84E-7	5.45E-7	3.71E-7	2.64E-7	1.48E-7
NW	3.67E-6	1.13E-6	8.80E-7	7.01E-7	4.77E-7	3.39E-7	1.90E-7
WNW	2.22E-6	6.79E-7	5.25E-7	4.16E-7	2.82E-7	2.00E-7	1.12E-7
W	1.29E-6	4.76E-7	3.84E-7	3.13E-7	2.18E-7	1.58E-7	8.91E-8
WSW	9.58E-7	3.83E-7	3.11E-7	2.55E-7	1.79E-7	1.30E-7	7.43E-8
SW	2.15E-6	9.47E-7	7.85E-7	6.51E-7	4.63E-7	3.39E-7	1.94E-7
SSW	2.21E-6	1.37E-6	1.18E-6	1.00E-6	7.32E-7	5.43E-7	3.16E-7
S	5.82E-6	6.28E-6	5.70E-6	4.95E-6	3.70E-6	2.78E-6	1.63E-6
SSE	3.11E-6	3.36E-6	3.05E-6	2.65E-6	1.97E-6	1.48E-6	8.73E-7
SE	3.25E-6	3.02E-6	2.73E-6	2.37E-6	1.76E-6	1.32E-6	7.75E-7
ESE	1.76E-6	1.25E-6	1.10E-6	9.36E-7	[illegible]	5.12E-7	2.99E-7
E	2.10E-6	1.12E-6	9.61E-7	8.11E-7	5.88E-7	4.35E-7	2.52E-7
ENE	2.04E-6	8.95E-7	7.38E-7	6.09E-7	4.32E-7	3.16E-7	1.82E-7
NE	5.30E-6	1.94E-6	1.57E-6	1.28E-6	8.96E-7	6.50E-7	3.70E-7
NNE	4.74E-6	1.60E-6	1.27E-6	1.02E-6	7.09E-7	5.10E-7	2.89E-7

Table H.4. Annual average χ/Q (sec/m^3) at various distances for the 16 compass directions, release height 27.4 m

Wind	Distance from effluent (m)						
Toward	335	790	940	1095	1400	1720	2400
N	2.06E-6	8.07E-7	6.38E-7	5.20E-7	3.72E-7	2.81E-7	1.75E-7
NNW	1.35E-6	5.88E-7	4.69E-7	3.84E-7	2.76E-7	2.09E-7	1.30E-7
NW	1.82E-6	7.62E-7	6.06E-7	[illegible]	3.55E-7	2.68E-7	1.67E-7
WNW	1.07E-6	4.63E-7	3.69E-7	[illegible]	2.15E-7	1.61E-7	9.93E-8
W	5.68E-7	2.76E-7	2.07E-7	1.91E-7	1.44E-7	1.13E-7	7.43E-8
WSW	3.95E-7	2.07E-7	1.73E-7	1.48E-7	1.14E-7	9.04E-8	6.04E-8
SW	7.43E-7	4.74E-7	4.05E-7	3.53E-7	2.79E-7	2.27E-7	1.56E-7
SSW	5.82E 7	5.13E-7	4.73E-7	4.38E-7	3.75E-7	3.23E-7	2.37E-7
S	1.02E-6	1.50E-6	1.57E-6	1.61E-6	1.56E-6	1.44E-6	1.15E-6
SSE	5.01E-7	7.99E-7	8.43E-7	8.64E-7	8.33E-7	7.72E-7	6.12E-7
SE	7.49E-7	7.94E-7	8.01E-7	8.03E-7	7.58E-7	6.97E-7	5.48E-7
ESE	4.85E-7	4.12E-7	3.90E-7	3.71E-7	3.29E-7	2.90E-7	2.19E-7
E	7.67E-7	4.69E-7	4.15E-7	3.74E-7	3.11E-7	2.64E-7	1.91E-7
ENE	7.59E-7	4.47E-7	3.82E-7	3.32E-7	2.62E-7	2.12E-7	1.45E-7
NE	2.45E-6	1.12E-6	9.15E-7	7.72E-7	5.83E-7	4.60E-7	3.04E-7
NNE	2.28E-6	9.86E-7	7.96E-7	6.62E-7	4.88E-7	3.78E-7	2.44E-7

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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.

2. Dames and Moore, "Supplemental Report, Meteorology and Air Quality, Environmental Report, White Mesa Uranium Project, San Juan County, Utah, for Energy Fuels Nuclear, Inc." Denver, Sept. 6, 1978.