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related to operation of

IRIGARAY URANIUM SOLUTION MINING PROJECT

WYOMING MINERAL CORPORATION**SEPTEMBER 1978****Docket No. 40-8502****U. S. Nuclear Regulatory Commission****Office of Nuclear Material
Safety and Safeguards**

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FINAL ENVIRONMENTAL STATEMENT
related to the
WYOMING MINERAL CORPORATION
IRIGARAY URANIUM SOLUTION MINING PROJECT

(Johnson County, Wyoming)

Docket No. 40-8502

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

September 1978

SUMMARY AND CONCLUSIONS

This Final 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 Wyoming Mineral Corporation for implementation of the Irigaray project, Docket No. 40-8502, in accordance with the Corporation's statement in its application and accompanying Environmental Report.

The Irigaray project consists of solution mining (in situ leaching) operations involving uranium ore deposits in Johnson County, Wyoming. Solution mining activities will include a processing facility with an annual production of 500,000 lb of U_3O_8 from up to 50 acres of well fields through the initial license authorization. The Irigaray project has an estimated lifetime of 10 to 20 years with known ore deposits and the current level of solution mining technology. The Nuclear Regulatory Commission staff proposes to limit initially the scope of the project as indicated in items 7 and 8.

3. Summary of environmental impacts and adverse effects:
 - a. The site is mostly used as grazing land for cattle and sheep. Pronghorn antelope, which graze primarily on big sagebrush, are common on the site. Initiation of the Irigaray project would result in the temporary removal from grazing and the disturbance of approximately 60 acres during operation as proposed by the staff. All disturbed surface areas will be reclaimed and returned to their original use.
 - b. With the staff's proposed production and restoration limitations approximately 1.2×10^6 m³ (1000 acre-ft) of water will be withdrawn from the ore zone aquifer. This water will be conveyed to the onsite waste ponds for evaporation. The long-term effects on groundwater use are expected to be minimal. An estimated 4.2×10^5 m³ (340 acre-ft) of groundwater is expected to temporarily contain increased concentrations of radioactive and toxic elements during the operation of each 4-ha (10-acre) well field. Restoration should return this water to a condition that is consistent with its premining use (or potential use). Surface water will not be affected by normal operations.
 - c. There will be no discharge of liquid effluents from the Irigaray project. Atmospheric effluents will be within acceptable limits, and the effects will be insignificant. The dose rates of radionuclides in the air at the nearest ranches from the plant site are given in the following table.

Dose rates of radionuclides in the air at the
nearest ranches from the plant site

Operation	Dose rate (millirems/year)				
	Total body	Bone	Lung	Kidney	Bronchial epithelium
Irigaray Ranch					
Well field	0.00013	0.00071	0.000080	0.0015	0.30
Recovery plant	0.0022	0.028	0.26	0.0071	
Total	0.0023	0.029	0.26	0.0088	0.031
Reculusa Ranch					
Well field	0.00048	0.0027	0.00028	0.0056	0.089
Recovery plant	0.0086	0.11	1.1	0.028	
Total	0.0091	0.11	1.1	0.033	0.089

- d. The Irigaray project proposes the production and utilization of 500,000 lb per year of U_3O_8 or equivalent. Small amounts of common construction materials, chemicals, reagents, and fuels will be irretrievably committed.
 - e. The Irigaray project will not produce any significant socioeconomic impact on the local area because of the small number of employees that will be employed at the project.
4. The principal alternatives considered were the following:
- a. Alternative mining methods.

Open-pit, underground, and solution mining (in situ leaching) methods were considered as well as a comparison of impacts associated with each. Solution mining (in situ leaching) is the preferred method for mining the Irigaray ore deposits although open-pit mining has not been precluded. Impacts associated with in situ leaching are generally less severe than impacts associated with open-pit and underground uranium mining.
 - b. Alternative leach solutions.

Alkaline and acidic leach solutions were examined. An alkaline leach solution is more favorable for the Irigaray ore deposits because of the mineral composition of the host sandstone.
 - c. Alternative mill process for an alternative open-pit or underground mine.

The conventional uranium milling processes are described and were compared with a solution mining operation. Solution mining does not require extraction of the ore, and no tailings are produced. The quantity of solid wastes from a solution mining operation is expected to be about 1% of the quantity generated by a conventional mill of comparable production.
 - d. Alternative methods for waste management.

Waste management alternatives that were considered included various onsite disposal methods as well as transport of solid wastes to an active mill tailings pond. Onsite disposal would result in the proliferation of small solid waste impoundments. The transfer of solid wastes to an active tailings pond is the recommended alternative.
 - e. Alternative energy sources.

Fossil and nuclear fuels were compared, and solar, geothermal, and synthetic fuels were considered.
 - f. Alternative of no licensing action.

The denial of a source material license is an alternative available to the NRC. If denied, the ore deposit could not be mined using the solution mining (in situ leaching) method.
5. The following Federal, State, and local agencies were asked to comment on the Draft Environmental Statement:
- Department of Commerce
Department of the Interior
Department of Health, Education, and Welfare
Federal Energy Regulatory Commission
Department of Transportation
Environmental Protection Agency
Department of Agriculture
Advisory Council on Historic Preservation
Department of Housing and Urban Development
Department of Energy
Office of the Governor, State of Wyoming
Department of Environmental Quality, State of Wyoming
Board of Commissioners, Johnson County, Wyoming

6. This Final Environmental Statement will be made available to the public, to the Environmental Protection Agency, and to other specified agencies in September 1978.
7. From the analysis and evaluation made in this Statement, the staff proposes that the source material license issued for the Irigaray project be limited to a maximum well field area of 20 ha (50 acres) and contain the following conditions:
 - a. The use of an ammonium bicarbonate lixiviant will be limited to a maximum well field area of 20 ha (50 acres). This area will include the existing well field for the 100-gpm, pilot-scale test (Sect. 5.1.5).
 - b. Restoration of the first production well field must be initiated upon mining termination of this unit (Sect. 5.1.5).
 - c. This production well field should be sufficiently isolated from any further operating well field within the 20-ha (50-acre) area to ensure that restoration operations will not be compromised by ongoing mining activities (Sect. 5.1.5).
 - d. Restoration of at least the first entire production well field must be completed prior to mining any area beyond the maximum 20 ha (50 acres) with an ammonium bicarbonate lixiviant (Sect. 5.1.5). (The applicant must provide a plan that reflects requirements b, c and d.)
 - e. The applicant will be required to develop and conduct an experimental study on ammonia transport and conversion on the restored section of the 517 test site (Sect. 6.3.2.2).
 - f. The applicant will dispose of all radioactive and toxic wastes by transporting them to an active tailings pond (Sects. 4.6.4 and 12.3.2).

In addition, (1) a maximum accumulation of five years of calcite waste will be permitted prior to removal from the site; and (2) other radioactive or toxic wastes from production and restoration activities will be removed and transferred to the tailings pond as the ponds fill or at the time of site reclamation.

- g. The applicant shall maintain a liquid seal on all waste storage ponds except when removing the solids content for disposal (Sect. 4.6.5).
- h. The applicant shall implement the environmental monitoring programs as discussed in Sect. 8. These include (1) preoperational monitoring of surface water (Sect. 8.1.5.1), (2) ecological baseline (Sect. 8.1.5.3), (3) operational monitoring of waste ponds (Sect. 8.2.1), (4) operational radiological monitoring (Table 8.4), and (5) postoperational well field monitoring (Sect. 8.2.3.7). Where noted in Sect. 8, monitoring programs will be conducted as required by the Wyoming Department of Environmental Quality.
- i. The applicant shall provide plans and procedures for implementing the necessary mitigating actions for any transportation accidents (Emergency action plan, Sect. 7.3.1).
- j. The applicant will provide plans for minimizing environmental impact on riparian habitats or streambeds (i.e., Willow Creek) prior to the conduct of activities in such areas (Sects. 6.6.1 and 6.6.3).
- k. Prior to initiating activities in any areas beyond the existing archaeological survey boundaries (Appendix F), the applicant shall have an archaeological survey conducted on any areas to be disturbed, and submit the results of the survey to NRC for review. The applicant shall not proceed with any land disturbance until the NRC, in consultation with the SHPO, has reviewed the report and given approval to proceed.
- l. The applicant shall establish a program which shall include written procedures and instructions to control all activities discussed in items a-k.
- m. Before engaging in any activity not evaluated by the NRC staff, the applicant will 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 evaluated, or that is significantly greater than that evaluated in this statement, the applicant shall provide a written evaluation of such activities and obtain prior approval of NRC for the activities.

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

8. The position of the NRC is as follows:

Solution mining (in situ leaching) of uranium is a developing technology. Uncertainties regarding environmental impacts, particularly with respect to groundwater contamination and the effectiveness of groundwater quality restoration techniques, have been recognized. Because of this, the Nuclear Regulatory Commission staff proposes to limit the scope of the Irigaray project through the above license conditions until additional data and experience are gained.

The position of the Nuclear Regulatory Commission is that after weighing the environmental, economic, technical, and other benefits of the Irigaray project against environmental and other costs and considering available alternatives, the action called for under the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51 is the issuance of a source material license to the applicant, subject to conditions 7a-n above.

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FOREWORD

This Final Environmental Statement is issued by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Material Safety and Safeguards, in accordance with the Commission's regulation, 10 CFR Part 51, which implements the requirements of the National Environmental Policy Act of 1969 (NEPA).

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

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historical, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- 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, Sect. 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 which 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 which 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 has determined that a detailed statement on the foregoing considerations with respect to Wyoming Mineral Corporation's application for a source material license for a uranium solution mining (in situ leaching) operation is required.

This Statement is based on information contained in correspondence, applications, and reports received from the Wyoming Mineral Corporation. The following documents were mainly used in preparing the Statement: application for source material license dated January 28, 1976; applicant's Environmental Survey dated January 28, 1976; correspondence from applicant dated May 6, 1976, June 15, 1976, November 16, 1976 (Amplifications on Environmental Survey); applicant's responses to NRC representatives (staff) questions of March 1, 1977; applicant's revised Environmental Report dated July 29, 1977, and clarifications received October 17, 1977; agency comments on applicant's revised Environmental Report, November 1977; the applicant's restoration demonstration reports of March 1978 and consultants' reviews in various disciplines in environmental concerns. Copies of the applicant's Environmental Report and correspondence are available for inspection in the NRC Public Document Room, 1717 H Street, N.W., Washington, D.C. 20555.

In conducting the required NEPA review, NRC representatives (staff) met with the applicant to discuss items of information in the environmental reports, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure a thorough understanding of the proposed project.

In addition, the staff sought information from other sources to assist in the evaluation and to conduct field inspections of the project site and surrounding area. Members of the staff also met with State and local officials who are charged with protecting State and local interests. On the basis of all the foregoing and other such activities or inquiries as were deemed useful and appropriate, the staff made an independent assessment of the consideration specified in Sect. 102(2)(C) of the NEPA.

This evaluation led to the issuance of a Draft Environmental Statement by the Office of Nuclear Material Safety and Safeguards in April 1978. The Statement was distributed to Federal, State, and local governmental agencies and other interested parties for comment. A summary notice was published in the *Federal Register* with respect to the availability of the applicant's Environmental Report and the Draft Environmental Statement.

After comments on the Draft Environmental Statement had been received and considered, the staff prepared this Final Environmental Statement. It 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. It is concluded (Sect. 13) that the overall benefit-cost balance for the limited Irigaray project is favorable and that the indicated action is that of granting a source material license for the Irigaray project.

This Final Environmental Statement is being made available to the Environmental Protection Agency, to those agencies commenting on the Draft Environmental Statement, and to the public in September 1978.

1. INTRODUCTION

1.1 THE APPLICANT'S PROPOSAL

An application for a source material license was filed by the Wyoming Mineral Corporation (hereafter referred to as the applicant or WMC) on January 28, 1976, to conduct production-scale solution mining of uranium (in situ leaching) at the Irigaray site in Johnson County, Wyoming. This consists of leaching uranium from subsurface ore-bearing sandstone by adding chemical reagents to existing groundwater to reverse the natural uranium precipitation process that deposited the uranium in the host sandstone. The resulting uranium-bearing liquor is recovered (pumped) from the mineralized (sandstone) zone to a surface processing plant where the uranium is extracted by conventional uranium recovery techniques. The solution from the uranium recovery operation, after further reagent addition, is recycled to the mineralized zone to dissolve additional uranium. After the ore zone is depleted of recoverable uranium, the reagents and other mobilized ionic species remaining in the zone are removed from the groundwater to restore it. Restoration is defined as the returning of affected groundwater to a condition consistent with its premining use (or potential use).

The applicant's proposal for solution mining is summarized below and described in more detail in Sect. 4. Because uranium solution mining is a developing technology with related uncertainties in the environmental impacts, particularly with respect to groundwater contamination and effectiveness of aquifer restoration techniques, the Nuclear Regulatory Commission staff proposes to limit the scope of the project through license conditions until additional data and experience are gained. These limitations are discussed in Sect. 5.

1.2 BACKGROUND INFORMATION

The WMC's proposed Irigaray project is located in northeast Wyoming within the Powder River Basin. As shown in Fig. 1.1, the Irigaray property is in southeast Johnson County, approximately 10 miles northeast of Sussex and 43 miles southeast of Buffalo. Access to the property is via gravel roads from the north and south.

The Irigaray property includes approximately 21,100 acres of leases and claims in T46N, R76W; T45N, T46N, and T47N, R77W; and T44N, T45N, and T46N, R78W (Fig. 1.2). Within the boundary of the Irigaray property, production-scale solution mining activities will initially be conducted in Sections 9 and 16, T45N, R77W. Surface and mineral ownership in this area is shown on Figs. 1.3 and 1.4. The initial production plant and associated facilities will occupy a 5-acre site, and the initial well field, located some 1,500 ft to the east, will include an area of up to 50 acres.

Subsequent well fields will be developed to follow the mineralized trend. Future mining may occur in Sections 19, 30, 29, and 32 of T46N, R77W and Sections 5, 4, 16, 21, and 28 of T45N, R77W (Fig. 1.2). Additional production plants may be constructed at different locations near the well fields depending on processing capacity requirements. It is anticipated that solution mining activities will affect approximately 1,000 acres of the 21,100 acres that comprise the Irigaray property over the lifetime of the project. These potential activities, however, are not covered under the initial license and will require additional licensing action. Figures 1.3 and 1.4 show the surface and mineral ownerships respectively.

1.2.1 Present activities

Under NRC license, two pilot-scale solution mining tests are presently in operation on the Irigaray property (Fig. 1.2). The 517 test area consists of a trailer-mounted plant and three five-spot well patterns occupying a 1-acre site in Section 5 of T45N, R77W. Research and development activities were initiated at this site in November 1975; aquifer restoration tests have been conducted and are discussed in Sect. 5.

A second test site was developed in 1977. It consists of a 1.5-acre portion of the planned production operation in Section 9 of T45N, R77W. Plant equipment is temporarily housed in the building shell which will eventually contain the 500,000-lb/year processing equipment. The well field, with ten seven-spot well patterns, is located near the center of the initial proposed production well field. Pilot test operations at the site began during the summer of 1977.

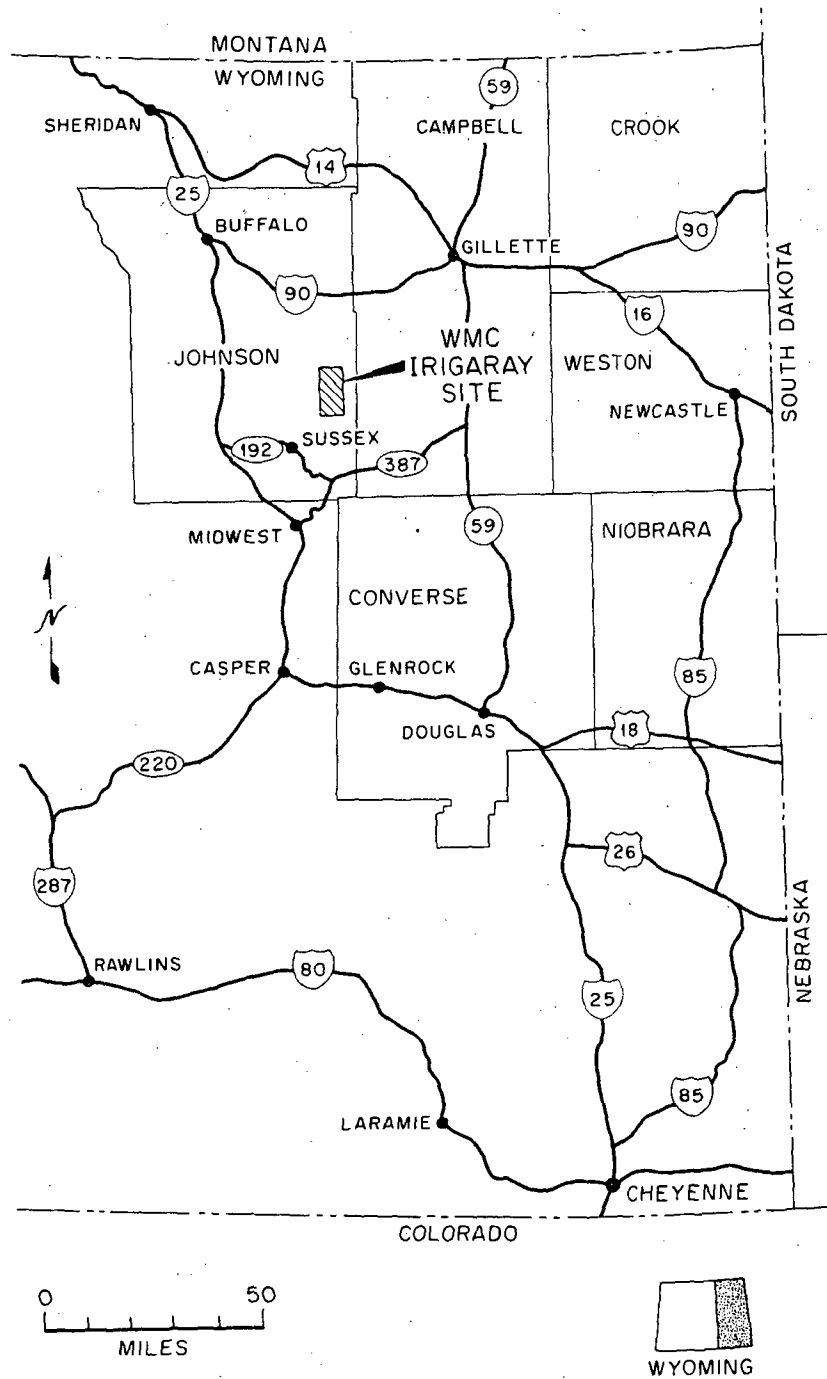


Fig. 1.1. Regional location of the Wyoming Mineral Corporation Irigaray Project.

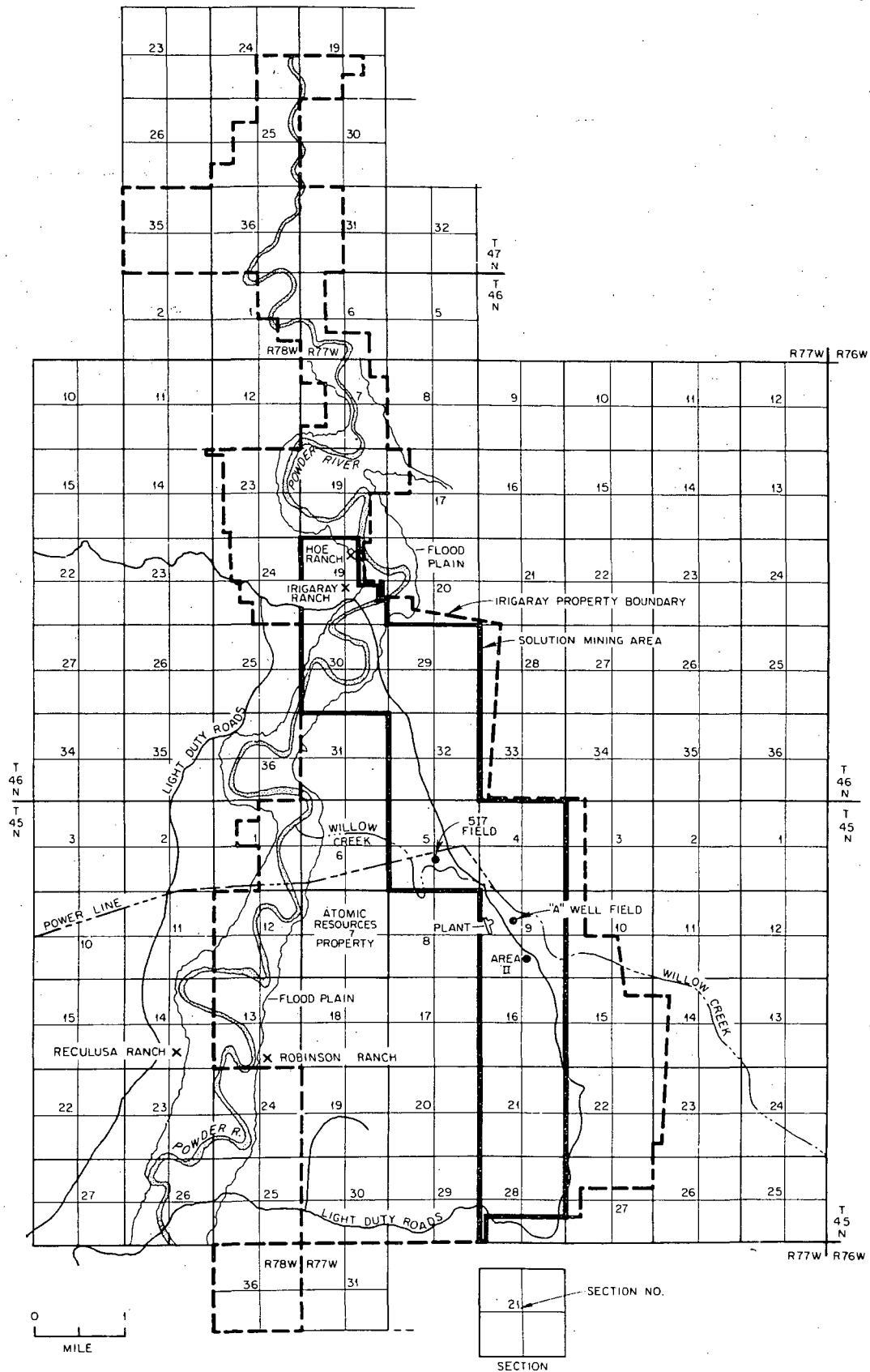


Fig. 1.2. Irigaray property and its immediate vicinity.

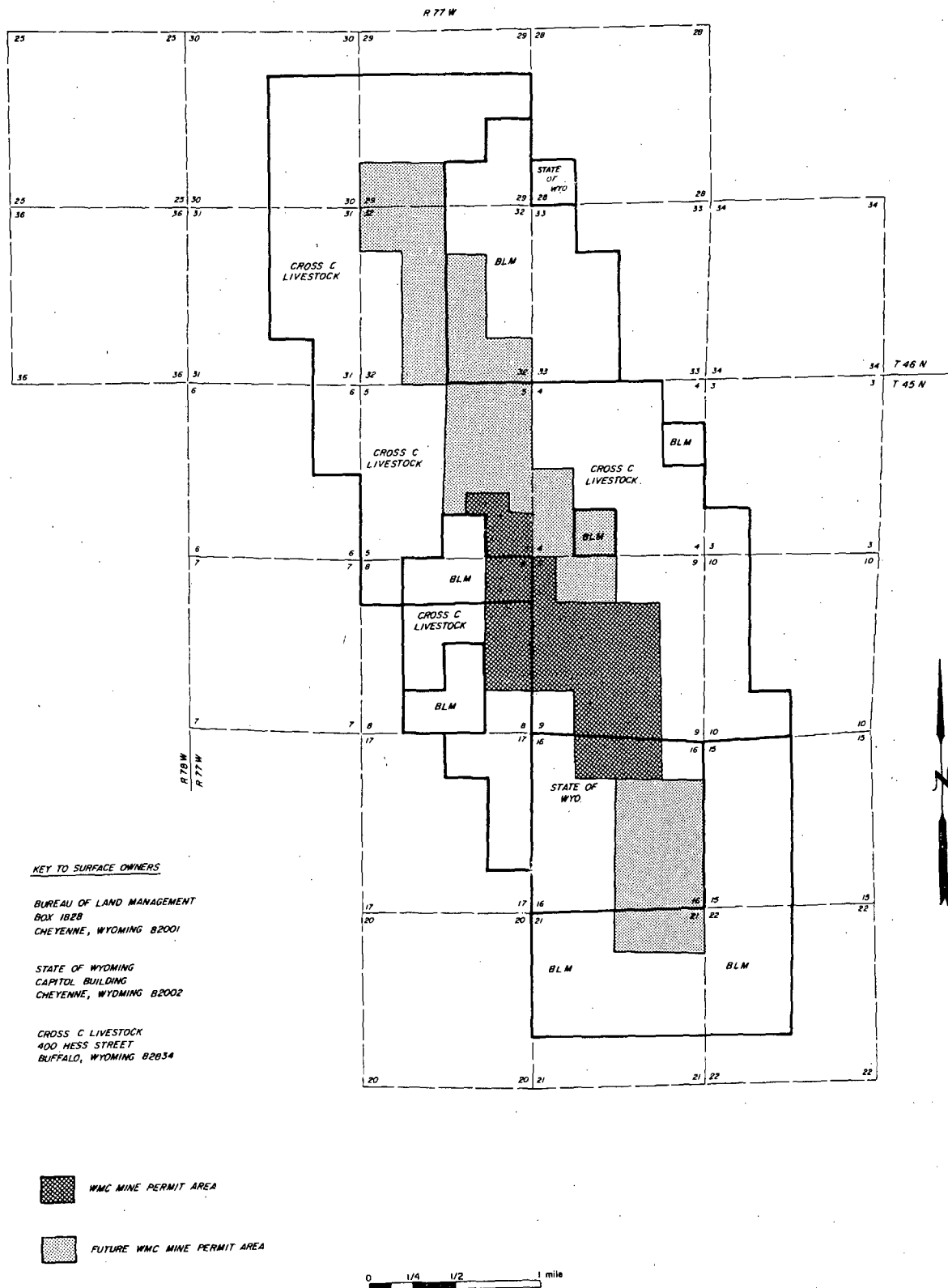


Fig. 1.3. Surface ownership of the Irigaray mine permit area and adjacent lands. Source: Wyoming Mineral Corporation, Application for In Situ Permit to Mine for the Irigaray Site, submitted to the Wyoming Department of Environmental Quality, Land Quality Division, April 1978 (revised 6/23/78).

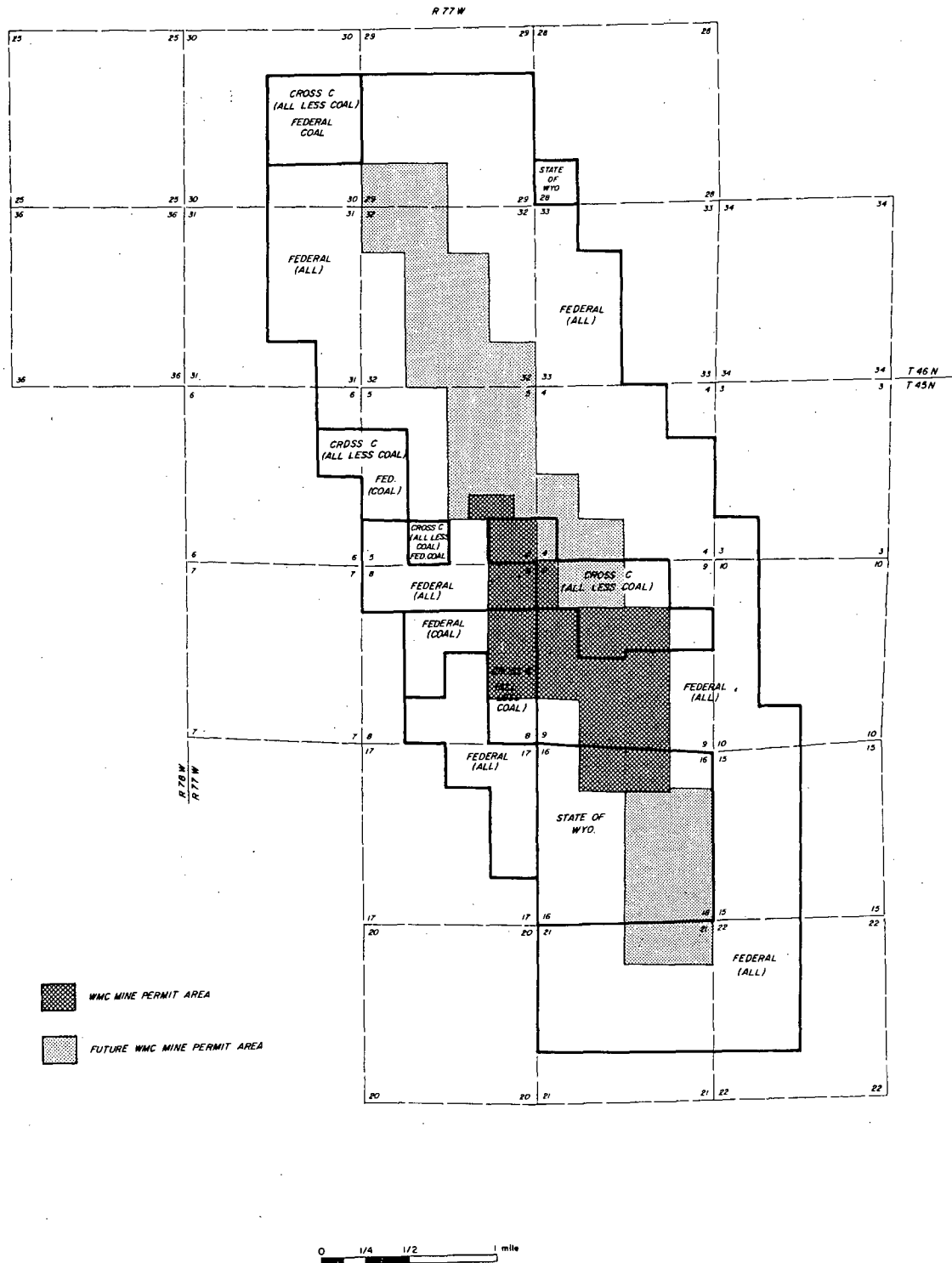


Fig. 1.4. Mineral ownership of the Irigaray mine permit area and adjacent lands. Source: Wyoming Mineral Corporation, Application for In Situ Permit to Mine for the Irigaray Site, submitted to the Wyoming Department of Environmental Quality, Land Quality Division, April 1978 (revised 6/23/78).

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 . . . any source material . . ." (i.e., uranium and/or thorium in any form, or ores containing 0.05% or more by weight of those substances). Title 10, Code of Federal Regulations, 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 for an action that may significantly affect the quality of the human environment.

The State of Wyoming Department of Environmental Quality administers the State's Environmental Quality Act of 1973 and implementing rules and regulations. Article 4 of the act established a permit and licensing plan which is designed to ensure adequate reclamation of mined lands. The licensing procedure is based on the operator's submission of a detailed reclamation plan to the State. A performance bond is required for reclamation. A performance bond will also be required for groundwater restoration.

1.4 STATUS OF REVIEWS AND ACTIONS BY STATE AGENCIES

The approvals and permits required from Wyoming State agencies are listed in Table 1.1. The applicant will obtain all necessary permits required for the proposed project.

Table 1.1. Regulatory approvals and permits required prior to initiation of solution mining project

Permit or license	Granting authority
License to mine	DEQ - LQD ^a
Permit to mine	DEQ - LQD
Air permit to construct	DEQ - AQD ^b
Air permit to install recovery plant processing equipment	DEQ - AQD
Sanitary sewage disposal	DEQ - WQD ^c
Potable water supply	DEQ - WQD
Water wells	SE ^d
Construction of an impoundment	SE, DEQ - WQD
Industrial siting permit	WISC ^e
Air permit to operate	DEQ - AQD
Industrial waste disposal site	DEQ - SWMD ^f

^aWyoming Department of Environmental Quality - Land Quality Division.

^bWyoming Department of Environmental Quality - Air Quality Division.

^cWyoming Department of Environmental Quality - Water Quality Division.

^dWyoming State Engineer.

^eWyoming Office of Industrial Siting Administration.

^fWyoming Department of Environmental Quality - Solid Waste Management Division.

1.5 NRC LICENSING ACTION

NRC licensing of production-scale solution mining (in situ leaching) operations currently follows the same procedures used in licensing a uranium mill. In accord with 10 CFR Part 40, a source material license is required in order to process or refine ores. An applicant for such a license is required to provide detailed information as discussed in NRC Regulatory Guide 3.5. The application must be accompanied by an Environmental Report in order for the NRC to assess the potential environmental effects of the proposed activity pursuant to 10 CFR Part 51. The information required in an Environmental Report is discussed in NRC Regulatory Guide 3.8.

In keeping with these requirements, the applicant submitted an application for a source material license accompanied by an Environmental Survey (hereafter referred to as the ES) on January 28, 1976.¹ Subsequent submittals by the applicant have included (1) Amplification of the Environmental Survey (hereafter referred to as the Amplification),² (2) correspondence from the applicant, dated May 6 and June 15, 1976, (3) applicant's response to staff questions,³ (4) Environmental Report (hereafter referred to as the ER),⁴ (5) Clarification and Information on the revised ER,⁵ (6) clarification and response to staff questions,⁶ (7) Irigaray Restoration Demonstration Program, Final Report,⁷ and (8) Irigaray Restoration Data Package.⁸ These documents form the basis for the staff evaluation of the applicant's proposed project pursuant to 10 CFR Part 51.

The NRC will publish a generic statement on uranium milling operations (excluding solution mining).⁹ In order that uranium mills may be granted a source material license prior to the publication of the generic statement, the NRC requires the address of "five criteria" for a uranium milling operation.⁹

While the proposed solution mining project does not contain all of the components utilized in a "normal" uranium milling operation, the primary product, yellow cake, is the same. For this reason, the staff has followed the June 1976 statement of the NRC and considered the "five criteria" as follows:

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 true for this project, since the uranium ore will not be removed from its natural underground location and would not be available for transport to another mill for processing.

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 foreclose significantly the alternatives available with respect to any other individual licensing action of this type.

None of the materials involved in the construction or operation of this project are unique or in short supply. Air, water, and land resources will be locally affected but not to an extent that would preclude later beneficial use of the local environment. The project will, in addition to providing yellow cake, supply operational and restoration data helpful in improving responsible licensing requirements for other individual licensing actions of this type.

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 Statement contains an evaluation of environmental impacts associated with the proposed licensing action and their severity and includes requirements for monitoring programs and other actions to mitigate the impacts. Cumulative impacts have been considered within the context of the individual license. The relative isolation of the proposed site virtually ensures that all appropriate environmental impacts can be adequately discussed in a site-specific environmental impact statement.

Restoration of the groundwater contained in the ore-bearing sandstone after the extraction of uranium is yet undemonstrated. The staff proposes to limit the scope of the applicant's solution mining project until restoration is demonstrated on a production-scale mining unit and the results are evaluated. The limited authorization minimizes the potential for any cumulative impacts.

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 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 context of the individual licensing action, inasmuch as this project is independent of other projects.

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 the operating reactors and reactors now under construction.

As stated in the June 1976 statement⁹ by the NRC, "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." Therefore an increase in uranium production as proposed by this project is in the public interest, since present national policy is to increase the production of electric power by construction of new nuclear reactors.

REFERENCES FOR SECTION 1

1. Wyoming Mineral Corporation, *Environmental Survey for Irigaray Uranium Mine Site, Johnson County, Wyoming*, Docket No. 40-8502, January 1976.
2. Wyoming Mineral Corporation, *Amplification of Wyoming Mineral Corporation Environmental Survey; Irigaray Uranium Solution Mine Site, Johnson County, Wyoming*, Docket No. 40-8502, Nov. 16, 1976.
3. Wyoming Mineral Corporation, *Draft Answers to NRC Questions*, Docket No. 40-8502, April 1977.
4. Wyoming Mineral Corporation, *Environmental Report - Irigaray Project, Johnson County, Wyoming*, Docket No. 40-8502, July 1977.
5. Wyoming Mineral Corporation, *Clarification and Information, Wyoming Mineral Corporation Revised Environmental Report*, Docket No. 40-8502, Oct. 17, 1977.
6. Wyoming Mineral Corporation, *Requested Answer Clarifications, NRC Questions, Revised Irigaray Environmental Report*, Docket No. 40-8502, Oct. 28, 1977.
7. Wyoming Mineral Corporation, "Irigaray Restoration Demonstration Program, Final Report," Lakewood, Colo., Docket No. 40-8502, Mar. 13, 1978.
8. Wyoming Mineral Corporation, "Irigaray Restoration Data Package," Lakewood, Colo., Docket No. 40-8502, March 1978.
9. "Uranium Milling, Intent to Prepare a Generic Environmental Impact Statement," *Fed. Regist.* 41: 22430-22431 (June 3, 1976).

2. THE EXISTING ENVIRONMENT

2.1 CLIMATE

2.1.1 General influences

The climate is semiarid; the mean annual precipitation is 12.0 in. More than 50% of the annual precipitation is received during the months of May, June, and July, in the form of wet snow and rain. Temperatures vary from summer highs near 38°C (100°F) to winter lows near -40°C (-40°F). The seasons are distinct, with mild summers and harsh winters. Spring and fall are transition seasons with warm days and cold nights. Heavy snowfalls can be expected during both of these seasons.¹

2.1.2 Winds

The prevailing wind direction at the site is expected to be westerly, based on annual average surface wind flow measurements from Sheridan and Casper as shown in Fig. 2.1. Strong winds are fairly frequent. Winds of 50 mph or more have been reported at Casper in every month of the year except November.² The local topography strongly influences the micrometeorological conditions.

2.1.3 Precipitation

Cooperative weather station data over the period 1970-1974 for four stations 48 to 64 km (30 to 40 miles) from the site in the prevailing wind pattern gave an "averaged" annual precipitation of 30.9 cm (12.2 in.). These stations, at Kaycee, Billy Creek, Buffalo, and Reno (Table 2.1), showed a low of 28.9 cm (11.4 in.) and a high of 33.2 cm (13.1 in.) of precipitation per year. Late spring and summer precipitation is normally derived from scattered thunderstorms, and the monthly extremes from each station vary widely. Fifty-three percent of the measured precipitation occurred in the period April-July, 12% occurred in October, and only 12% occurred in the period November-January. Table 2.1 shows the 1970-1974 average values for both precipitation and snow for each of the four stations. The last column contains the maximum and minimum values observed for all years and all stations and demonstrates the large variability that may be observed.³

2.1.4 Storms

Winter storms, with attendant snowfall, low temperatures, and high winds, are common. Thunderstorms, occasionally spawning tornadoes, are frequent in spring and summer.

2.2 AIR QUALITY

As a result of fairly constant daily winds, air dispersal capabilities in the Powder River Basin are relatively good. Because of the clear skies and rapid nighttime cooling, low-level nocturnal inversions are common. These inversions are usually dissipated shortly after sunrise by rising surface temperatures and increased wind speeds. Upper-level inversions [above 150 m (492 ft)], resulting in stagnant air, may be expected an average of 40 episode days per year.⁴ Episodes lasting at least five days occur on an average of four times a year.⁴

There has been no site-specific air quality monitoring near the proposed WMC site. However, because of the distance of the WMC site from any urban or industrial emission sources, the air quality may be expected to be very good, with concentrations of major pollutants at very low background levels. Fugitive dust from oil fields, gravel borrow pits, and unpaved roads may occasionally affect air quality in the WMC vicinity. At sites within the Powder River Basin removed from localized dust sources, background suspended particulate concentrations range from 13 to 21 $\mu\text{g}/\text{m}^3$.⁴ The Wyoming State ambient air quality standards are listed in Table 2.2.

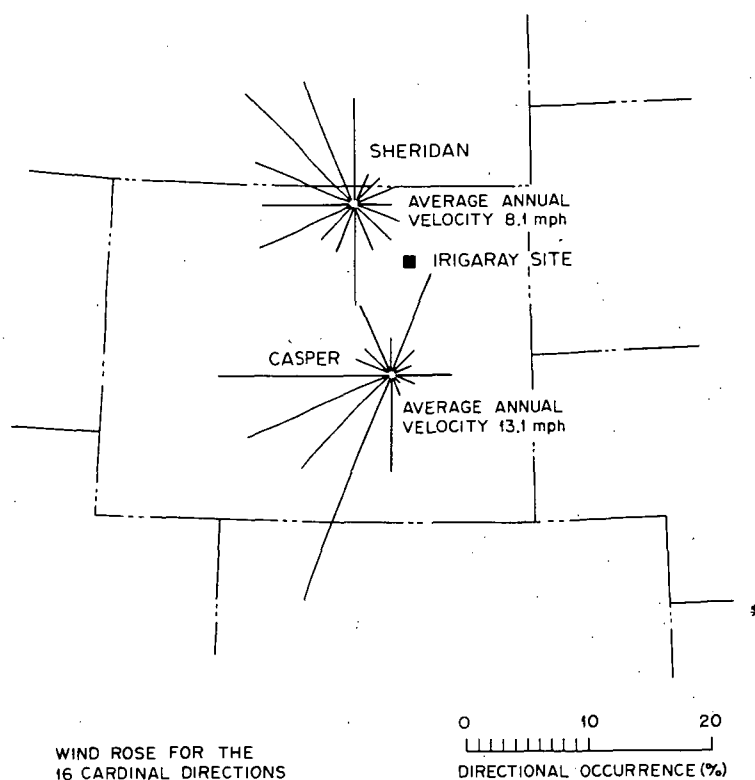


Fig. 2.1. Annual surface wind flow at Sheridan and Casper, Wyoming. Source: U.S. Department of Commerce, *Local Climatological Data - Summary with Comparative Data, 1973, Casper, Wyoming*.

Table 2.1. Average precipitation 1970-1974

All values in inches

Month	Kaycee		Billy Creek		Buffalo		Reno		All stations	
	Precip	Snow	Precip	Snow	Precip	Snow	Precip	Snow	Max	Min
January	0.54	6.4	0.33	5.2	0.42	4.5	0.34	4.6	1.28	0.03
February	0.27	3.0	0.30	3.7	0.52	6.5	0.16	1.0	1.26	0.01
March	0.82	7.4	0.75	8.6	1.39	9.4	0.59	4.7	1.75	0.00
April	2.51	11.9	1.37	6.2	1.91	2.2	1.22	7.3	4.62	0.92
May	1.98	1.0	1.37	Trace	1.73	0.4	1.96	Trace	3.88	0.37
June	1.80	0	1.21	Trace	1.55	0	1.99	0	3.53	0.58
July	1.02	0	1.55	0	1.04	0	1.49	0	3.30	0.15
August	0.76	0	1.08	0	1.07	0	1.04	0	2.90	0.00
September	0.88	5.5	0.75	1.0	1.14	Trace	0.85	Trace	2.65	0.28
October	1.41	4.0	1.68	6.1	1.64	2.0	1.14	8.3	3.58	0.37
November	0.45	3.4	0.42	5.2	0.52	9.0	0.16	0.3	0.92	0.01
December	0.37	4.7	0.27	4.2	0.17	3.3	0.47	5.4	0.45	0.00
Yearly	12.81	47.3	11.49	40.2	13.10	37.3	11.41	31.6		

Source: Cooperative Weather Station Data, National Weather Service Station Data, National Climatic Center, Asheville, N.C., 1970-1974, U.S. Department of Commerce.

Table 2.2. Wyoming State ambient air quality standards

Pollutant	Averaging period	Maximum acceptable concentration
Total suspended particulates	Annual (geometric mean) 24 hr	60 $\mu\text{g}/\text{m}^3$ 150 $\mu\text{g}/\text{m}^3$ ^a
Total settleable particulates	30 days 30 days	5 g/m ² per month (residential areas) ^a 10 g/m ² per month (industrial areas) ^a
Sulfur dioxide	Annual (arithmetic mean) 24 hr 3 hr	60 $\mu\text{g}/\text{m}^3$ 260 $\mu\text{g}/\text{m}^3$ ^a 1300 $\mu\text{g}/\text{m}^3$ ^a
Sulfation rate	Annual 30 days	0.25 mg SO ₃ per 100 cm ² per day 0.50 mg SO ₃ per 100 cm ² per day ^a
Hydrogen sulfide	0.5 hr 0.5 hr	70 $\mu\text{g}/\text{m}^3$ ^b 40 $\mu\text{g}/\text{m}^3$ ^c
Photochemical oxidants	1 hr	160 $\mu\text{g}/\text{m}^3$ ^a
Nonmethane hydrocarbons	3 hr (6 AM–9 AM)	160 $\mu\text{g}/\text{m}^3$ ^a
Nitrogen dioxide	Annual	100 $\mu\text{g}/\text{m}^3$
Carbon monoxide	8 hr 1 hr	40 mg/m ³ ^a 10 mg/m ³ ^a

^aNot to be exceeded more than once a year.

^bNot to be exceeded more than twice a year.

^cNot to be exceeded more than two times during any five-day period.

Source: Wyoming Environmental Quality Act (1975), Chapter 1, Sections 3 through 12, Air Quality Standards and Regulations, amended January 31, 1975.

2.3 TOPOGRAPHY

The Irigaray property is located in the southern portion of the Powder River Basin, which is a part of the Great Plains physiographic province. The Powder River Basin is a structural and topographic basin covering approximately 64,750 km² (25,000 sq miles) in eastern Wyoming and southern Montana.⁴ The basin is bounded on the east by the Black Hills and on the west by the Bighorn Mountains and Casper arch (Fig. 2.12). The Laramie Range and Hartville uplift serve as the southern boundary, while the Miles City arch, in Montana, demarcates the northern extent of the basin.

The surface configuration in the Irigaray property area is characterized by gently rolling uplands, which have been extensively dissected, and broad valleys. The Powder River valley is from 1/2 to 1 mile wide, and the valley of Willow Creek is from 1/4 to 1/2 mile wide on the Irigaray property. Elevations range from 1280 m (4200 ft) along the Powder River in the northern section of the property to 1433 m (4700 ft) near the southeast property boundary.

The topography in the vicinity of both the existing pilot-scale test activities and the proposed initial well field areas is shown in Fig. 2.2.

2.4 REGIONAL DEMOGRAPHY AND SOCIOECONOMIC PROFILE

2.4.1 Demography

2.4.1.1 Current population and distribution

Because of accessibility to the site, the proposed project work force would be expected to reside primarily in Buffalo, the county seat of Johnson County, approximately 68 km (42 miles) from the site. In 1970, Buffalo had a population of 3394 people, out of about 5600 people residing in the county. The populations of other nearby ranches and towns are shown in Table 2.3. The locations of the towns are shown in Fig. 2.3. In 1976 the population of Buffalo was reported as 4200, and the total population of Johnson County was 5300.⁵ The population density for Johnson County is 1.29 persons per square mile.

The applicant reports 1403 housing units in Buffalo and a vacancy rate of 8% or 112 units (ER, p. 46). The permanent project work force is expected to be less than 60; many are already residents of Buffalo.

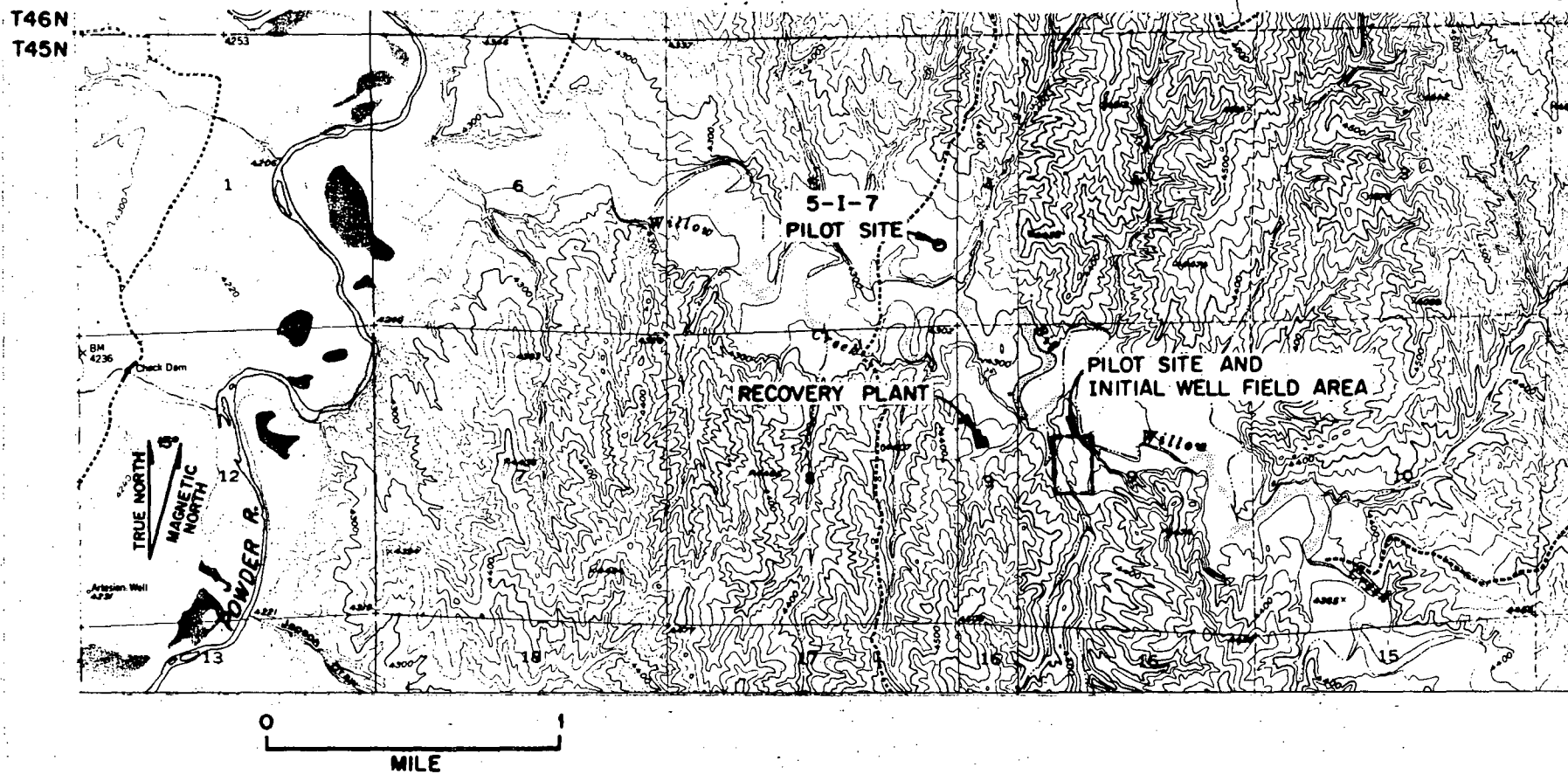


Fig. 2.2. Topographic map with the location of solution mining activities on the Irigaray property. Note: Scale, 1:24,000. Source: U.S. Department of the Interior Geological Survey, Topographic maps of the Nipple Quadrangle and the Hoe Ranch Quadrangle, 7.5 Minute Series, 1953.

Table 2.3. Ranch and town populations near Irigaray property

Ranch or town	Distance from site (miles)	Population
Reclusa Ranch	4.1	8-10
Irigaray Ranch	4.4	6
ZL Bar Ranch	5.6	12
Falxa Camp	5.7	2
Urruty Ranch	7.2	4-5
Sussex	15.0	30
Linch	20.0	300
Kaycee	28.0	272
Buffalo	42.0	3394
Gillette	42.0	7194

2.4.1.2 Projected population and distribution

Population growth in the Powder River Basin was 39% from 1940 through 1970. The Johnson County population increased only 12% during these 30 years. At present, coal and uranium mining in the region is increasing the employment opportunities, and the population is growing. The new residents migrate to communities such as Buffalo, which increased in population by 24% from 1970 to 1976.⁵ This increase in urban population is expected to continue.

2.4.1.3 Transient population

Interstate highway 25, a major tourist route, passes through Buffalo 68 km (42 miles) away from the site. Few tourist accommodations are present, and this transient population has almost no effect on the community.

2.4.2 Socioeconomic profile

2.4.2.1 Social profile

Privately owned homes in Buffalo comprise 79% of the dwelling units. There are no public housing units. There is a police force of seven and a volunteer fire department. Buffalo has a high school and an elementary school, whose enrollments are 410 and 680 respectively. The ratio of students to teachers is 18.8, and the total expenditure per student was about \$1300 in 1976. Buffalo is served by five physicians and three dentists. The local hospital has 24 beds and an occupancy rate of 66%.

2.4.2.2 Economic profile

Buffalo has a combined labor force of 2810 workers, of whom 1913 (68%) are male and 897 (32%) are female. The unemployment rate is 2.8% for the total work force.

Statistics on the distribution of employment are tabulated in Table 2.4.

The total assessed tax value of Johnson County is \$42,975,195, of which \$4,231,289 lies within the city of Buffalo.

The bonded indebtedness for the city is \$113,000 and for the school district \$140,000. The total tax revenue collected in 1975 by Johnson County was \$2,287,437, and the city of Buffalo collected \$299,389.

The distribution of the tax levy for the county, city, and school district for 1970, 1974, and 1975 is tabulated in Table 2.5.

2.5 LAND USE

2.5.1 Land resources

Cattle and sheep ranching are the major land uses in the region surrounding the proposed project site. About 94% of the land in the Powder River Basin is classified as rangeland.⁶ Native rangeland vegetation provides the majority of the livestock forage in the region. Major native forage species are blue grama grass (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), needlegrasses (*Stipa* spp.), prairie june grass (*Koeleria cristata*), and numerous forbs. Crested wheatgrass (*Agropyron desertorum*), the principal introduced forage plant, is often planted on reclaimed disturbed land.

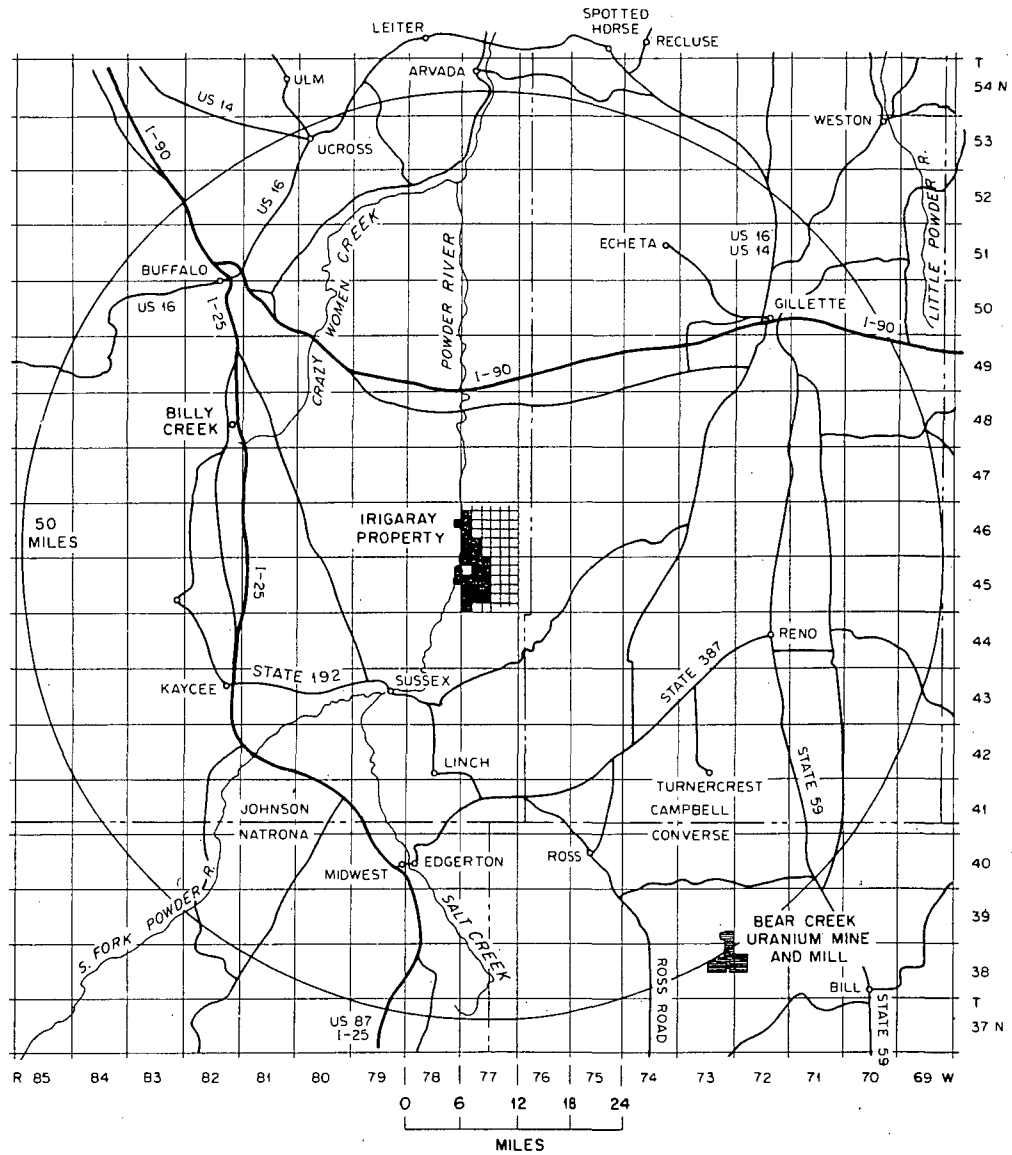


Fig. 2.3. Irigaray property and the surrounding area.

Table 2.4. Distribution of labor force

Contract construction	236
Transportation, communications, and utilities	85
Finance, insurance, and real estate	55
Service with local government	218
Mining	205
Manufacturing	96
Wholesale trade	11
Retail trade	365
Federal government	35
Agriculture	640
Nonagricultural	720
Other	144
Total	2810

Table 2.5. Tax levy

Unit	Tax levy (mills)		
	1970	1974	1975
City	7.7	17.6	17.09
County	29.5	9.5	12.56
School	18.3	40.6	41.10
Total	55.76	68.5	70.76

The area within a 15-km (9-mile) radius of the WMC site includes portions of five ranches. Table 2.3 lists the populations at the headquarters of these ranches and their distances from the WMC site. All of the Irigaray site is currently grazed. According to a generalized land use map of Johnson County,⁷ the majority of the land on the proposed site is classified as fair to poor rangeland. From past grazing records of the site filed with the Bureau of Land Management District Office in Buffalo, the grazing capacity of the land is estimated to be 3.5 ha (9 acres) per animal unit month (ER, p. 89). The land along the floodplains of Willow Creek and the Powder River, with its denser cover of perennial grasses, is better rangeland and may have a grazing capacity of 0.8 to 1.5 ha (2 to 4 acres) per animal unit month.⁶

Major transportation routes in Johnson County are shown in Fig. 2.3. Access to the proposed WMC site is from Wyoming Highway 192 just west of Sussex via a graveled light-duty road.

Extraction of energy-related minerals is the major industrial land use in the Powder River Basin. Mineral resources of the region are discussed in detail in Sect. 2.7.2. Oil and gas production and, more recently, coal and uranium mining have been significant factors in the economy of the Powder River Basin. Future trends in land use point to more land being committed to minerals production.^{6,8}

Since the land is privately owned, recreational uses of the WMC site and adjacent lands are limited. Hunting is permitted by some landowners. Pronghorn antelope and mule deer are the most important game species. Upland game birds, primarily sage grouse, and small game such as cottontail rabbits are a minor hunting resource.

2.5.2 Historical and archaeological sites and natural landmarks

The archaeological and paleontologic resources of the Powder River Basin remain largely uninvestigated. Most known archaeological sites in the region were found as a result of surveys connected with recent minerals-related development in Campbell County, 65 km (40 miles) to the east of the WMC site. The nearest known sites of paleontologic value are located approximately 8 km (5 miles) west of the WMC site at the Reculosa blowout.⁶ Mammalian fossils of Eocene age have been collected from the Reculosa sites.⁶ An archaeological survey conducted by the Office of the State Archaeologist on the portion of the WMC site to be affected by mining activities revealed no archaeological resources (Appendix F).

There are no sites within the WMC site boundaries that are currently listed on the National Register of Historic Places, nor any that have been determined to be eligible for inclusion, nor any that have been nominated for consideration of eligibility. This statement is based on a search of the latest listing of the National Register⁹ and all weekly and monthly supplements. The Hoe Ranch, located within the WMC site boundaries (Fig. 2.4), is not a National Register site but has some historic value as a ranch headquarters that entered into the history of the Johnson County range wars.⁶ The site consists of a massive stone chimney and other ruins of the old ranch. The Hoe Ranch has not been nominated for consideration of eligibility for inclusion into the National Register. The locations of National Register sites near the WMC site are shown in Fig. 2.4. Fort Reno and Cantonment Reno are currently included in the National Register.^{9,10} The Portuguese Houses site has been determined as eligible for inclusion in the National Register.¹¹ The Office of the State Historic Preservation Officer has been contacted regarding the WMC project. Site clearance has been given (Appendix F).

Based on a search of the National Registry of Natural Landmarks and all current supplements, there are no natural landmarks in the vicinity of the WMC project area.¹²

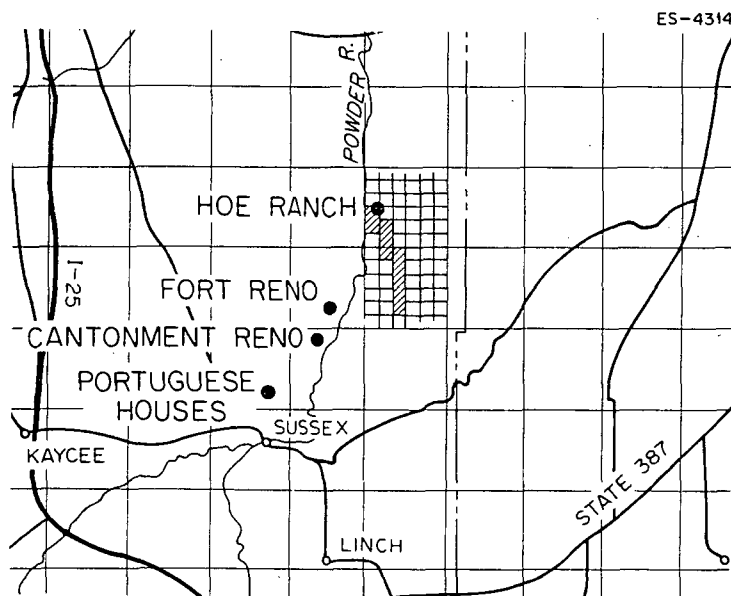


Fig. 2.4. Historic sites in the vicinity of the WMC site.

2.6 WATER

2.6.1 Surface water

The Powder River, which flows through the western part of the Irigaray property, rises near the center of Wyoming and flows northward, draining 8% of Wyoming's area (Fig. 1.2). Willow Creek, which flows intermittently westward across the central part of WMC's site, is a tributary of the Powder River. The WMC plant and several well fields lie near the Willow Creek streambed (Fig. 2.7 and 4.1).

The surface waters of Johnson County are described by Wendell et al.¹³ The Powder River is fed by both surface flows and groundwater. Most of the streams feeding the Powder River rise in the Bighorn Mountains, where precipitation is highest. As shown in Fig. 2.5, most of the runoff occurs during the months of March through July, due to heavy winter snowpacks and rainfall caused by air rising over the Bighorn Mountains.

The flow and character of surface streams depend on geology, topography, vegetation, and climate. Nonmountain streams have low flows and high sediment loads. Soil erosion is a problem in the basin area due to sparse cover, easily eroded soils, and nonresistant rock units. Some surface streamflows are apparently lost to groundwater recharge as they cross carbonate rocks in the mountains, but most of the streamflows emerge as springs and seeps in the foothills.¹³

The U.S. Geological Survey gaging stations on streams near the WMC site are listed in Table 2.6 and shown in Fig. 2.6. Data regarding discharge and water quality at these stations are summarized in Tables 2.6 and 2.7. WMC provided data regarding water quality in the Powder River at two points near the plant (ER, p. 83). WMC's "upstream" station is located about 9 km (5.7 miles) southwest of WMC's plant. WMC's "downstream" station is located about 5 km (3 miles) northwest of the plant site at the Irigaray Ranch. These sampling locations are shown in Fig. 2.7. Water quality data from these stations are presented in Table 2.8.

Water quality in the Powder River varies greatly, as indicated in Table 2.7. The pattern described by Kittrell often applies,¹⁴ namely, the concentrations of many parameters, such as alkalinity and hardness, often vary inversely with streamflows. During periods of low flow, most streamflow is water that has entered the stream from groundwater (ER, p. 79). Water in shallow aquifers generally has a higher dissolved solids concentration than the runoff from precipitation. At lower streamflows, higher dissolved solids concentrations generally occur and often exceed that of the aquifer source, due to the evaporative concentration in stream channels.¹⁵

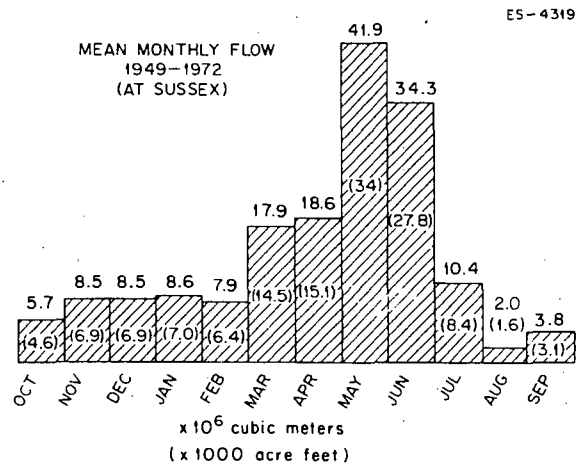


Fig. 2.5. Mean monthly flows on the Powder River at Sussex, 1949-1972. Source: W. G. Wendell et al., *Johnson County, Wyoming, Geologic Map, Atlas, and Summary of Land, Water, and Mineral Resources*, County Resource Series No. 4, Geologic Survey of Wyoming, 1976.

Table 2.6. U.S. Geological Survey stream gaging stations near the Irigaray site

Figures are for water years 1972, 1973, and 1974

Map code	Station No. ^a	Station name	Drainage area (sq miles)	Discharge (cfs)	
				Range	Average
A	3125	Powder River near Kaycee	980	0.68-920	126.8
B	3130	South Fork Powder River near Kaycee	1150	0-165	23.9
C	3134	Salt Creek near Sussex	765	5.9-110	29.0
D	3164	Crazy Woman Creek at upper station near Arvada	945	0.2-770	45.8
E	3170	Powder River near Arvada	6050	9.1-2050	350.7

^aLocations of stations are shown in Fig. 2.5. Listed in downstream order.

Source: U.S. Geological Survey, *Water Resources Data for Wyoming, Part 2, Water Quality Records, 1972, 1973, and 1974*.

In the Powder River the total dissolved solids concentrations usually exceed the recommended drinking water criteria for chloride and sulfate of 250 mg/liter.¹⁶ Total dissolved solids concentrations frequently exceed 3000 mg/liter, and such water may produce undesirable effects when used for livestock watering or irrigation.¹⁷

The Wyoming Department of Environmental Quality considers the Powder River at Salt Creek and Arvada to contain "problem segments." Below its confluence with Salt Creek, the Powder River shows high salt concentrations. Salt Creek consists mainly of wastewater from oil field operations. Flows from Salt Creek added 47% of the salinity recorded in the Powder River at Sussex during water year 1976.¹⁸ The Powder River at Arvada exceeds standards and criteria for many parameters, including fecal coliforms, chromium, mercury, iron, and cadmium. Dissolved oxygen concentrations below the recommended level are also found.¹⁸ The Department of Environmental Quality believes that diffuse nonpoint sources are responsible for high metal concentrations. Oxygen depletion is a result of low flow conditions in the summer; runoff from grazing areas produces occasional excesses of fecal coliforms.¹⁸

Willow Creek is normally dry (ER, p. 84). During the spring, snowmelt and discharge from high water tables may produce flow for periods of several weeks. Runoff from convective storms may also cause temporary flow in Willow Creek. The applicant uses analyses from the U.S. Geological Survey¹⁹ to calculate flood risk. Willow Creek's drainage is approximately 250 km² (96 sq miles). The mean annual flood discharge is predicted to be 19,255 liters/sec (680 cfs). A flood with a 50-year recurrence interval would have a discharge of 168,310 liters/sec (5944 cfs) (ER, p. 84). Floods could interrupt project operations.

No data are available to describe the water quality in the normally dry Willow Creek.

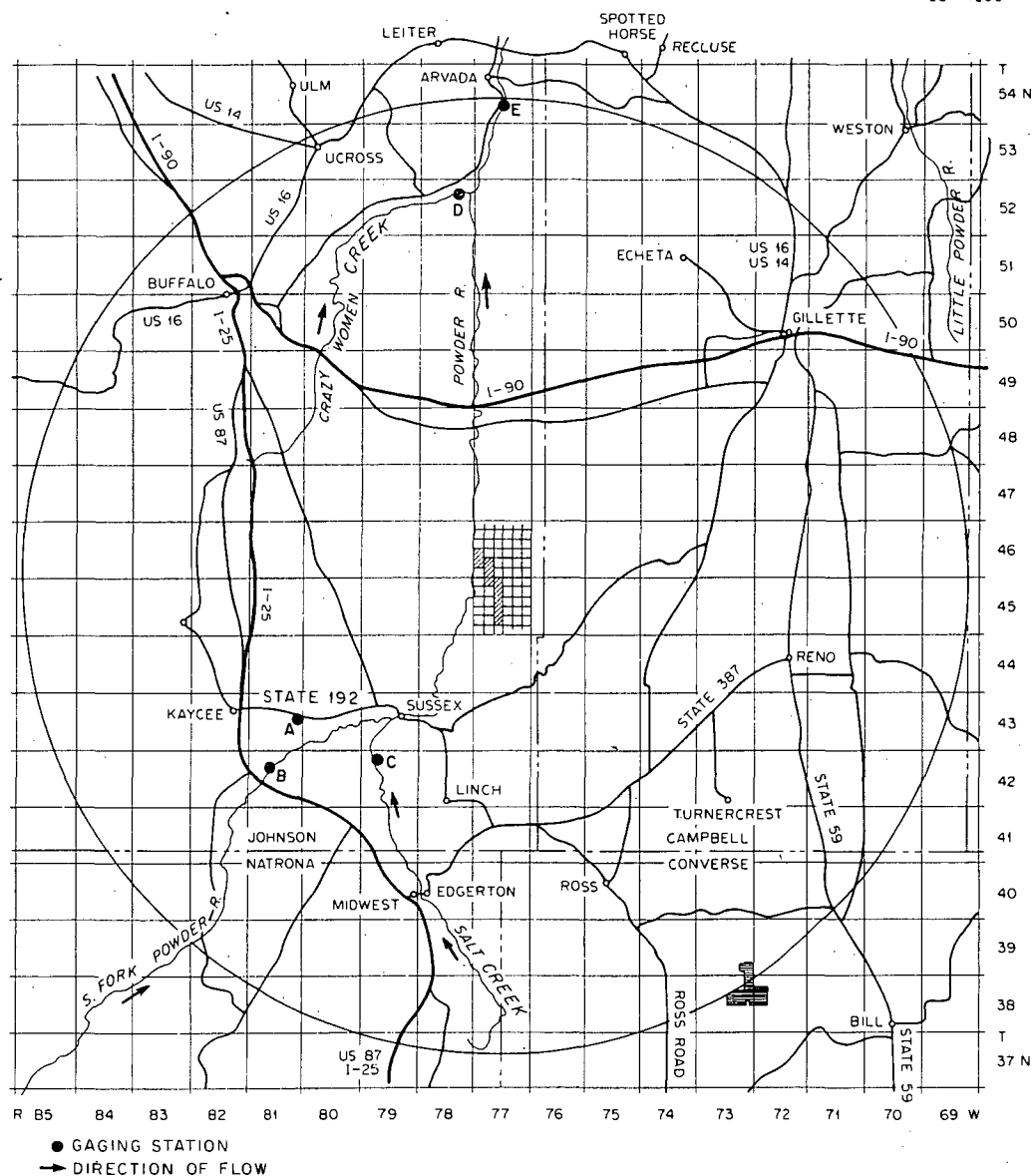


Fig. 2.6. U.S. Geological Survey stream gaging stations near the Irigaray site.

2.6.2 Groundwater

2.6.2.1 Hydrologic units

Hydrologic units on the Irigaray site include surface alluvium, the Wasatch Formation, and the Fort Union Formation, both of Cenozoic age. Older rocks are at least 1219 m (4000 ft) below the Irigaray site, and little is known of their hydrologic characteristics. Solution mining will be limited to the Wasatch Formation, which is about 480 m (1575 ft) thick in the Pumpkin Buttes area (see Sect. 2.7.1).

The following description of the major hydrologic units comes from Hodson and others¹⁹ and is not site-specific unless so indicated.

Table 2.7. Summary of monthly water quality data for the years 1972-1974 for Powder River and tributaries near the Irigaray site

Station ^a code	Dissolved solids (sum of constituents) (mg/liter)	Dissolved Fe ^b (μg/liter)	Dissolved bicarbonate (mg/liter)	Dissolved sulfate (mg/liter)	Dissolved nitrate (mg/liter)	Specific conductance (micromhos)	pH
A (Powder River)							
Range	263-1306	0-200	119-287	100-672	0-2.9	421-1750	7.6-8.3
Average	827	68	244	265	1.2	1190	8.09
Min discharge (6/20/74)	1220		262	632	0.2	1710	8.1
Max discharge (5/17/72)	263	50	119	100	2.8	421	7.9
B (South Fork)							
Range	1590-4390	0-470	104-345	990-2300	0-19	2040-5460	7.7-8.4
Average	2310	97	182	1560	2.96	3099	7.99
Min discharge (12/15/71)	3790	10	345	2300	3.3	4570	7.8
Max discharge (4/12/73)	2280	470	162	1500	4.0	2760	8.0
C (Salt Creek)							
Range	3070-5660	0-440	453-1410	93-1790	0-34	4440-8370	7.5-8.4
Average	4710	141	862	1279	1.3	6843	8.0
Min discharge (11/20/73)	5650		1180	1300	0.7	7820	7.9
Max discharge (4/21/72)	3710	50	453	1700	0.2	5140	7.8
D (Crazy Woman)							
Range	300-2360	0-1000	74-360	130-2000	0.2-3.7	508-3340	7.2-8.4
Average	1208	166	229	748	0.69	1551	8.03
Min discharge (8/7/74)	2360		360	1500	0.7	2670	7.9
Max discharge (2/29/72)	289	20	74	150	3.7	443	7.5
E (Powder River)							
Range	766-3207	0-590	145-620	380-1500	0.02-2.3	1110-4430	7.4-8.4
Average	1903	137	278	1122	0.83	2639	7.92
Min discharge (7/17/73)	2600	90	256	1300	0.4	3430	7.7
Max discharge (4/23/74)	2060		150	1300	1.4	2580	8.1

^a Locations are shown in Fig. 2.6.

^b Data regarding concentration of Fe were collected only in 1972-1973.

Alluvium

The alluvial aquifer consists of thin, unconsolidated clay, silt, sand, and gravel. Its thickness varies from less than 0.3 m (1 ft) on topographically high areas to as much as 30 m (100 ft) along the major river valleys. Well yields range from a few to 1000 gallons per minute (gpm), depending on the saturated thickness of the alluvium, grain sorting, well construction, and development methods. Total dissolved solids range from about 100 to over 4000 mg/liter but are more commonly 500 to 1500 mg/liter. Water in the alluvium from the Powder River valley and central Powder River Basin is generally of a poorer quality than elsewhere in the basin.

Wasatch Formation

The Wasatch Formation yields water from lenticular sandstone bodies. Smaller volumes are derived from jointed coal and clinker beds. Well yields range from 10 to 15 gpm in the northern part of the basin but may be over 500 gpm in the southern Powder River Basin. The specific capacity of wells varies from 5 to 14 gpm per foot of drawdown. Total dissolved solids range from less than 200 to more than 8000 mg/liter but are more commonly 500 to 1500 mg/liter. There is no apparent relationship between depth and water quality, but total dissolved solids concentration generally decreases to the south.

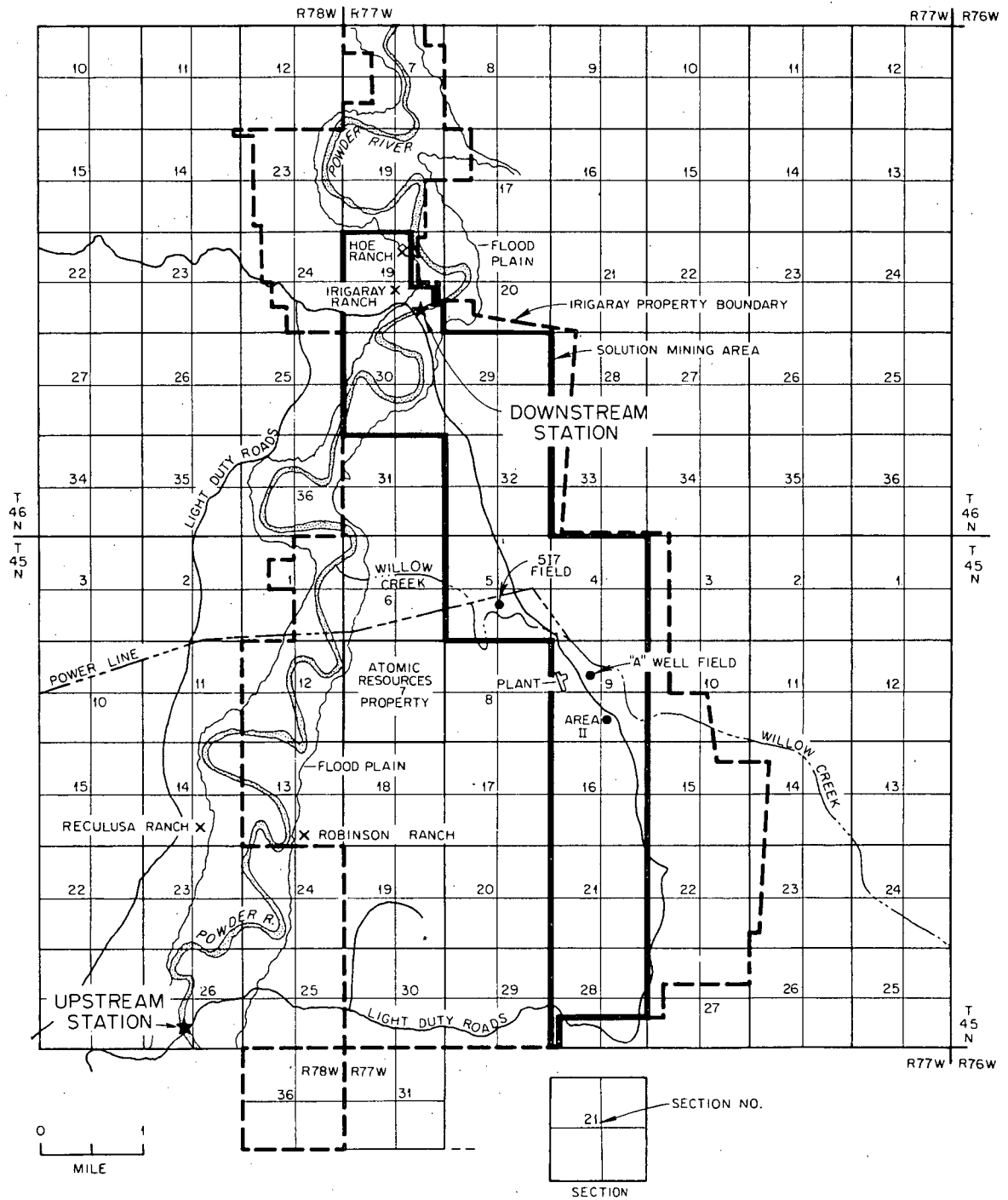


Fig. 2.7. Locations of WMC's sampling points in the Powder River.

Table 2.8. Water quality data for the Powder River upstream and downstream from WMC Irigaray plant site

Analysis	Unit	Station ^a	
		Upstream	Downstream
As	ppb ^b	5.0	6.5
Ba	ppm ^c	0.30	0.33
B	ppm	0.71	0.60
Cd	ppb	7.0	7.0
Cr	ppb	14	36
Cu	ppb	12	28
Mn	ppm	0.05	0.27
Hg	ppb	0.40	0.27
Ni	ppb	30	52
Se	ppb	<5	<5
Ag	ppb	6	<5
Zn	ppb	0.03	0.09
Pb	ppb	42	62
Total dissolved solids -	ppm	2,090	2,110
Ra-226	pCi/liter	0.9 ± 0.5	1.0 ± 0.5
Gross alpha	pCi/liter	19 ± 7	13 ± 6
Gross beta	pCi/liter	46 ± 17	42 ± 17

^aStation locations are shown in Fig. 2.6. Upstream station is located adjacent to the river in the southwest quarter of Section 26, T45N, R78W; downstream station is located at Irigaray bridge near the Irigaray Ranch, Section 19, T46N, R77W.

^bppb is parts per billion.

^cppm is parts per million (equivalent to mg/liter).

Source: ER, p. 83.

Fort Union Formation

The Fort Union Formation yields water from fine-grained sandstone and jointed coal and clinker beds. Maximum yields are about 150 gpm. The specific capacity varies from 0.3 to 0.9 gpm per foot of drawdown. Total dissolved solids range from about 200 to over 3000 mg/liter but are usually between 500 and 1500 mg/liter. The water type is primarily sodium bicarbonate and secondarily sodium sulfate.

2.6.2.2 General characteristics

The Powder River Basin is a relatively independent groundwater system. Recharge to both the Wasatch and Fort Union formations in most of the Powder River Basin is by precipitation.¹⁹ Discharge is by evaporation, springs, transpiration by plants, and well pumpage. Annual water-level fluctuations in observation wells are small, indicating a balance between recharge and discharge.¹⁹ The water table for the Wasatch Formation is relatively shallow in the western part of the basin.

A regional potentiometric surface map of the Wasatch Formation aquifer, as provided by the applicant, is shown in Fig. 2.8. The equipotential lines are based on water level readings in wells taken by WMC in 1974. The regional hydraulic gradient is approximately 0.005 ft per foot to the north-northwest, and the estimated groundwater flow rate is 5 to 8 ft/year. The groundwater moves approximately parallel to the long axis of the ore body. Beneath the Powder River floodplain, however, groundwater moves upward through the Wasatch Formation and discharges into the Powder River²⁰ (Fig. 2.9).

2.6.2.3 Site-specific groundwater characteristics

Local variations in the groundwater flow rate are to be expected in the fluvial sedimentary deposits underlying the Irigaray site (Sect. 2.7.1.2). At Irigaray pilot-scale test site 517 (Fig. 2.10) the hydraulic gradient averages 0.033 ft per foot to the west and the groundwater flow rate as calculated by the staff, is about 60 ft/year. Groundwater level monitoring data, gathered from June 1976 through October 1976, indicate at least 3 m (10 ft) of fluctuation in groundwater levels; water levels were high in June and low in October.

Aquifer tests of the Upper Irigaray sandstone were conducted by the applicant at three locations from 1975 to 1977 (Fig. 2.10). Test analyses indicate that transmissivities ranged from 373 to 1410 gpd/ft. Storage coefficients varied from 1.85×10^{-4} to 7.44×10^{-5} , indicating that the aquifer system is under artesian head. The primary direction of groundwater flow and major hydraulic conductivity is to the northwest.

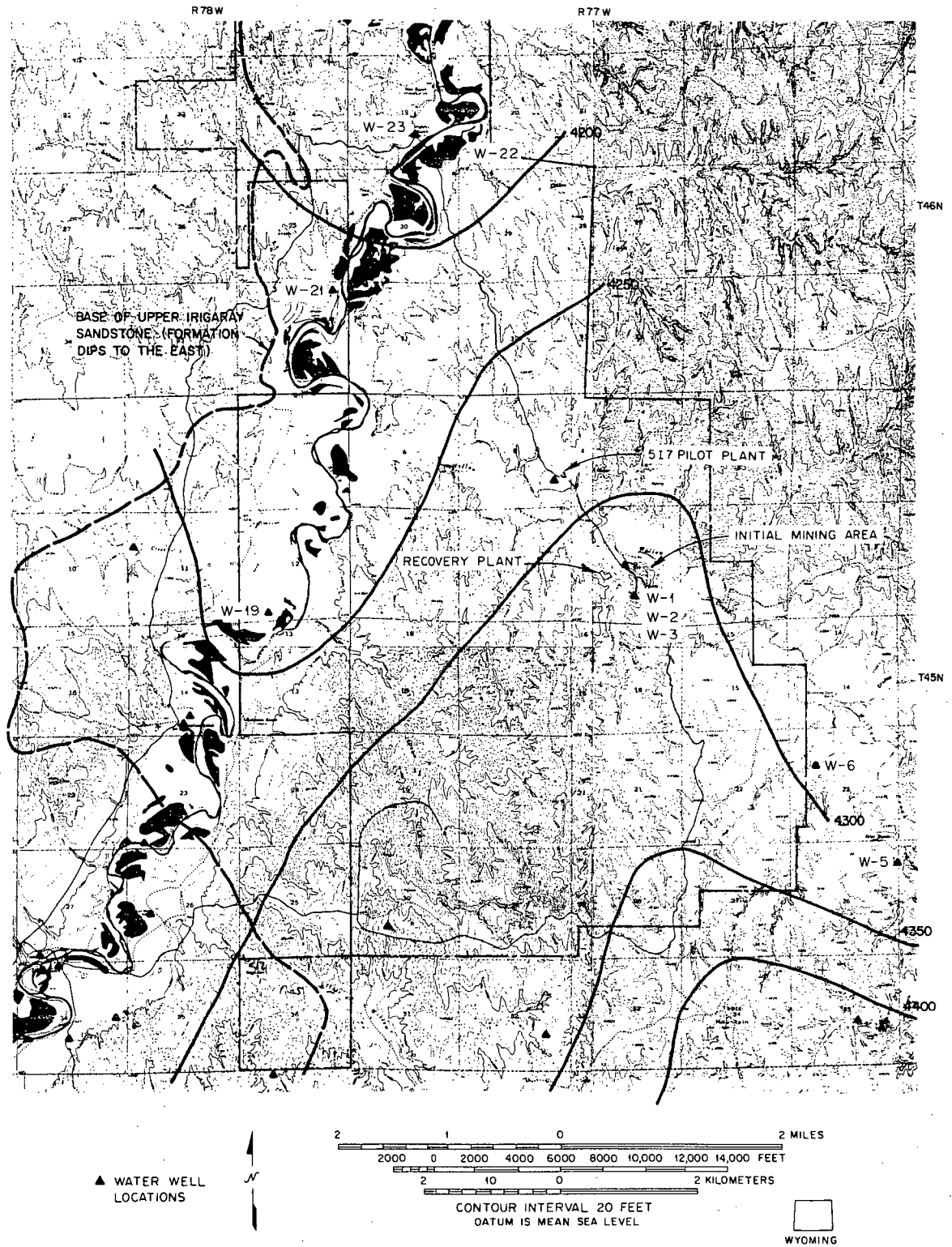


Fig. 2.8. Elevation contour map of potentiometric surface, Wasatch Formation, Irigaray, Wyoming. W-1, W-2, etc., indicate the location of wells listed in Appendix B, Table B.1. Note: W-1, W-2, and W-3 are WMC test wells, and the nearest private wells are W-6, W-22 and W-23.

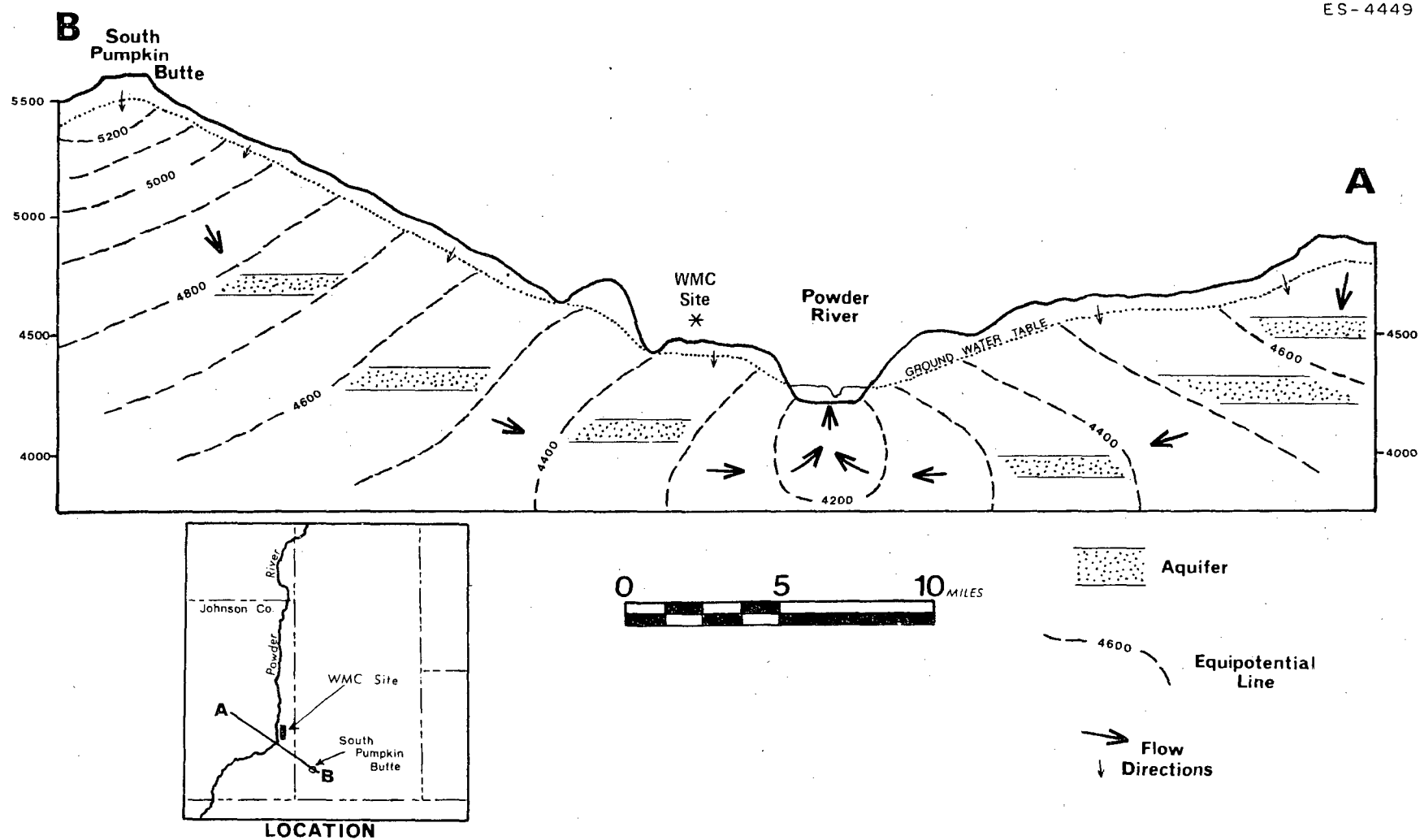


Fig. 2.9. Regional groundwater flow pattern in the vicinity of the Irigaray site. Note the orientation of the insert.
 Source: Modified from J. Hagmaier, *Groundwater Flow, Hydrochemistry, and Uranium Deposition in the Powder River Basin, Wyoming*, Ph.D. dissertation, University of North Dakota, 1971.

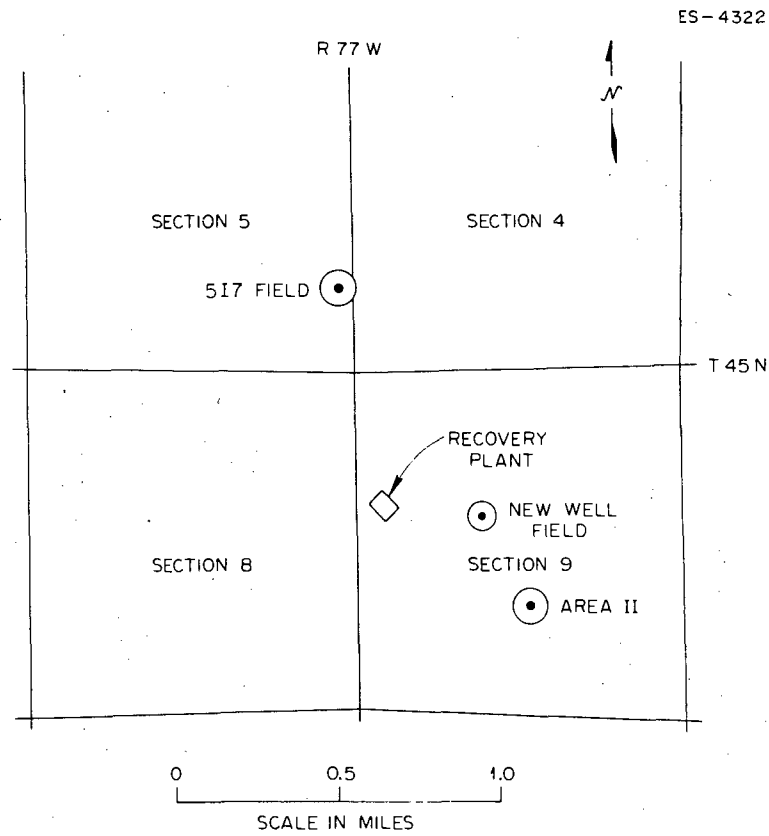


Fig. 2.10. Locations of pump test sites (circles).

The area II site was tested in August 1975, using two observation wells in addition to the pumped well. This continuous-drawdown test was conducted for 27 hr at a pumping rate of approximately 20 gpm. The drawdown at the end of the test was 30 m (100 ft), indicating that the pumped well's specific capacity is about 0.2 gpm per foot of drawdown. Transmissivities ranged from 925 gpd/ft for the pumped well and 1035 and 1100 gpd/ft for the two observation wells. Calculated storage coefficients were 3.6×10^{-5} and 6.7×10^{-5} .

An aquifer test was conducted at the 517 pilot-scale test field during November 1975. The test consisted of a 19-hr continuous-drawdown test at a pumping rate of 15 gpm. There were eight observation wells in addition to the pumped well. The drawdown at the conclusion of the test was 49 ft; the specific capacity of the pumped well was therefore approximately 0.3 gpm per foot of drawdown. The 37-m (120-ft) aquifer was only partially penetrated; however, no partial penetration corrections were deemed necessary by the applicant in the test analyses. Transmissivity values derived from observation well data ranged from 1030 to 1410 gpd/ft. Storage coefficients varied between 1.85×10^{-4} and 7.44×10^{-5} . Major and minor hydraulic conductivities were 11.6 and 6.7 gpd/ft² (566 and 327 ft/year), and the hydraulic gradient was 0.033 to the west-northwest.

The proposed production area site was tested in February 1977. The 15-hr continuous-drawdown test was conducted by pumping one well at a rate of 10 gpm and noting the effects on four observation wells. All wells partially penetrated the aquifer thickness. Transmissivity values ranged from 373 to 770 gpd/ft. Storage coefficients varied between 1.0×10^{-5} and 2.6×10^{-4} . The hydraulic gradient at the proposed production site was approximately 0.009, due west.

Limited data were supplied to analyze accurately the groundwater environment at the Irigaray site. From the information contained in the applicant's pump tests, however, some tentative conclusions can be made. The various field tests indicate that the aquifer is anisotropic and heterogeneous in nature. The data provided are insufficient for determining if the mining zone aquifer is hydraulically connected with other units.

Conclusions based on the above described aquifer tests can be misleading. While they may be used to generalize the hydraulic characteristics of the aquifer, individual lenses or channels within

the aquifer may behave quite differently. If the production test and observation wells do not penetrate a particular channel sand, its hydraulic characteristics cannot be measured directly. Parameters such as hydraulic conductivity may be an order of magnitude too low, for example, if good hydraulic connection between wells is not established through the main channel of a buried channel sand. The penetration of high permeability lenses or channels is often a matter of chance.

2.6.2.4 Groundwater quality

The applicant initiated groundwater quality studies in 1974 with sampling and analysis of surrounding private wells. Additional site-specific groundwater studies have been conducted at both pilot-scale test sites, and groundwater sampling is continuing in the proposed initial well field. Groundwater data supplied by the applicant are contained in Appendix B.

In general, waterwells in the area supply water from the Wasatch Formation, which also contains the uranium deposit to be mined. Most of these wells are used for domestic and stock-watering purposes. Groundwater from wells within an 8-km (5-mile) radius of the site generally meets EPA drinking water standards. One private well on the Irigaray site (W-6, Appendix B, Table B.1) exceeded the standards with a selenium level of 0.07 ppm (EPA and USPHS drinking water standard is 0.01 ppm and the State of Wyoming wildlife and livestock limit is 0.05 ppm).²¹⁻²⁴ Total dissolved solids are low (less than 500 ppm), and the predominant cation and anion are sodium and sulfate. Water quality data (Appendix B, Table B.1) can be compared with the various water quality criteria and toxic concentrations listed in Table 6.2.

Groundwater has also been sampled and analyzed by the applicant in the immediate vicinity of the uranium ore deposits (mineralized zone). The pilot scale-test area in Section 9 is near the center of the proposed initial well field. Water samples were taken from November 1976 to February 1977 from wells in the mineralized zone and from wells located at distances of 61 and 137 m (200 and 450 ft) from the test well field (see Table B.3, Appendix B, for complete data and Fig. 4.4 for well locations). Some of these wells, however, may be located in the mineralized zone because they encircle the test well field. As shown in Table 2.9, the groundwater chemistry from these wells exhibits considerable variability. Groundwater in the mineralized zone (production well zone) generally exceeds drinking water standards for radium, uranium, and gross alpha (Table 2.9). At distances of a few hundred feet from mineralized areas (depending on rock structure and configuration of the ore body) the groundwater generally meets drinking water standards. Complete water quality data from wells in the vicinity of the mineralized zone are contained in Appendix B and include wells W-1, W-2, and W-3 in Table B.1, Table B.2, and Table B.3.

Table 2.9. Selected groundwater chemistry data from wells on the site and relevant water standards

Species	Concentration		Drinking water standards ^a	Wyoming wildlife and livestock standards ^b
	Production well zone	Monitor well zone		
As, ppm	<0.01–0.10	<0.01–0.01	0.05	0.20
Cl, ppm	9.7–12.5	12.1–17.0	250	2,000
NO ₃ (as N), ppm	0.32–0.58	0.42–0.78	10.0	
NH ₄ , ppm	<0.2–0.18	<0.2–0.24		
Th-230, (pCi/liter)	0.2–9.0	0.08–0.9		
U, ppm	0.34–11.96	0.02–0.09	5.0	
Ra-226, (pCi/liter)	23.5–144.3	0.3–6.8	5.0	
Gross alpha, (pCi/liter)	122.4–6,341	2.9–19.4	15	
Gross beta, (pCi/liter)	117.8–1,644	63.2–102.0	1,000	

^aDrinking water standards are from: U.S. Public Health Service, *Drinking Water Standards*, PHS Publication 956, 1962. U.S. EPA, "National Interim Primary Drinking Water Regulations," *Fed. Regist.* 40 (248): 59566–59577 (1975). U.S. EPA, "Proposed National Secondary Drinking Water Standards," *Fed. Regist.* 42 (62): 17143–47 (1977).

^bWyoming Department of Environmental Quality, Land Quality Division, Guideline No. 4 (Revised), Part II: Water Quality Criteria for Wildlife and Livestock Impoundments, Nov. 9, 1977.

Premining (baseline) groundwater quality values for the proposed well fields will be obtained as discussed in Sect. 8.1.5.2.

2.6.3 Water use

Availability of water is a major factor influencing activity in the Powder River Basin of Wyoming. Surface and groundwaters are used primarily to support ranching. Irrigation accounts for the largest part of consumptive water use in the region. Most of the irrigated acreage is used to produce hay for winter feeding.²⁵ Municipal, domestic, and industrial uses of water are relatively minor, but these usages are expected to increase, particularly industrial usage associated with energy development.²⁶ Based on data obtained in 1974 from the Wyoming State Engineer's office, the Bureau of Land Management tabulated the average annual streamflow and water use from the Powder River in Wyoming,²⁷ as shown by the following:

	<u>Acre-feet per year</u>	
State live streamflow under natural conditions		419,100
Man's depletions of streamflow in Wyoming:		
Irrigation	66,100	
Municipal, domestic, and stock	2,100	
Industrial	700	
Reservoir evaporation	<u>27,600</u>	<u>-96,500</u>
Depleted streamflow leaving Wyoming		322,600

Near the WMC site, groundwater is used only for livestock watering and private water supply. The applicant states that there is no irrigation farming within the mining area (ER, p. 69). Although there are no quantitative data describing water use near the WMC site, it is assumed to be small due to the low densities of people and livestock. Figure 2.8 shows the locations of some private wells in the area. Table D-11 of the applicant's mine permit application submitted to the State of Wyoming lists 23 groundwater wells within 5 km (3 miles) of the permit area.²⁸ The wells vary in depth from 27 to 326 m (90 to 1070 ft); most are artesian but four are windmill- or electric-driven. All these wells provide water for livestock, and five are used for domestic water in addition. Wells are located mostly on the floodplain of the Powder River, with the nearest wells used for drinking water located 6.5 km (4.4 miles) northwest (Irigaray Ranch) and southwest (Reclusa Ranch) of the plant site.

The only reliable sources of surface water near the Irigaray site are the Powder River and stock ponds supplemented with well water. Intermittent flow precludes the regular use of water from Willow Creek, although livestock and wildlife undoubtedly take water from the creek when it is available. Within a 5-km (3-mile) perimeter of WMC's permit area, the only adjudicated surface water right is an appropriation of 1982 liters/sec (70 cfs) from the Powder River to Joseph Irigaray.²⁸ This water is appropriated for irrigation of 19 ha (48 acres) approximately 6 km (4 miles) northwest of the Irigaray Ranch and 12 km (7 miles) from the plant site.

2.7 GEOLOGY, MINERAL RESOURCES, AND SEISMICITY

2.7.1 Geology

2.7.1.1 Regional geology

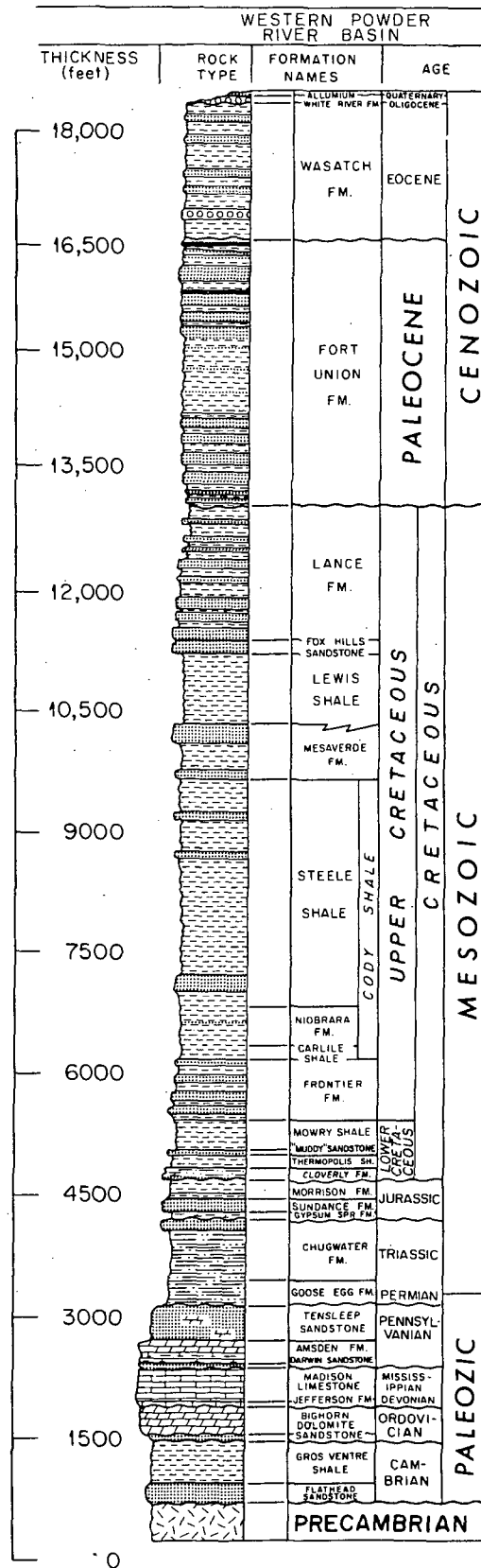
The stratigraphic succession in the western Powder River Basin is shown in Fig. 2.11. The uranium-bearing unit to be mined is in the Wasatch Formation, of Eocene age.

2.7.1.2 Wasatch Formation

Sediments of the Wasatch Formation were deposited approximately 40,000,000 years ago after late Paleocene uplift caused erosion and locally tilted the Fort Union Formation.²⁹ The resulting increased stream gradient in early Eocene time caused rapid erosion of the mountains, and powerful streams carrying coarse debris flowed far into the Powder River Basin. Based on sediment coarseness, cross bedding, and mineralogy, Sharp and Gibbon indicate a source area to the south exposing Precambrian igneous and metamorphic rocks.³⁰ Figure 2.12 is a map showing the Eocene paleogeography of northeast Wyoming.

During flood stage the rivers overflowed their banks and, depending on local topography, deposited thick to thin layers of silt and clay over extensive areas of the basin. The contemporaneous deposition of coarse channel sands and fine floodplain deposits resulted in rapid lateral changes in lithology over short distances. Figure 2.13 is a generalized geologic map of northeast Wyoming and shows the general distribution of coarse- and fine-grained clastic rocks in the Wasatch

Stratigraphic Column



LEGEND

- | | |
|---------------------------------------|-----------------------------|
| CONGLOMERATE | LIMESTONE |
| SANDSTONE | DOLOMITE |
| SHALE | GYPSUM |
| COAL | IGNEOUS & METAMORPHIC ROCKS |
| — UNCONFORMITY (A SURFACE OF EROSION) | |
| FM. = FORMATION | |

Fig. 2.11. Stratigraphic succession in the western Powder River Basin, Wyoming.
 Source: W. M. Sharp, E. J. McKay, F. A. McKeown, and A. M. White, *Geology and uranium deposits of the Pumpkin Buttes area of the Powder River Basin, Wyoming*, U.S. Geol. Survey Bull. 1107-H, 1964.

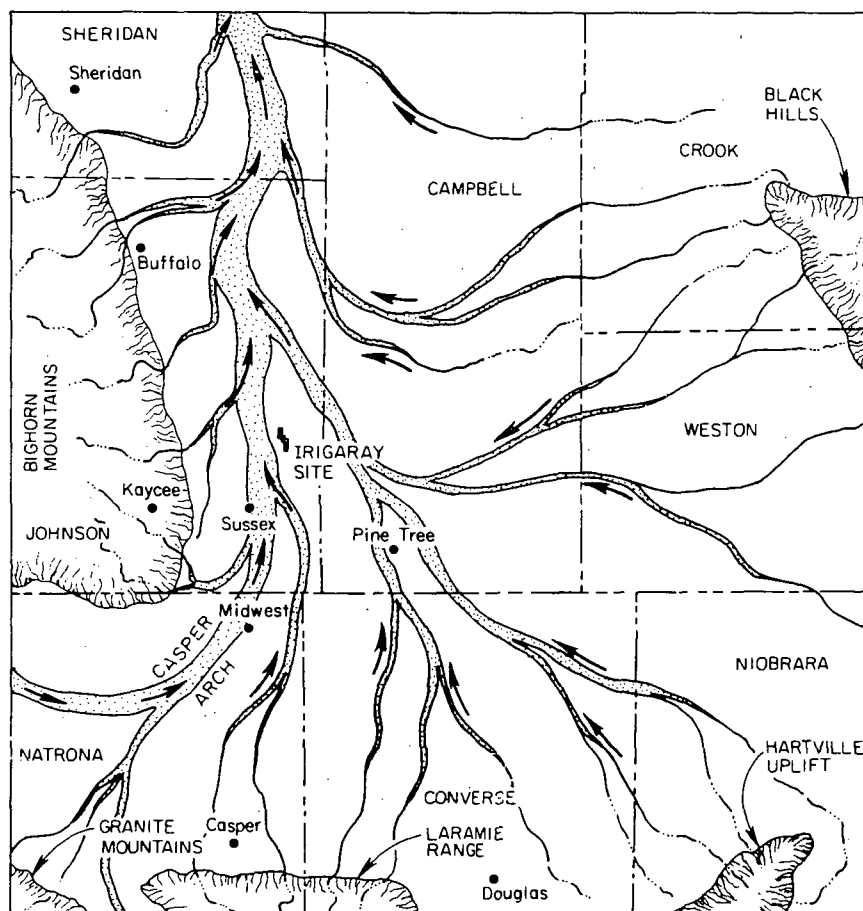


Fig. 2.12. Eocene paleogeography of northeast Wyoming. Source: Modified from David A. Seeland, "Relationships Between Early Tertiary Sedimentation Patterns and Uranium Mineralization in the Powder River Basin, Wyoming," in *Geology and Energy Resources of the Powder River, Wyoming Geological Assoc. 28th Annual Field Conference Guidebook*, Casper, Wyo., 1976.

Formation. Sharp and others indicate that the sandstone units are restricted to the central part of the basin but that in this area sandstones occur erratically throughout the Wasatch Formation.²⁹ Along the periphery of the basin, thick coal beds accumulated where deposition of clay predominated. The predominance of gray and generally drab-colored fine-grained flood deposits, plus peripheral coal beds, suggests deposition in a reducing environment during Wasatch time.

In the Pumpkin Buttes area, a few miles southeast of the Irigaray site, the Wasatch Formation is about 480 m (1575 ft) thick and consists of claystone, some marlstone, siltstone, carbonaceous shale, thin lignite, and fine to very coarse, poorly sorted sandstone. The following brief descriptions of the major lithologic units in the Wasatch Formation are from Sharp and others²⁹ from their studies in the Pumpkin Buttes area.

The claystone is medium-dark gray to dark greenish gray in beds 1.5 to 3.0 m (5 to 10 ft) thick. Some claystone beds are up to 9 m (30 ft) thick and can be traced laterally into siltstone or carbonaceous shale or are cut by channels of coarse-grained sandstone. Siltstone is the most abundant rock type in the Wasatch Formation and is drab yellowish brown to pale yellowish gray in thin to thick beds. Carbonaceous shale beds several feet thick and containing coarsely crystalline gypsum are numerous, and some can be traced more than 16 km (10 miles). Sandstone constitutes one-third of the thickness of the Wasatch Formation at Pumpkin Buttes, and solution mining at the Irigaray site will be within a channel sandstone. Therefore the characteristics of these deposits will be discussed in more detail.

Sandstone units in the Pumpkin Buttes area vary from a few feet to over 30 m (100 ft) thick but are commonly 0 to 9 m (20 to 30 ft) thick. Because most of the sandstone deposits are of fluvial origin, they fill distinct channels and are elongated. Some sandstone lenses are 30 to

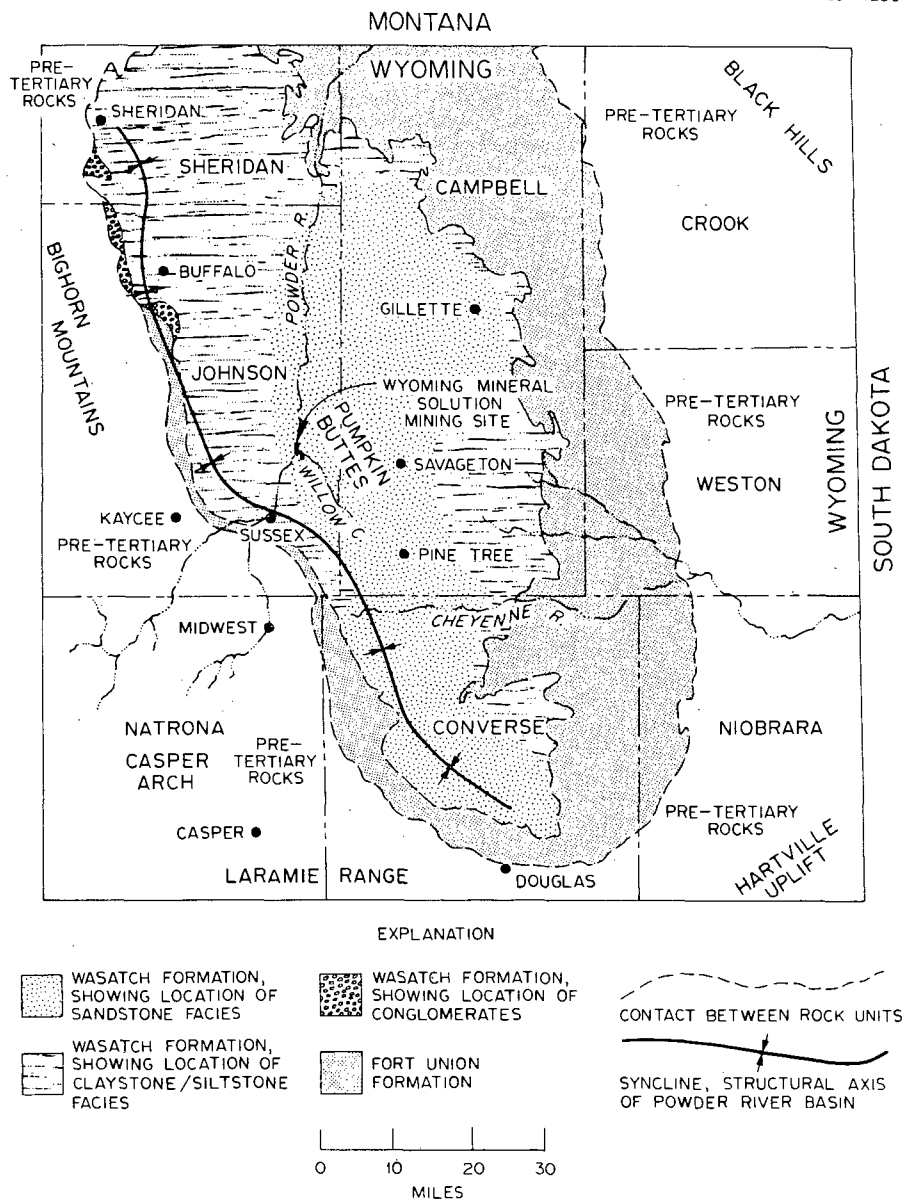


Fig. 2.13. Generalized geologic map of the Powder River Basin, showing the location of coarse-, medium-, and fine-grained rocks in the Wasatch Formation. Source: Modified from W. M. Sharp and A. B. Gibbon, *Geology and Uranium Deposits of the Southern Part of the Powder River Basin, Wyoming*, U.S. Geol. Survey Bull. 1147-D, 1964.

61 m (100 to 200 ft) across and 12 m (40 ft) thick at midchannel and were probably the result of coalescing channels of a braided stream. Many channel remnants, however, are as much as 10 to 13 km (6 to 8 miles) by 6 to 8 km (4 to 5 miles) in extent and up to 15 m (50 ft) thick. In some places at least two subparallel channels lie several hundred ft apart in the same stratigraphic horizon. Cross lamination is common; it is typically 1-1/2 to 2 ft thick and overlain by as many as 12 similar sets. Most sandstones show intervals of graded bedding, the coarsest particles being less than 1/2 in. in diameter. Calcium carbonate concretions, about 6 to 10 in. in diameter, occur sporadically in thick sandstone units, but otherwise the sandstone is only slightly calcareous.

2.7.1.3 Structure

Structurally, the Powder River Basin is an asymmetric syncline, the deepest part lying close to the Bighorn Mountains. The outcrop width of the Fort Union Formation clearly reflects this structure (Fig. 2.13). The structural axis projected to the surface from the Precambrian basement is approximately parallel to the front of the Bighorn Mountains and is about 40 km (25 miles) west of the Irigaray site (Fig. 2.13). Dips of pre-Tertiary strata on the east side of the Bighorn Mountains vary from 30° east to locally overturned. The dip of the Wasatch Formation in the Pumpkin Buttes area is generally less than 3° northwest.

Although the Powder River Basin is less deformed than other Wyoming basins, the Precambrian basement is nonetheless over 4572 m (15,000 ft) below sea level. The middle of the basin is characterized by gentle folding and minor faulting. In the Pumpkin Buttes area, Sharp and others report two slight anticlines in surface rocks trending north-southeast and east-west, which are superimposed on a broad southwest-plunging anticline in Precambrian rocks.²⁹ The folds in the Wasatch Formation are not reflected in the overlying White River Formation and are therefore pre-White River, post-Wasatch in age.

No faults have been recognized in the Pumpkin Buttes area, but a few minor reverse faults offset coal beds along the Powder River.²⁹ Jointing in calcareous sandstone and 1- to 2-ft-wide clastic dikes cutting claystone and siltstone occur sporadically and trend from north 40° east to north 80° east.

2.7.1.4 Site geology

The Wasatch Formation is exposed at the surface and dips to the west from 1° to 2°. Figure 2.14 is a composite section of a part of the Wasatch Formation at the site. Uranium mineralization occurs within the applicant's designated Upper Irigaray sandstone (UISS), which was deposited by a north-flowing stream with a channel width of approximately 11 km (7 miles). The host sandstone is 23 to 46 m (75 to 150 ft) thick and from 23 to 152 m (75 to 500 ft) below the surface (Figs. 2.15-2.18). The UISS shows a series of vertically graded sands from coarse at the bottom to fine at the top and at least two periods of downcutting and subsequent filling. Because of the mainly fluvial depositional environment of the Wasatch Formation, horizontal and vertical facies changes occur rapidly, making it difficult to correlate the highly lenticular beds across the site.

Figure 2.15 shows the locations of the cross sections shown in Figs. 2.16 and 2.17. It is not known whether the Lower Irigaray sandstone (LISS) extends into the southern part of the permit area (cross section A-B-C, Fig. 2.16). On cross section D-B-E (Fig. 2.17) the claystone unit separating the UISS and LISS is believed to pinch out to the east, thus connecting the UISS and LISS in this area. To date, drilling below the LISS has shown discontinuous beds of sandstone interbedded with siltstone, claystone, and shale (Fig. 2.17).

2.7.2 Mineral resources

Uranium occurrences in the Powder River Basin were first reported by Love in the Pumpkin Buttes area.³¹ Mining in this district from 1953 to 1964, however, yielded only 2,408 tons of uranium from numerous small surface mines.¹³ Since the mid-1960s, when uranium ore was discovered at depth, drilling has defined many large deposits in a wide zone south from the Irigaray site into the southern Powder River Basin. Most of these deposits occur in the Fort Union and Wasatch formations of Early Tertiary age. From the standpoint of drilling, the Powder River Basin is the most active area in the United States for uranium exploration.³²

According to Monsson, oil accounted for nearly 98% of the mineral valuation in Johnson County in 1975; production was about 5,561,500 m³ (3,500,000 bbl) per year.³³ Currently producing oil and gas fields near the Irigaray site are Heldt Draw (T46N, R77W), Jepson Draw (T45N, R77W), and Holler Draw (T44N, R76W). The fields were discovered in 1973-1974 and produce from Upper Cretaceous rocks at depths between 2743 and 3048 m (9000 and 10,000 ft) below the surface. As of December 1974 the three fields had a cumulative production of 286,644 m³ (180,393 bbl) of oil and 1.437 x 10⁹ m³ (50,731 million cubic feet) of gas.¹³ In addition, the Table Mountain oilfield (T45N, R77W) was discovered in 1977.

Coal production in the Powder River Basin is centered in Campbell County; the main belt of strippable coal is about 56 km (35 miles) east of the Irigaray site. Campbell County should become the leading coal producer in the State, having 50% of Wyoming's remaining coal resources and 84% of its known strippable coals.³⁴ In contrast, Glass estimates that Johnson County has 9% of Wyoming's identified coal resources and only 4% of its known strippable coal,³⁵ located at least 32 km (20 miles) west and north of the Irigaray site. Most of the thick coal beds, some up to 37 m (120 ft) thick, occur in the upper member of the Fort Union Formation east of

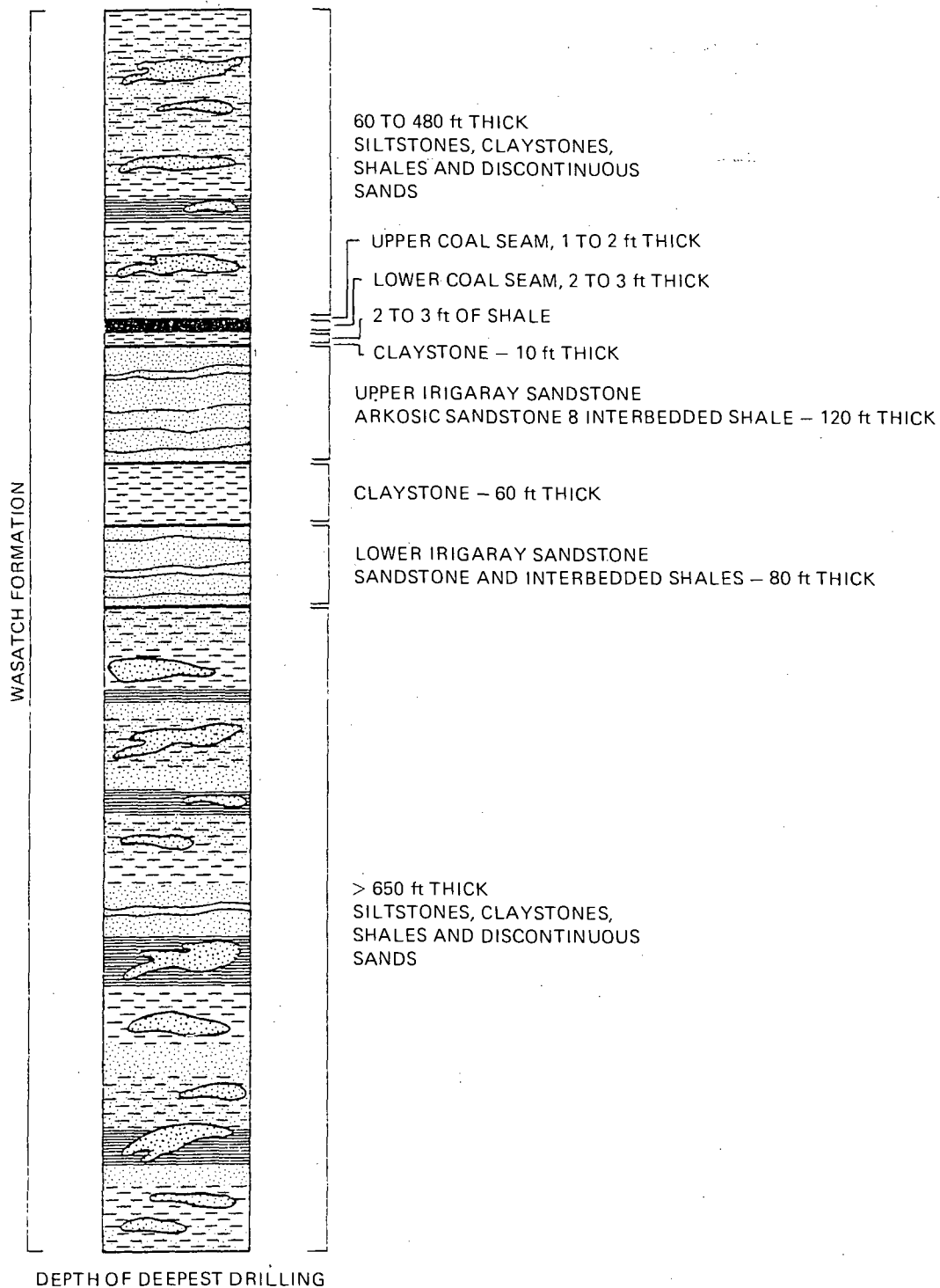
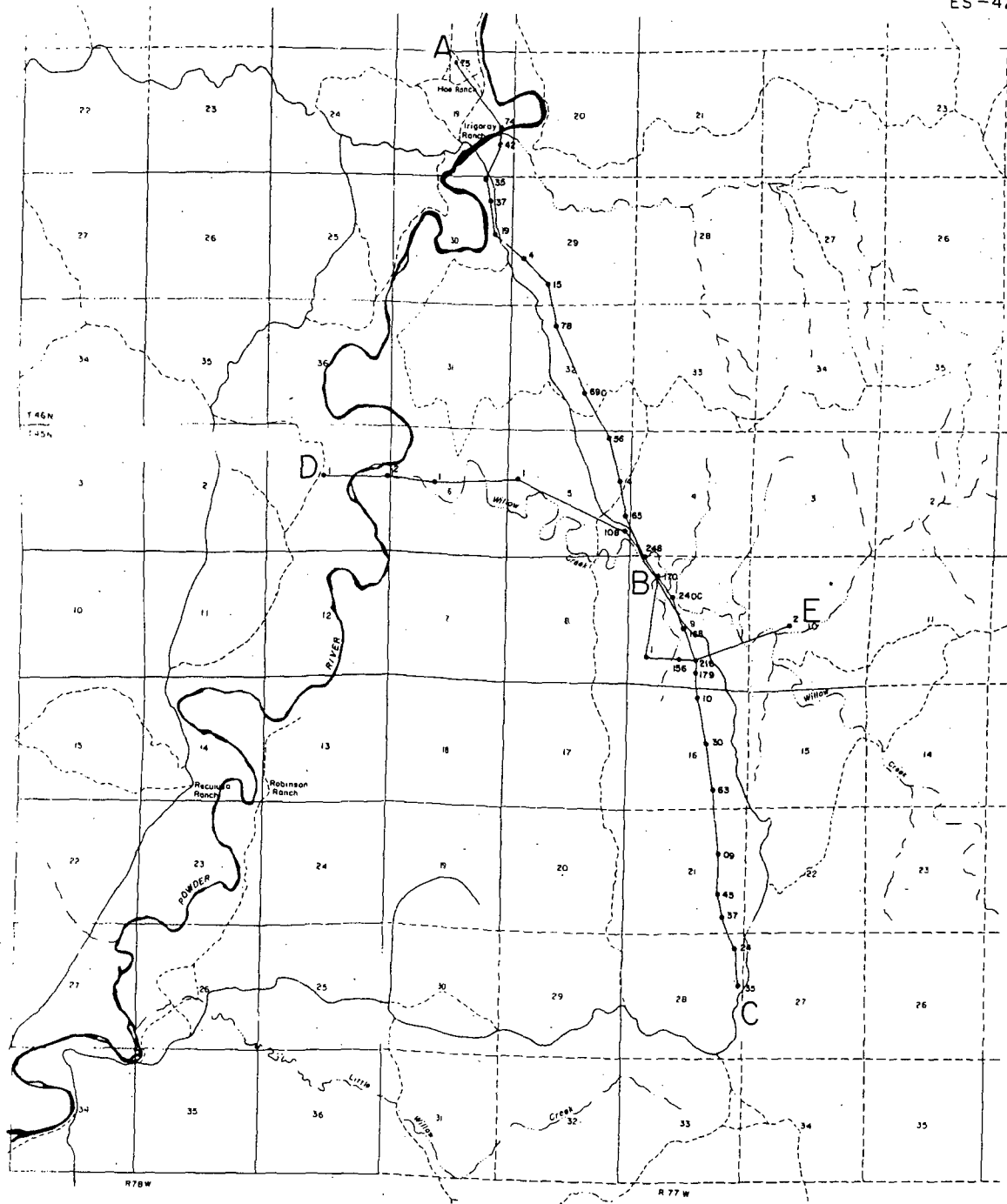


Fig. 2.14. Composite section of the Wasatch Formation at the Irigaray site. Source: ER, Fig. 3-2.



LEGEND

- ~ INTERMITTENT STREAMS
- UNIMPROVED ROADS
- LIGHT DUTY ROAD, HARD OR IMPROVED SURFACE
- WELL NUMBER

1/2 0 1 MILE



Fig. 2.15. Locations of geologic cross sections (Figs. 2.16 and 2.17) at the Irigaray site.
Source: ER, Fig. 3-3.

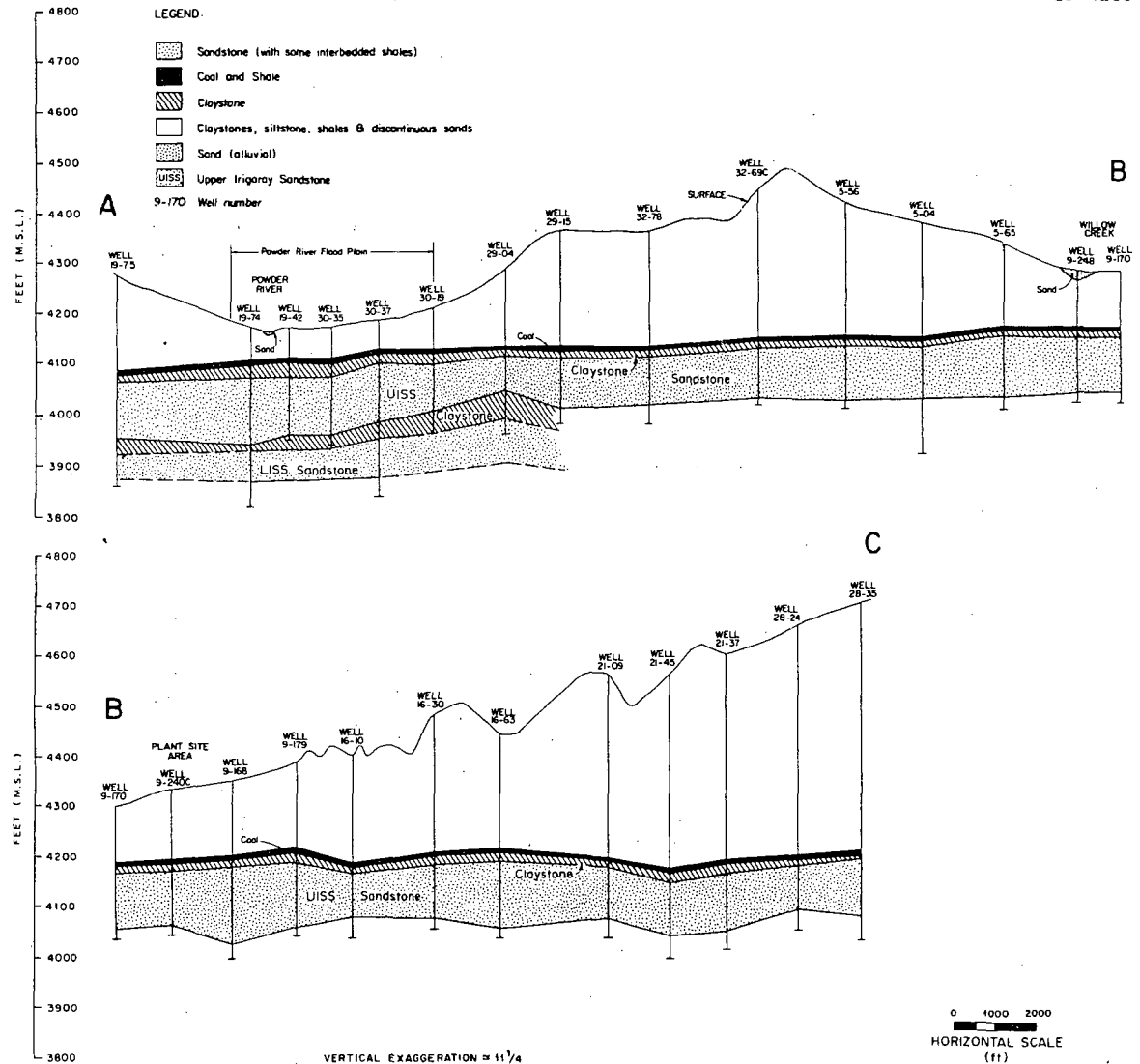


Fig. 2.16. Geologic cross sections A-B and B-C (Fig. 2.15) at the Irigaray site. Source: ER, Figs. 3-4 and 3-5.

Gillette. At the site, two thin [1 m (3 ft)] coal beds in the Wasatch Formation occur between 18 and 146 m (60 and 480 ft) below the surface (Figs. 2.14, 2.16, and 2.17). Because of the more abundant and easily strippable coal elsewhere in the basin, the coal underlying the Irigaray site is not considered presently to be economically important.

Other mineral occurrences near the site may include zeolites, which are known to occur in some of the ash units of the Wasatch Formation. Gold, copper, manganese, and rare earth minerals are reported in small quantities along the east flank of the Bighorn Mountains. These deposits are 48 km (30 miles) west of the Irigaray site, and no production has been reported since 1942.¹³ The same area also contains gypsum and bentonite deposits, and bentonite is currently being mined.

2.7.3 Seismicity

The Intermountain seismic belt (including Yellowstone Park) is continuous from western Montana to north-central Utah. Earthquakes with epicenters in or near Yellowstone Park are likely to create some of the strongest motions to be experienced in the Powder River Basin; only locations

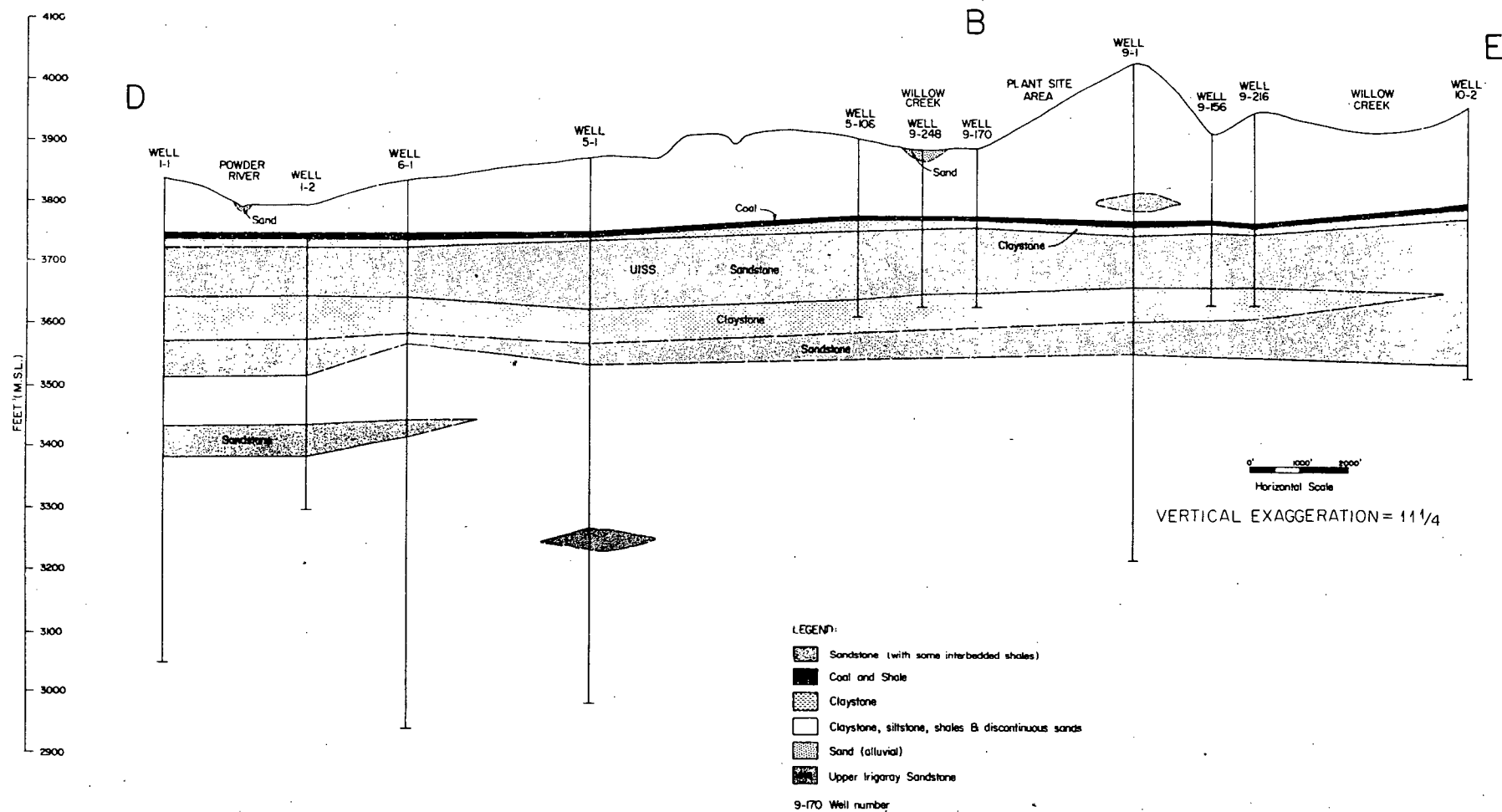


Fig. 2.17. Geologic cross section D-B-E (Fig. 2.15) at the Irigaray site. Source: ER, Fig. 3-6.

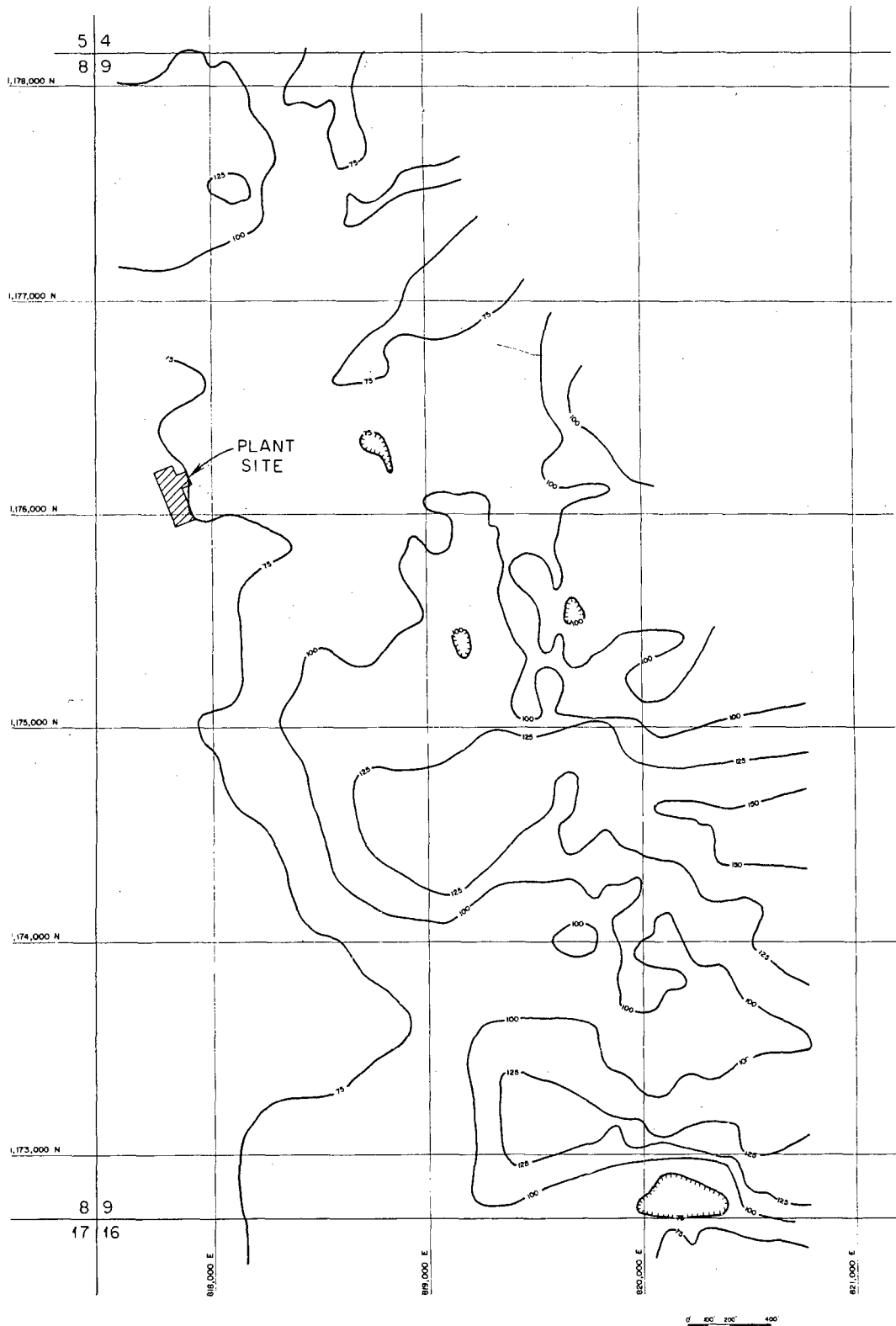


Fig. 2.18. Isopachs (thickness) of the Upper Irigaray sandstone in Section 9. Source: Modified from ER; Fig. 3-7.

within about 30 km (19 miles) of the epicenter of an earthquake occurring within the basin will experience stronger motion. The local intensity of distant earthquakes will nevertheless be low. For example, the Irigaray site lies near the boundary of the felt area for the Hebgen Lake earthquake of 1959.³⁶

Although distant earthquakes may produce shocks strong enough to be felt in the Powder River Basin, the region is considered to be one of minor seismic risk (Fig. 2.19).³⁷ In the past 80 years only four earthquakes having epicenters within 160 km (100 miles) of the Irigaray site were strong enough to be felt.³⁸ The 1897 earthquake (intensity VII on the modified Mercalli scale) near Casper, Wyoming, was strong enough to cause significant damage. In the same region only five earthquakes (all of magnitude less than 5 on the Richter scale) have been instrumentally recorded since 1965.³⁸ These data are too limited to establish reliable recurrence intervals, but they suggest that a magnitude 6 earthquake is a rare event. Magnitude 6 (intensity VII-VIII) earthquakes occur perhaps an order of magnitude less frequently than magnitude 5 (intensity VI-VII) earthquakes.³⁹ Historical records indicate that magnitude 5.0 to 6.0 earthquakes occur about once every 20 years within 160 km (100 miles) of the Irigaray site. Therefore an earthquake between 6.0 and 7.0 can be expected to recur once in 200 years (ER, p. 68). The Irigaray site would have to be in the epicentral area [8-km (5-mile) radius] of a maximum credible intensity Powder River Basin earthquake to experience slight damage. The historical record of seismicity in the Powder River Basin suggests that the probability of the occurrence of such an event during the lifetime of the Irigaray plant is vanishingly small.

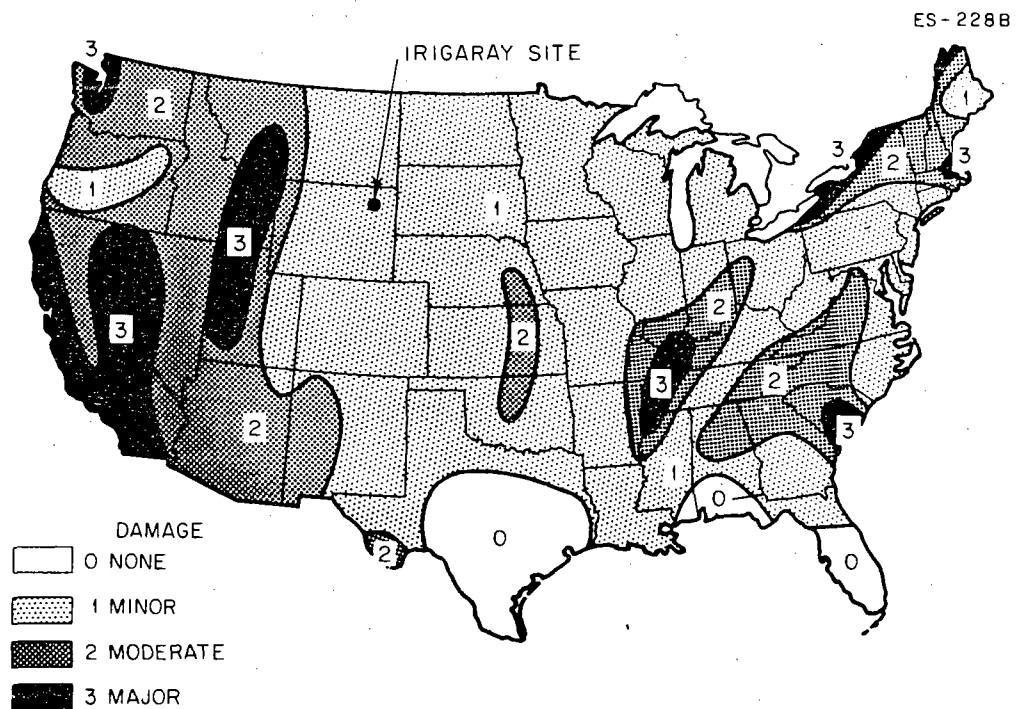


Fig. 2.19. Seismic risk map of the United States. Source: Modified from S. T. Algermissen, *United States Earthquakes*, U.S. Government Printing Office, Washington, D.C., 1968.

2.8 SOILS

The following discussion of soils is based on a recently published soil survey of southern Johnson County by the U.S. Soil Conservation Service.⁴⁰

The upland soils of the WMC site belong to the Shingle and Stoneham series. The upland soils are generally suitable only for range and wildlife habitat. The Shingle series, which covers a majority of the site, occurs on hillsides and ridgetops. It consists of relatively thin and poorly developed soils formed from residuum weathered from sandstone and siltstone bedrock. Effective rooting depth is limited, since bedrock occurs at 20 to 25 cm (8 to 10 in.). Shingle soils are moderately alkaline loams with moderate permeability and low available water capacity. Runoff from these soils is rapid and erosion hazard is high. Vegetative cover supported by Shingle soils is predominantly shortgrasses such as blue grama.

Soils of the Stoneham series develop on alluvial fans that form along lower slopes, mainly adjacent to the Powder River and Willow Creek. Stoneham soils are better developed and deeper than Shingle soils. Effective rooting depth may be down to 150 cm (60 in.). Permeability is moderate and available water capacity is high. These soils generally support stands of sagebrush and grasses such as western wheatgrass. If cover is removed, the hazard of wind erosion is high on Stoneham soils.

Soils along the floodplains of the Powder River and Willow Creek are a complex of a number of soil associations and material that is classified as alluvial land. The majority of the soil associations belong to the broader category of the Haversen series, which consists of well-drained soils formed in alluvium. The soils in this series are moderately alkaline loams with moderate permeabilities and high available water capacity. The effective rooting depth may be down to 150 cm (60 in.). Haversen soils are suitable for irrigated hay, pasture, and small grain, as well as for range and wildlife habitat.

Alluvial land consists of materials that comprise old gravel bars and meanders along the Powder River and Willow Creek. The soil material is depositional in origin, is highly stratified, and ranges from loam to sand in texture. Alluvial land is subject to frequent flooding and generally supports stands of cottonwood and willow. It is suitable only as range and wildlife habitat.

2.9 ECOLOGY

2.9.1 Terrestrial ecology

The following discussion of terrestrial ecology is based on a search of the literature and on a biologic study conducted for the applicant near the Irigaray site (included here as Appendix C).

2.9.1.1 Vegetation

The Irigaray site is located within the Powder River Basin of northeast Wyoming. Vegetation in the basin exhibits a broad transition between two major vegetation types — the grasslands of the northern Great Plains to the east and the sagebrush steppe that occurs over much of the range-land of the western basins. Big sagebrush (*Artemisia tridentata*) is the most prevalent and important shrub species in the Powder River Basin. Characteristic and dominant grasses include blue grama grass (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), prairie June grass (*Koeleria cristata*), and needlegrasses (*Stipa* spp.). The composition and structure of the sagebrush-shortgrass community vary with localized soil and moisture conditions and past use, resulting in intergrading sagebrush and shortgrass-sagebrush associations. In general, dense stands of big sagebrush and other shrubs occur on the moister slopes of draws and drainages. On the drier and more exposed uplands, however, the community has a grassland aspect, and big sagebrush occurs only as low and widely scattered individual plants.

A list of major plant species observed near the WMC site is available in Appendix C. The majority of the site (over 95%) is covered by the shortgrass-sagebrush association typical of the Powder River Basin. Except in the draws and drainages where shrub cover is relatively dense, most of the site has a shortgrass prairie aspect. A generalized vegetation map of Johnson County lists the vegetation of the WMC site as primarily grasses and weeds with western wheatgrass, prairie June grass, and needle-and-thread grass (*Stipa comaea*) as the dominant species.⁴¹ Big sagebrush and other shrubs such as Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), silver sagebrush (*Artemisia cana*), and fringed sagewort (*Artemisia frigida*) occur as low and widely scattered individuals. Other common species include prickly pear (*Opuntia polyacantha*), soapweed (*Yucca glauca*), and a number of species of wild buckwheat (*Eriogonum* spp.). With the exception of the floodplains of Willow Creek and the Powder River, total vegetative cover on the majority of the WMC site ranges from 5 to 25%.⁴¹

A riparian vegetation type exists along the floodplains of Willow Creek and the Powder River. In moist areas adjacent to the water, there is a dense, meadow-like cover of perennial grasses, sedges, and rushes. Trees, primarily plains cottonwood (*Populus sargentii*) and willows (*Salix* sp.), are limited to the floodplains. Where soils are moist but not saturated along Willow Creek and the Powder River and along tributary drainages and draws, there is a fairly dense shrub cover. Shrubs such as big sagebrush, silver sage, wild rose (*Rosa woodsii*), skunkbush sumac (*Rhus trilobata*), and serviceberry (*Amelanchier* sp.), which occur in this habitat, provide excellent wildlife browse. The riparian habitat along the Powder River and Willow Creek is important wildlife habitat. The trees, shrubs, and moist meadows provide food, shelter, and breeding areas for a variety of wildlife species that would not otherwise occur on the site. Studies have shown that the density and diversity of wildlife species associated with riparian habitats may be five to ten times those in the surrounding grasslands.⁴²

2.9.1.2 Wildlife

Wildlife species that occur on the WMC site are those characteristic of the sagebrush grasslands of the Powder River Basin and, indeed, most of the sagebrush rangelands of the western United States. The fauna of the Powder River Basin has been described in recent environmental impact statements and other documents concerning energy-related development in the basin.⁴³⁻⁴⁵ The most abundant animals are rodents, such as the deer mouse (*Peromyscus maniculatis*) and thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), and a number of species of grassland passerine birds. Predators that are common in the region near the WMC site include badgers (*Taxidea taxus*), long-tailed weasels (*Mustela frenata*), coyotes (*Canis latrans*), and red foxes (*Vulpes vulpes*). A number of raptor species occur in the area. Waterfowl utilize the stock watering ponds and reservoirs of the area as resting places during migration, and some individuals remain through the summer to breed.

Game species

The Powder River Basin is nationally known for its outstanding hunting resource of pronghorn antelope (*Antilocapra americana*). It is estimated that 45 to 50% of the world's pronghorn population occurs in Wyoming.⁴⁶ Pronghorn prefer open, rolling topography such as that in the Powder River Basin. The animals depend primarily upon big sagebrush for winter browse, and sagebrush stands are important for concealment of the fawns during spring and early summer. The region in which the WMC site is located is classified by the Wyoming Game and Fish Department as year-round pronghorn habitat. Estimates of pronghorn density on habitat similar to that on the WMC site range from 2 to 4 animals per square kilometer (5 to 10 per square mile).⁴³⁻⁴⁵

Another popular big game species that occurs on the WMC site is mule deer (*Odocoileus hemionus*). Deer frequent the riparian habitats along Willow Creek and the Powder River and the draws, where dense shrub cover provides browse and concealment. The areas along the Powder River and Willow Creek could represent important mule deer winter habitat. During winter field studies near the WMC site, from 7 to 22 deer were sighted per day (Appendix C).

Compared to large game, upland small game are a minor hunting resource in the Powder River Basin. The most important small game species occurring in the vicinity of the WMC site is sage grouse (*Centrocercus urophasianus*). No estimate of grouse density on the WMC site was available, but the site apparently has all the components of good sage grouse habitat. From late fall to early spring sage grouse are solely dependent upon big sagebrush for food. Strutting grounds are usually within relatively open areas surrounded by sagebrush. The dense sagebrush cover and the moist, meadowlike vegetation in draws and drainages and along Willow Creek and Powder River represent good brood-rearing habitat.

Other common small game species that would occur on the WMC site include mourning doves (*Zenaida macroura*) and cottontails (*Sylvilagus auduboni*). Doves are migratory and their densities on the site fluctuate seasonally. Cottontail populations are somewhat cyclic; rabbit densities in habitat similar to that on the site may vary from 20 to 150 per square kilometer (50 to 375 per square mile).^{43,45} Wild turkeys (*Meleagris gallopavo*) occur in Johnson County. The Powder River in the vicinity of the WMC site would be good turkey habitat, and the species likely occurs there. A number of species of waterfowl nest in the many small stockwater impoundments scattered through the Powder River Basin. Common species include mallard (*Anas platyrhynchos*), blue-winged teal (*A. discors*), gadwall (*A. strepera*), and pintail (*A. acuta*).

Rare and endangered species

A number of proposed endangered plants occur in Wyoming.⁴⁷ However, according to Mr. Robert Dorn, of the Wyoming Department of Environmental Quality, who is familiar with Wyoming's rare plants, none of the endangered plant species occur in the Powder River Basin of eastern Wyoming.

Of the species currently on the Federal list of endangered species,⁴⁸ only the black-footed ferret (*Mustela nigripes*), the peregrine falcon (*Falco peregrinus*), and the bald eagle (*Haliaeetus leucocephalus*) could potentially occur in the Powder River Basin. Breeding pairs of peregrine falcons are not likely to occur near the WMC site, since the required breeding habitat of cliffs is lacking. The black-footed ferret is closely associated with prairie dog towns. According to the applicant, there are no prairie dog towns known to occur on or near the WMC site, so it is unlikely that ferrets occur on or near the site. According to the Wyoming Game and Fish Department, bald eagles are known to winter along the Powder River, but no active nest sites have been observed (Robert Oakely, Wyoming Game and Fish Department, Lander District, telephone conversation with K. M. Oakes of Oak Ridge National Laboratory, Aug. 4, 1978). If eagles do winter along the Powder River near the WMC site, their occurrence in the mining area would only be transitory, because the site is away from the main river.

The State of Wyoming has no state endangered species law. In the recent publication of the current status of wildlife in Wyoming,⁴⁹ there is a list of animals considered rare in Wyoming. According to the ranges and habitat preferences listed for the rare species, two could potentially occur near the WMC site, the burrowing owl (*Speotyto cunicularia*) and the milk snake (*Lampropeltis triangulum*). The burrowing owl is seldom found in the absence of active colonies of burrowing mammals such as prairie dogs.⁴⁹ Since, according to the applicant, there are no prairie dog towns on the WMC site, it is unlikely that the owls would occur on the site. Milk snakes have been collected from central Sheridan County and are thought to inhabit other portions of eastern Wyoming.⁴⁹ The species inhabits a variety of habitats, including riparian areas, shrub woodlands, and rocky hillsides. The species apparently prefers habitats in which there is sufficient cover in the form of rocks, rotting logs, and dense shrubs. Since habitat suitable for milk snakes is present on the WMC site, this species could potentially occur on the site.

2.9.2 Aquatic ecology

The aquatic habitats that might be affected by WMC's operations are the Powder River and Willow Creek. These areas are described below.

Near WMC's site the Powder River meanders across its floodplain with a gentle gradient of less than 2 m/km (10 ft/mile). The arid plains in the area are composed mostly of erodible shales, silstones, and sandstones.¹⁵ This land contributes substantial sediments to the Powder River and tributaries, especially if land is overgrazed. The Powder River has generally high levels of suspended sediments; 80 km (50 miles) downstream from the WMC site (station E, Arvada, Fig. 2.6) the suspended sediment concentration varied from 172 to 39,800 mg/liter and averaged 6419 mg/liter for water years 1972-1974.⁵⁰⁻⁵²

Near the WMC site the Powder River provides poor habitat for game fish due to high turbidity, low water quality, and, in summer, low streamflows and excessive water temperatures (see Sect. 2.6.1). The Wyoming Game and Fish Department classifies all of the Powder River below Kaycee (station A, Fig. 2.6) as "very low production waters — often incapable of sustaining a fishery."⁵³

There has apparently been little sampling of fish populations in the Powder River near the WMC site. However, the Wyoming Game and Fish Department has sampled nearby drainage systems, including the Little Powder and the Belle Fourche rivers.⁵⁴ Based primarily on this, the Department of the Interior listed the following nongame species as present or suspected present in the Powder River:⁶ flathead chub (*Hybopsis gracilis*); carp (*Cyprinus carpio*); goldeye (*Hiodon alosoides*); northern redhorse (*Moxostoma macrolepidotum*); white, longnose, and mountain sucker (*Catostomus commersoni*, *C. catostomus*, *C. platyrhynchus*); fathead minnow (*Pimephales promelas*); longnose dace (*Rhinichthys cataractae*); sturgeon chub (*Hybopsis gelida*); river carpsucker (*Carpionodes carpio*); plains minnow (*Hybognathus placitus*); and silvery minnow (*Hybognathus nuchalis*).

The Bureau of Land Management indicates that bullheads (*Ictalurus* sp.) and stonecats (*Noturus flavus*) are present in the stretch between Kaycee and Barnum and that "shovelnose sturgeon and sturgeon chub are known to inhabit the silty currents of the lower Powder River."⁵⁵ The Wyoming Game and Fish Department reports that a rough fishery of nongame species is maintained in deep water areas below Arvada.⁵⁶ Recently, the Wyoming Game and Fish Department has found young-of-the-year channel catfish (*Ictalurus punctatus*) at the bridge where Interstate 90 crosses the Powder River, approximately 30 km (20 miles) north of the WMC site.⁵⁷ In the Powder River north of Arvada, especially in southern Montana, a healthy fishery of channel catfish has apparently developed, including individuals up to 5.5 kg (12 lb). Channel catfish may be migrating upstream during periods of high flow, and the Powder River near WMC's site could provide habitat for this species.

The Wyoming Game and Fish Department considers 13 species of fish to be "rare" in Wyoming.⁴⁹ The four species that have been reported from the Powder River are described in Table 2.10.

Three nationally listed endangered aquatic species, the humpback chub (*Gila cypha*), Colorado River squawfish (*Ptychocheilus lucius*), and Kendall warm springs dace (*Rhinichthys osculus thermalis*), occur in Wyoming.⁴⁶ However, none of these are believed to occur in the eastern Powder River Basin.⁵⁸

Very little is known about Willow Creek and any aquatic biota that may inhabit it. (The Environmental Report makes no mention of biota in Willow Creek or the Powder River.) Although Willow Creek is intermittent, it may provide breeding habitat for fish during parts of the year. Hynes notes that intermittent streams frequently support surprisingly diverse aquatic communities, especially if there are pools of standing water.⁵⁹ Some organisms survive in pools despite high temperatures and low oxygen concentrations. Other species have eggs that can survive long dry periods, and some species survive by aestivating or burrowing into a continually moist substratum. In addition, when streamflow does occur, the stream may be reinvaded by fish from downstream

Table 2.10. Rare fish species of the Powder River

Common name	Scientific name	Distribution	Comment
Shovelnose sturgeon	<i>Scaphirhynchus platorhynchus</i>	Powder River	May be extinct in Wyoming
Goldeye	<i>Hiodon alosoides</i>	Lower Powder River Crazy Woman Creek Lower Clear Creek Little Missouri River	Tolerant of high turbidity
Sturgeon chub	<i>Hybopsis gelida</i>	Powder River in Sheridan County Lower Big Horn River	Adapted to areas of gravel bottom in large silty river
Silvery minnow	<i>Hybognathus nuchalis</i>	Lower Powder River Belle Fourche River Lower Little Missouri River	Prefers larger rivers

Source: Wyoming Game and Fish Department, *Current Status and Inventory of Wildlife in Wyoming*, Cheyenne, Wyo., 1977.

waters. If pools exist in Willow Creek for extended periods, they may develop biotic communities typical of stock watering ponds, as shown in Fig. 2.20.

2.10 RADIATION ENVIRONMENT

2.10.1 Surface

The intensity of cosmic radiation is a function of altitude and at the Irigaray site would be approximately 50 millirems per year to the whole body.⁶⁰ The total natural radiation background is estimated to be 150 millirems per year.⁶¹ The whole-body dose rate from domestic and industrial sources in Wyoming is estimated to be 25 millirems per year. The medical whole-body dose is estimated to be 75 millirems per year.^{61,62}

The radon flux to the atmosphere from a dry, sandy soil containing 1 pCi/g of radium-226 (Table 8.1) is estimated to be 1.6 pCi/m²·sec.^{63,64} The concentration of Ra-226 in sedimentary soil is about 0.5 pCi/g, which would give a radon-222 flux of 0.8 pCi/m²·sec.^{63,64} Although this general estimate does not take into account all of the variations of radium-226 concentrations and soil conditions at the Irigaray site, the staff believes that this estimate does show the magnitude of natural radon emanation in and around the Irigaray property. The annual quantity of radon released from a 21,000 acre (8500 ha) area, an area about equal to that occupied by the Irigaray property, is estimated to be less than 2200 Ci. Concentration of radon in air is estimated to be in the range of 500 to 1000 pCi/m³. Exposure to a radon concentration of 1000 pCi/m³ on a continuous basis would result in a dose of 625 millirems per year to the bronchial epithelium.

The annual average concentration (20 mg/m³) of particulates in Wyoming air will contain about 4 x 10⁻⁵ pCi/m³ of radium-226, 8 x 10⁻⁵ pCi/m³ of thorium-232, and 4 x 10⁻⁵ pCi/m³ of thorium-230. The dose from these particulates to the lungs under normal conditions would be about 2 millirems per year. The dose to the bone would be less than 1 millirem per year.

2.10.2 Subsurface

The concentration of radioactive materials in groundwater is influenced by the chemistry and nature of the aquifer in the zone of interest. Wells located in the mineralized trend (i.e., well P4, Appendix B, Table B.3) may exceed the EPA drinking water standards (Table 2.9) for gross alpha, gross beta, radium-226, and natural uranium by factors of at least 400, 1.6, 30, and 2.7 respectively. Wells located outside of the mineralized zone (wells M4 and M5, Appendix B, Table B.3) show gross alpha, gross beta, radium-226, and natural uranium levels well below the standards (see Sect. 2.6.2.4 on groundwater quality).

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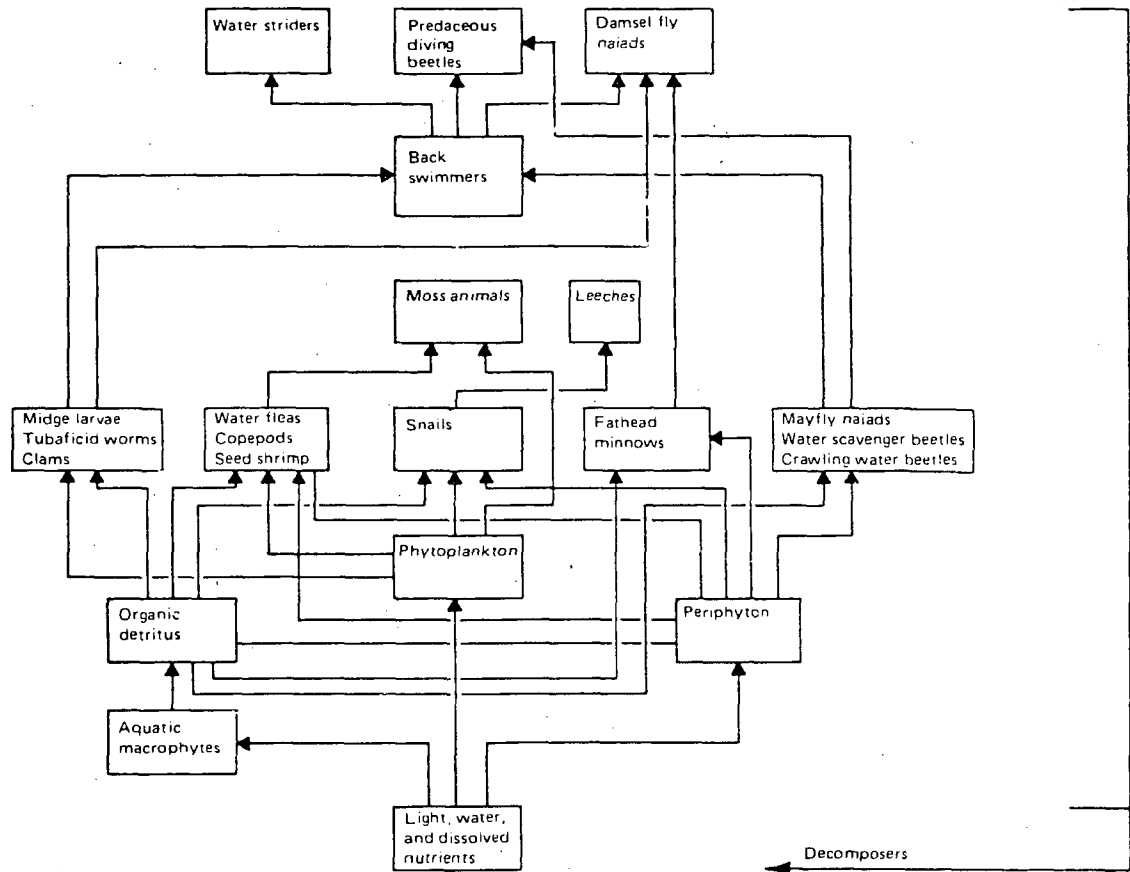


Fig. 2.20. Typical food web of livestock ponds in Campbell and Converse counties. Source: Applicant's Environmental Assessment for a Proposed Gasification Project in Campbell and Converse Counties, Wyoming, prepared for Wyoming Coal Gas Company and Rochelle Coal Company by SERNCO, Inc., 1974.

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3. SOLUTION MINING (IN SITU LEACHING) OF URANIUM

This section provides background information on solution mining (in situ leaching) of uranium. A glossary of terms abstracted from the International Glossary of Hydrology¹ as well as a selected bibliography on this subject are also included.

3.1 INTRODUCTION

In situ leaching (solution mining) of uranium is a potential addition to the list of conventional mining methods currently used to extract uranium. Basically, the in situ leaching method involves (1) the injection of a leach solution (lixiviant) into a uranium-bearing ore body to complex the contained uranium, (2) mobilization of the uranium complex formed, and (3) surface recovery of the solution bearing the uranium complex via production wells. Uranium is then separated from the leach solution by conventional milling unit operations (ion exchange).

The environmental advantages of in situ leaching of uranium appear to be significant. While the conventional extraction of minerals produces significant impact on the environment, the solution mining method appears potentially to result in a lesser impact. Compared with the conventional uranium mining and milling operations, in situ leaching will also permit economical recovery of currently unrecoverable low-grade uranium deposits, thereby enhancing the nation's uranium reserves.

In conventional uranium recovery techniques, the ore is mined (open pit or underground), crushed, ground in mills, and subsequently leached, using either an acidic or basic oxidizing solution to extract the uranium. In solution mining, an acidic or basic oxidizing solution is injected into and produced from the naturally situated ore body via wells to extract the uranium. The chemical technology is about the same in both cases. In solution mining, however, no ore mining, transporting, and grinding operations are needed before chemical processing to recover the uranium. Moreover, there are no mill tailings to be disposed of, although solid wastes are generated that would require controlled disposal.

In conventional uranium mining, for each ton of mined ore, more than 1900 lb of solid waste (tailings) are produced, containing essentially all of the associated radium-226 and other daughter products. With solution mining, less than 5% of the radium from an ore body would be brought to the surface.

Since the technology for in situ solution mining of uranium is still actively developing, variations among the different operations are not unusual. Thus, the following background discussion is general. Specific procedures proposed by the applicant are described and discussed in later sections of this Statement.

For consistency and clarification, two major terms are defined.

3.1.1 Solution mining

Solution mining is a general term describing the extraction of minerals in liquid form. The solution may only contain the mineral sought from the natural source (e.g., salt, sulfur) or may include other materials such as excess chemicals that have been added to aid in the dissolution of the resource from its source host, reaction by-products, and other materials associated with the mineral deposit co-dissolved in the process.

The mineral-bearing solution can be obtained from its source in several ways. A fluid can be injected and recovered through wells from the mineralized host beneath the surface (borehole mining) or sprayed over mineral-bearing materials that have been brought to the surface (e.g., dump or heap leaching). In all cases, a solution containing the mineral sought is produced.

3.1.2 In situ leaching

In situ leaching is one of the many types of solution mining. In this technique, the mineral sought is dissolved from its host source *in place* (in situ) and extracted as a liquid, while leaving the solid host material in its natural position. The basic unit operations of in situ leaching of uranium involve (1) the introduction of a leach solution via injection wells into a uranium-bearing ore body, (2) mobilization of the uranium from the host material via creation of a soluble complex salt, and (3) removal of the complexed uranium-bearing solution via production wells. The uranium in the uranium-bearing solution is recovered in a conventional surface facility where, generally, an ion exchange process is used for recovery.

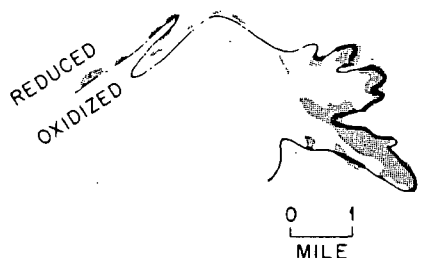
3.2 PROCESS DESCRIPTION

Uranium in situ solution mining involves the following basic components and associated processing activities: (1) the ore body, (2) the well field, (3) the lixiviant or leach liquor, (4) the uranium recovery process, (5) the waste treatment process(es), (6) waste management process(es), and (7) aquifer restoration and land reclamation process(es). The interrelationships of these are discussed in the following.

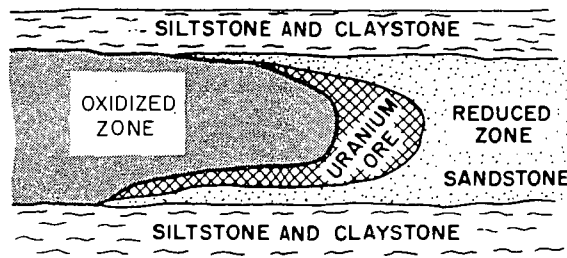
3.2.1 Ore body

Roll-type uranium deposits are generally associated with fluvial sandstones and conglomerates. The mineral in the ore is concentrated by a liquid oxidizing front moving down the hydrologic gradient in the reduced host zone (sands). Uranium is thereby precipitated along the interface of the oxidizing and reducing sides of the front. The physical shape of an ore roll is dependent on the local permeability of the matrix material and its continuity and distribution in the geologic unit (Fig. 3.1). Such ore bodies are prevalent in most of the established uranium mining districts in the western United States. In situ leaching, however, can be conducted only on those ore deposits that meet certain criteria. These generally include: (1) the ore deposit must be located in a saturated zone, (2) the ore deposit must be confined both above and below by impermeable layers, (3) the deposit must have adequate permeability, and (4) the deposit must be amenable to chemical leaching.

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PLAN VIEW OF DEPOSIT



CROSS-SECTION OF ROLL FRONT

Fig. 3.1. Plan view of uranium ore deposit and cross section of geochemical cell or roll front. Source: A. R. Dahl and J. L. Hagmaier, "Genesis and Characteristics of the Southern Powder River Basin Uranium Deposits, Wyoming, USA," *Formation of Uranium Ore Deposits*, pp. 201-218 in *Proc. Symp.*, Athens, 6-10 May 1974, International Atomic Energy Agency, Vienna, Austria, 1974.

The ore body is a basic part of the process circuit in in situ leaching. Additionally, the mineralogic and hydraulic properties of the ore body are pertinent factors in the engineering design of the total operation.

3.2.2 Well field

The well field provides the means by which leach solution (lixiviant) is circulated through the ore body to extract the uranium. Therefore the well field design determines the effectiveness of lixiviant circulation, confinement, and utilization. It also affects the efficiency of uranium extraction. Principal engineering considerations in well field design are the well spacing, the injection and production patterns, the well completion methods, and the number of wells to be used. Well spacing is determined by the hydrologic characteristics of the formation. These influence the rate and efficiency of lixiviant circulation. The pattern of injection and production wells is determined by the injectivity rate(s) to the formation and the horizontal hydraulic sweep efficiency through the mineralized well field zone. The well completion method and local permeability determine the vertical confinement and vertical sweep efficiency of the lixiviant through the mineralized zone.

The applicant's proposed well field(s) is discussed in Sect. 4.3.

3.2.3 Lixiviant chemistry

Initially, in situ solution mining of uranium utilized a dilute sulfuric acid lixiviant enhanced by an oxidizing agent such as sodium chlorate. Such a lixiviant is suitable in working low-alkaline (low-carbonate) ore deposits. However, acidic solutions also tend to dissolve other trace minerals associated with such an ore and, therefore, are less specific for uranium. As a result, basic (ammonium or sodium bicarbonate-carbonate) lixiviants with an oxidizing agent are now generally used in most in situ activities where carbonate minerals are known to be associated with the ores (Table 3.1).

Table 3.1. Typical concentrations of major constituents in basic lixiviant solutions used in solution mining of uranium

Constituent	Concentration (mg/liter)	
	Pawnee project ^a	Palangana project ^b
Ammonium bicarbonate-carbonate	2,000-10,000	8,000
Hydrogen peroxide	100- 800	1,500
Sodium	150- 200	250
Chloride	200- 350	200
Sulfate	75- 350	1,500

^aTexas Water Quality Board, "Permit to Dispose of Wastes under Provisions of Article 7621 d-1, Vernon's Texas Civil Statutes. Permit No. 02050, January 1977, Intercontinental Energy Corporation."

^bTexas Water Quality Board, "Permit to Dispose of Wastes under Provisions of Article 7621 d-1, Vernon's Texas Civil Statutes. Permit No. 02051, January 1977, Union Carbide Corporation."

At startup, the necessary chemicals are added to water drawn from the ore zone aquifer. This solution is then recirculated through the localized ore zone (well field). Typically, the desired concentration of a basic lixiviant (e.g., ammonium bicarbonate) is maintained by chemical reconstitution operations and by controlling the pH (about 8). Carbon dioxide and ammonia or other soluble basic carbonate salt may be used to adjust concentrations. An oxidant (oxygen, air, or hydrogen peroxide) is normally added to the lixiviant at the well field prior to its injection into the ore zone.

The applicant's lixiviant is listed in Table 4.2.

3.2.4 Uranium recovery process

As depicted in Fig. 3.2, a generalized solution mining process has four main processing circuits or units: (1) a lixiviant sorption circuit, (2) a resin transfer circuit, (3) an elution and precipitation circuit, and (4) a product drying and packaging unit. The movement of uranium through these circuits and the relationships of various process components are discussed in the following sections. The applicant's proposed process is discussed in Sect. 4.4.

3.2.4.1 Lixiviant sorption circuit

The lixiviant sorption circuit consists of the ore body, the well field, the uranium adsorption column(s), lixiviant bleed, lixiviant makeup unit, and calcium control unit. The process begins with the injection of lixiviant into the ore body. This solution oxidizes the uranium in the localized ore zone and forms a soluble uranium ion complex. The complexed uranium, mobilized reaction by-products, and unreacted reagents in the lixiviant flow to a production well and are pumped to the surface (produced from the ore zone). This uranium-bearing solution then passes through a uranium sorption column (near the well field or in the recovery plant) via the use of an ion exchange resin that preferentially extracts the uranium ion complex from the pregnant solution. The solution leaving this resin column is essentially barren of uranium. It also contains residual lixiviant chemicals. This barren solution is passed to the makeup unit, where it is reconstituted with the necessary lixiviant chemicals and is recycled to the well field for reinjection.

A solution bleed in the plant enables some control of groundwater flow. By diverting part of the barren solution leaving the uranium sorption column, less recycle solution is reinjected. This reduces the water level in the localized ore zone, permitting water from the surrounding aquifer to migrate into the mined zone. The rate of the groundwater incursion should be equal to the bleed rate. This groundwater influx would tend to limit the excursion of lixiviant out of the localized well field area.

The presence of calcium compounds in the lixiviant or barren solution is generally disadvantageous in the processing. Calcium could precipitate as calcite (CaCO_3) in basic leach solutions or as gypsum (CaSO_4) in sulfuric acid leach solutions. Either precipitate could plug injection and production wells or interfere with the ion exchange process. Calcium removal units utilizing either ion exchange (water softening) or solution pH control techniques may be placed in the lixiviant sorption circuit to mitigate potential calcium-related problems.

3.2.4.2 Resin transfer circuit

The ion exchange resin used in the uranium extraction column is eluted periodically to recover the sorbed uranium and to regenerate the resin before it is returned to the sorption circuit. The resin transfer circuit cycles the ion exchange resin between the sorption and elution circuits. Most solution mining operations house the ion exchange columns in a recovery building. Alternatively, the ion exchange columns may be located near the active well fields and the resin trucked to a central recovery facility (satellite recovery system).

The resin transfer circuit also allows the flushing of the uranium-loaded resin and rinsing of the regenerated (eluted) resin to control other contaminants that may affect the efficiencies of the elution and the extraction process respectively.

3.2.4.3 Elution and precipitation circuit

The elution and precipitation circuit consists of the elution column, the precipitator, and the contaminant control and eluant makeup units. Uranium-loaded resin from the column is the feed for this circuit. After transfer of the loaded resin to the elution column, the uranium-loaded resin is eluted with a moderately concentrated chloride salt solution (1 to 2 M Cl). The chloride ion in this solution displaces the uranium ion complex sorbed on the resin and thus regenerates the resin. The regenerated resin is returned to the uranium extraction column, and the uranium-rich eluate is transferred to the precipitation unit.

In the precipitation unit, the desorbed uranium ion complex is destroyed by acidification. The resultant uranium ion is precipitated with ammonia as ammonium diuranate $[(\text{NH}_4)_2\text{U}_2\text{O}_7]$, which is commonly known as ADU. The ammonium diuranate, in slurry form, is transferred to the drying and packaging unit. The barren eluate is recycled through the contaminant control unit and eluant makeup unit to the elution column.

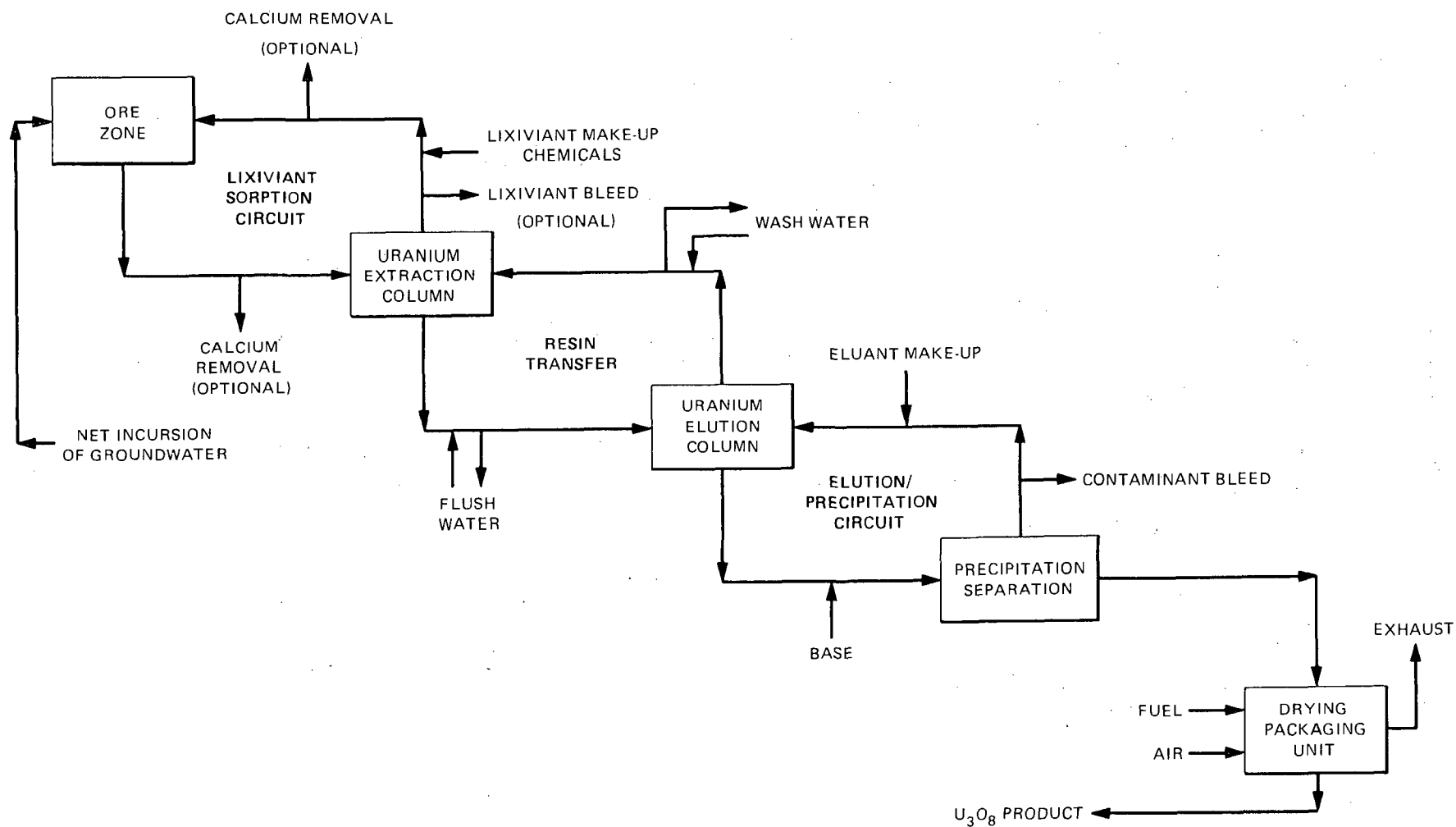


Fig. 3.2. Generalized uranium recovery process.

In the uranium recovery process, contaminants such as sulfate and vanadium are also sorbed on the ion exchange resin and stripped into the elution and precipitation circuit along with uranium. In the absence of any control, the concentration of such contaminants could build up to affect the product purity and/or elution process efficiency. For contaminant control, a bleed-off of some of the contaminated recycle eluant is effected by replacing a bled volume with an equal amount of fresh eluant. This controls the contamination level but requires the increased use of makeup water and elution chemicals and the discharge of a concentrated liquid waste stream to a holding pond that must be ultimately managed.

Water consumption can be reduced through the use of precipitation and physical adsorption processes in contaminant control. For example, sulfate levels can be controlled by the addition of barium chloride (BaCl_2) to the recycle eluant, precipitating insoluble barium sulfate (BaSO_4). This can be stored in an interim solid waste impoundment; vanadium can be adsorbed on activated carbon and recovered as a by-product or disposed of with the carbon as a solid waste.

The nature, level, and even the need of contaminant control depend on the composition of the ore body and the chemistry of the specific solution mining process. The prevailing conditions in the solution mine field, the chemical reagent costs, and the wastewater disposal techniques employed will determine what contaminant control measures will be used.

Prior to entering the elution column, the recycle eluant passes through an eluant makeup unit. In this unit, the chloride ion concentration, depleted during elution and contaminant control operations, is restored by the addition of a chloride salt. Makeup water may also be added here to maintain the system flow.

3.2.4.4 Product drying and packaging unit

The uranium leaves the elution and precipitation unit as a slurry of ammonium diuranate and may be dried prior to packaging for shipment. Upon entering the product drying and packaging unit, the slurry is washed and dewatered. The rinse water, which contains some soluble uranium, is returned to the elution and precipitation unit. The moist diuranate cake enters a dryer and calciner, where it is converted to U_3O_8 and the by-products (water and ammonia) are driven off. Following drying and calcining, the oxide product (yellow cake) is crushed and placed in drums for shipment.

To mitigate particulate uranium releases in this unit process, the exhausts from the dryer and calciner, crusher, and packaging equipment areas are treated in Venturi scrubbers (see Sect. 3.2.5). The spent scrubber solution is recycled to the elution and precipitation circuit to recover any entrained uranium.

3.2.5 Waste effluent treatment processes

In general, liquid and solid waste and atmospheric effluents will result from the solution mining activities. Liquid wastes from well field overpumping (i.e., production flow in excess of injection flow), elution and precipitation circuit bleeds, and subsequent aquifer restoration represent the major waste streams to be managed from solution mining activities. Since the dissolved solids content of the wastewater precludes any uncontrolled releases, some form(s) of waste management is necessary. Generally, for liquid waste management, evaporation ponds are utilized; however, deep well disposal has been used in Texas. The ponds vary in size depending on the flow rate of liquid waste streams to the pond and the rate(s) of water evaporation and seepage from the pond. To minimize unwanted seepage of the wastewater, the ponds are lined during construction with clay, asphalt, or continuous plastic membranes. The specific method(s) used is dependent on the conditions at each solution mining operation.

Solar evaporation is a consumptive use of water. When recycle of wastewater is desirable, water reclamation by reverse osmosis, ion exchange, chemical treatment, or multieffect distillation may be attempted.

Solid wastes generated, for example, from the calcium control unit in the lixiviant sorption circuit and from the contaminant control unit in the elution and precipitation circuit also require controlled management. During the life of a solution mining operation, solids may be impounded in specific storage ponds as a slurry and be maintained and monitored under a liquid seal to minimize particulate emissions and radon gas evolution. Permanent disposal techniques, in accord with NRC and/or responsible State agency regulations, will subsequently isolate the solids from the environment.

Sources of atmospheric emissions include the open surfaces of ponds and tanks, the product drying and packaging unit, the internal combustion engines in vehicles and drilling rigs used at the site, dust due to vehicular movement on unimproved roads, and processes using ammonia. Tank emissions can be limited by venting them through liquid or solid absorbents before release to the atmosphere. Venturi or impingement scrubbers are used to control both particulate and gaseous emissions from drying and packaging operations. Exhaust emission controls are presently provided for internal combustion engines.

3.2.6 Groundwater quality restoration process

After termination of solution mining operations, procedures are implemented to restore the water quality of the affected aquifer. Restoration will remove or immobilize chemical species injected into or mobilized as a result of chemical actions in the ore body during mining. The restoration process is intended to reduce the mobilized species content and composition of the groundwater to levels set by appropriate regulatory agencies.

Groundwater restoration technology is still in the development stage. A process that requires the pumping of large quantities of water from the aquifer (groundwater sweeping) is currently in general use. By this technique, the contaminated water removed from the aquifer is replaced by groundwater entering the localized ore zone from the surrounding area or is replaced by purifying (for example, by reverse osmosis) the contaminated water and recycling it into the aquifer. The water entering this ore zone aquifer will gradually sweep the residual impurities from the solution mining operations toward the production wells, where they will be withdrawn to the surface for management. The efficiency of the sweeping action may not be very high. Impurities, e.g., ammonia, are chemically sorbed on clay minerals within the aquifer host formation and are only removed slowly, because their migration rate is retarded by repeated sorption and desorption from the clays. Unless some efficient elution or immobilization techniques are developed, long-term aquifer pumping may be the only method of ore zone groundwater restoration. Water produced by such a restoration process or other processes under development should be managed by the methods discussed in Sect. 3.2.5.

3.3 GLOSSARY OF TERMS RELATED TO SOLUTION MINING OF URANIUM

Adsorptive capacity. Physical limit of adhesion of ions in solution to the surfaces of solids with which they are in contact.

ADU. Ammonium diuranate. Approximate chemical composition is given as $[\text{UO}_2(\text{OH})_2 \cdot x \text{H}_2\text{O} \cdot \text{NH}_4^+]$ salt. ADU is not the oxide form of uranium, namely, U_3O_8 (triuranium octaoxide).

Alkalinity. A measure of the power of a solution to neutralize hydrogen ions expressed in terms of an equivalent amount of calcium carbonate.

Alluvium. Clay, silt, sand, gravel, or other rock materials transported by flowing water and deposited in comparatively recent geologic time as sorted or semisorted sediments.

Annular space (annulus). The space between casing or well screen and the wall of the drilled hole.

Aquiclude. Formation that, although porous and capable of absorbing water, does not transmit it at rates sufficient to furnish an appreciable supply for a well or spring.

Aquifer. Porous water-bearing formation (bed or stratum) of permeable rock, sand, or gravel capable of yielding significant quantities of water.

Aquifer, leaky. Aquifer overlain and/or underlain by a thin semipervious layer through which flow into or out of the aquifer can take place.

Aquitard. Geological formation of a rather impervious and semiconfining nature which transmits water at a very slow rate compared with an aquifer.

Area of influence. Area around a pumping well in which the water table or the piezometric surface (in confined aquifers) is lowered by pumping.

Artesian. The occurrence of groundwater under greater than atmospheric pressure.

Artesian (confined) aquifer. An aquifer overlain by confining beds containing water under artesian conditions.

Artesian well. Well tapping a confined artesian aquifer in which the static water level stands above the surface of the ground.

Assessment actions. Those actions taken during or after an accident to obtain and process information that is necessary to make decisions to implement specific emergency measures.

Backblowing. Reversal of flow of water under pressure, for example, in a well to free the screen or strainer and the aquifer of clogging material.

Baseline. The environmental condition that existed prior to mining as determined by physical and/or chemical parameters and their natural variability.

Bleed system. A production adjustment technique whereby more fluids are pumped from the production zone than are injected, creating an inflow of groundwater into the production area.

Borehole. An uncased drilled hole.

Boundary, geohydrologic. Lateral discontinuity in geologic material, making the transition from the permeable material of an aquifer to a material of significantly different geohydrologic properties.

Boundary, impervious. Boundary of a flow domain through which no flow can take place because of greatly reduced permeability at the other side of the boundary.

Brine. A highly mineralized solution (usually greater than 100,000 mg/liter), especially of chloride salts.

Capacity. Volume that can be contained by a tank, pond, etc.; rate of flow that can be carried by any conveying structure.

Capacity, specific. Ratio of discharge of a well to drawdown at equilibrium.

Capillary diffusion. Movement of water by capillarity in a porous medium.

Capillary water. Water held in the soil above the water table by capillarity; soil water above hygroscopic moisture and below the field capacity.

Casing. Steel or plastic pipe or tubing that is placed in a borehole to prevent entry of loose rock, gas, or liquid or to prevent loss of drilling fluid.

Chemical water quality. The nature of water as determined by the concentration of chemical and biological constituents.

Clogging. Deposition of fine particles such as clay or silt at the surface and in the pores of a permeable porous medium, e.g., soil, resulting in the reduction of permeability.

Concentration. The weight of solute dissolved in a unit volume of solution.

Conductivity, hydraulic. Combined property of a porous medium and the fluid moving through it in saturated flow, which determines the relationship, called Darcy's law, between the specific discharge and the head gradient causing it.

Cone of depression. The depression, ideally conical in shape, that is formed in a water table or potentiometric surface when water is removed from a well.

Confining bed. Formation overlying or underlying a much more permeable aquifer.

Consumptive use. That part of the water withdrawn that is no longer available because it has been evaporated, transferred, incorporated into products or crops, or otherwise removed from the immediate water environment.

Contamination. The degradation of natural water quality as a result of man's activities to the extent that its usefulness is impaired. There is no implication of any specific limits, since the degree of permissible contamination depends upon the intended end use, or uses, of the water.

Corrective actions. Those measures taken to ameliorate or terminate a situation at or near the source of the problem in order to prevent an uncontrolled release of radioactive or toxic material or to reduce the magnitude of a release, e.g., shutting down equipment, repair and damage control, or reorganizing pumping arrangements.

Curie. The quantity of any radioactive material giving 3.7×10^{10} disintegrations per second. A picocurie is one trillionth (10^{-12}) of a Curie, or a quantity of radioactive material giving 2.22 disintegrations per minute.

Darcy. Unit of intrinsic permeability defined as the permeability of a medium in which a liquid of dynamic viscosity of 1 centipoise discharges $1 \text{ cm}^3/\text{sec}$ through a cross section of 1 cm^2 under a gradient normal to the section of 1 atm/cm .

Darcy's law. Law expressing the proportionality of the specific discharge of a liquid flowing through a porous medium to a hydraulic gradient in laminar flow (low Reynolds numbers).

Degradable. Capable of being decomposed, deteriorated, or decayed into simpler forms with characteristics different from the original; also referred to as biodegradable when readily decomposed by organisms.

Degradation of water quality. The act or process of reducing the level of water quality so as to impair its original usefulness.

Depletion. Continued withdrawal of water from groundwater at a rate greater than the rate of replenishment; reduction of groundwater storage in an aquifer or of the flow of a stream or spring caused by discharge exceeding natural recharge.

Dewatering. Removing water by gravity or by pumping.

Dewatering coefficient. Amount of water removed per unit horizontal area and unit drawdown.

Diffusivity (of an aquifer). Coefficient of transmissivity of an aquifer divided by its coefficient of storage.

Dispersivity. Property of a porous matrix to cause spreading of a tracer traveling through it.

Dissolved solids, total (TDS). Total weight of dissolved material constituents in water per unit volume or weight of water in the sample.

Dominant direction of groundwater movement. The principal expected direction of groundwater flow. This dominant direction of movement is a result of three major variables: the transmissivity of the aquifer, the hydraulic gradient, and the differential applied hydraulic pressure.

Downstream. In the direction of the current.

Drawdown. Lowering of the water table or piezometric surface caused by the extraction of groundwater by pumping, by artesian flow from a borehole, or by a spring emerging from an aquifer.

Drawdown, equilibrium. Drawdown of the water table or of the piezometric surface near a pumping well, at constant discharge, after a stationary condition has been reached.

Effluent. A waste liquid, solid, or gas, in its natural state or partially or completely treated, that discharges into the environment.

Eluant. The solution that removes (elutes) a material (uranium) adsorbed on ion exchange resin.

Emergency action levels. Specific contamination levels of airborne, water-borne, or surface-deposited concentrations of radioactive or toxic materials; or specific instrument indications that may be used as thresholds for initiating such specific emergency measures as designating a particular class of emergency, initiating a notification procedure, or initiating a particular protective action.

Excursion. The movement of lixiviant (leachate solution) out of a mine zone as evidenced by measured movement past a trend or monitor well. Measurement is by an increase of selected parameter values above their established upper control limits.

Freeboard. Vertical distance between the normal maximum level of the surface of the liquid in a conduit, reservoir, tank, canal, etc., and the top of the sides of an open conduit, the top of a dam or levee, etc.

Groundwater. Water beneath the land surface in the saturated zone that is under atmospheric or artesian pressure; the water that enters wells and issues from springs.

Groundwater management. The development and utilization of the underground resources (water, storage capacity, and transmission capacity), frequently in conjunction with surface resources, in a rational and optimal manner to achieve defined and accepted water resource development objectives. Quality as well as quantity must be considered. The surface water resources involved may include imported and reclaimed water as well as tributary streams.

Groundwater, mining of. Withdrawal from a groundwater reservoir in excess of the average rate of replenishment.

Groundwater recession. Natural lowering of the groundwater level in an area.

Grout. To fill, or the material filling, the space around the pipe in a well, usually between the pipe and the drilled hole. The material is ordinarily a mixture of portland cement and water.

Hardness, carbonate. Hardness of water resulting from the presence of dissolved calcium and magnesium bicarbonates (temporary hardness).

Hardness, noncarbonate. Hardness of water resulting from the presence of dissolved calcium and magnesium salts other than carbonates (permanent hardness).

Hardness of water. That property of water, due mainly to bicarbonates, chlorides, and sulfates of calcium and magnesium, which prevents the production of abundant lather with soap.

Hazardous waste. Any waste or combination of wastes (which pose a substantial present or potential hazard to human health or living organisms) whose properties include flammability, evolution of toxic or irritating vapors, contact irritation, or human or animal toxicity.

Heads grade. The uranium content of recovered lixiviant, normally expressed in parts per million.

Heavy metals. Metallic elements, including the transition series, which include many elements required for plant and animal nutrition in trace concentrations but which become toxic at higher concentrations. Examples are mercury, chromium, cadmium, and lead.

Hydraulic gradient. The change in static head per unit of distance along a flow path.

Impoundment. A body of water formed by collecting water, as by a dam.

Infiltration. The flow of a liquid into soil or rock through pores or small openings.

Injection well. A well used for injecting fluids into an underground stratum or ore body by gravity flow or under pressure.

Ion exchange. Reversible exchange of ions absorbed on a mineral or synthetic polymer surface with ions in solution in contact with the surface. In the case of clay minerals, polyvalent ions tend to exchange for monovalent ions.

In situ. In its original or natural position.

Isopach. A line on a map drawn through points of equal thickness of a designated geological unit.

Leachate. The liquid that has percolated through solid ore, waste, or other man-emplaced medium and has extracted dissolved or suspended material from it.

Leakage. In groundwater, the flow of water from or into an aquifer through an underlying or overlying semipervious layer.

Lignite. A brownish-black coal in which the alteration of vegetal material has proceeded farther than in peat but not so far as in subbituminous coal.

Lixiviant. Leachate solution pumped underground to a uranium ore body; it may be alkaline or acid in character.

Mine field. Refers to the well-field area(s) and affected surface associated with solution mining. The term is often used interchangeably with well field.

Mine zone. The area from which uranium is extracted, including related buildings and structures. In this instance, it would include the ore body, all associated surface areas, and related well fields, process equipment, and buildings.

Mining unit (production unit). A segment or portion of an ore body capable of economically supporting mineral extraction; the minable limits of an ore body, which would normally include several production fields.

Monitor well. A surveillance (observation) well located usually along the periphery of a well field. It is used to indicate containment and/or lixiviant migration beyond the well field boundary. When the upper control limit of a monitor well is exceeded, corrective action is initiated.

Monitor well zone. The area of possible monitor well location. This zone is normally outside the limits of mineralization.

Nonpoint source. A source from which the contaminant enters the receiving water in an intermittent and/or diffuse manner.

Nonproduction zone(s). Those stratigraphic intervals underlying and overlying the production zone that are aquifers or that are relatively permeable.

Ore body. The mineralized portion of the sandstone formation where uranium is found in various grades and concentrations that can be extracted economically.

Osmosis. Passage of a solvent from a dilute solution to a more concentrated one through a semipermeable membrane (one that is permeable to the solvent only).

Oxidation. A chemical reaction in which there is an increase in positive valence of an element from a loss of electrons; in contrast to reduction.

Percolation. Movement under hydrostatic pressure of water through unsaturated interstices of rock or soil.

Permeability. Property of a porous medium to allow for the movement of liquids and gases through it under the combined action of gravity and pressure.

Permeable rock. Rock having a texture that permits water to move through it perceptibly under a head gradient ordinarily found in subsurface water (pervious rock).

pH. Minus the logarithm of the hydrogen ion concentration (activity). It is used as an indicator of acidity (pH less than 7) or alkalinity (pH greater than 7).

Phreatic divide (groundwater divide). Line on a water table along the sides of which the groundwater flows in opposite directions.

Piezometric surface. The surface defined by the levels to which water under artesian conditions will rise in tightly cased wells; also called potentiometric surface.

Plume. A body of contaminated groundwater originating from a specific source and influenced by such factors as the local groundwater flow pattern, density of contaminant, and character of the aquifer.

Point source. Any discernible confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, or concentrated animal feeding operation, from which contaminants are or may be discharged.

Pollutants (water). Substances that may become dissolved, suspended, absorbed, or otherwise contained in water and impair its usefulness.

Pollution (water). The degradation of natural water quality, as a result of man's activities, to the extent that its usefulness is impaired.

Ponds. Small storage reservoirs.

Population at risk. Those persons for whom protective actions are being or would be taken.

Pore. An open space in rock or soil.

Porosity. The relative volume of the pore spaces between mineral grains in a rock as compared with the total rock volume.

Porous medium. Solid body containing interconnected pores more or less evenly distributed.

Production area. The area of injection and production activity, which can be portrayed by a plan view of the well field area and vertically by a cross section extending from the surface to at least 10 ft below the bottom of the lowest production zone.

Production cell. The grouping of injection wells about a production or recovery well arranged in various configurations and varying in number.

Production field (zone unit). Mine or well field(s) actively used for production. It could consist of two or more well fields.

Production module. A process plant that is modularized for ease of installation and removal and is capable of handling a given production flow and output.

Production well (recovery well). A well from which lixiviant is recovered for conveyance to a process plant.

Production zone. That stratigraphic interval into which leaching chemicals are introduced. This interval extends horizontally in all directions in and beyond the production area.

Pump test. Extraction of water from a well at one or more selected discharge rates, during which piezometric or phreatic levels are measured regularly at the pumped well and at nearby observation wells. The data are used for determining the aquifer parameters in the vicinity of the pumped well.

Purification. Treatment of water for the removal of harmful or undesirable physical properties, chemical substances, and living organisms.

Radius of influence. Distance from the axis of a pumped or recharged well at which the effect of the well on the piezometric or the phreatic surface is no longer perceptible.

Recharge. The addition of water to the groundwater system by natural or artificial processes.

Reclamation. The return of the surface environment to acceptable preexisting conditions. This normally includes equipment removal, well plugging, surface contouring, reseeding, etc.

Recovery actions. Those actions taken after an emergency to restore the plant or facility as nearly as possible to its preemergency condition.

Reduction. A chemical reaction in which there is a decrease in positive valence as a result of gaining of electrons.

Restoration. The returning of all affected groundwater to its premining quality for its premining use by employing the best practical technology.

Reynolds number. Defined as $R = \alpha v \rho / \eta$, where ρ is the fluid density, η is the fluid viscosity, α is a length characteristic of the porous structure, such as the average pore size, and v is the volume of fluid crossing unit area per unit time.

Roll front. Uranium deposition localized as a roll or interface separating an oxidized interior from a reduced exterior. The reduced side of this interface is significantly enriched in uranium.

Runoff. Direct or overland runoff is that portion of rainfall which is not absorbed by soil; evaporated, or transpired by plants but finds its way into streams as surface flow.

Saturated zone. The zone in which interconnected interstices are saturated with water under pressure equal to or greater than atmospheric.

Sedimentary rock. Rocks formed from the accumulation and compaction of sediment.

Seepage. Slow movement of water in unsaturated rock material; loss of water by infiltration into the soil from a canal or other body of water.

Semiconfining bed. Poorly pervious yet water-transmitting layer.

Solution channels (holes or cavities). Fractures, joints, bedding planes, or other openings in soluble rocks, through which flow can occur (especially in limestone).

Sorption. A general term used to encompass processes of adsorption, absorption, desorption, ion exchange, ion exclusion, ion retardation, chemisorption, and dialysis.

Specific conductance. The ability of a cubic centimeter of water to conduct electricity; varies directly with the amount of ionized minerals in the water.

Stratigraphy. Concerning the sequence of rock types formed on the earth's surface. Each stratum is defined by its composition, distribution, succession, and geologic era.

Subsidence. Surface caving or distortion brought about by collapse of deep mine workings or cavernous carbonate formations, or from overpumping of certain types of aquifers.

Surface water. That portion of water that appears on the land surface (oceans, lakes, rivers).

Toxicity. The ability of a material to produce injury or disease upon exposure, ingestion, inhalation, or assimilation by a living organism.

Transmissivity. Rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is expressed as the product of the hydraulic conductivity and the thickness of the saturated portion of the aquifer.

Trend well. Surveillance well for production control and/or monitoring located between the well field and the monitor wells.

Unsaturated zone. Consists of interstices occupied partially by water and partially by air and is limited above by the land surface and below by the water table.

Upconing. The upward migration of groundwater from underlying strata into an aquifer caused by a reduced hydrostatic pressure in the aquifer as a result of pumping.

Upper control limit (UCL). A concentration value for any designated chemical species (indicator species) that must not be exceeded in a monitor well. Corrective actions are initiated when the upper control limits are exceeded and are continued until migration is brought under control.

Upstream. In the direction opposite to the main current.

Waste. Solids or liquids from solution mining or associated processes of no further value and subject to no additional productive processing. These are normally stored for concentration and ultimate disposal. Some process streams may be waste streams.

Water, brackish. Water containing significantly less salt than seawater. The concentration of total dissolved solids is usually in the range of 1,000-10,000 mg/liter.

Water conservation. Measures introduced to reduce the amount of water used for any purpose and/or to protect it from pollution.

Water demand. Actual quantity of water required for various needs over a given period as conditioned by economic, social, and other factors to satisfy a known or estimated requirement.

Water, drinking. Water suitable for drinking.

Water, fresh. Water neither salty nor bitter to the taste and in general chemically suited for human consumption (having a low dissolved solids content).

Water quality. Pertaining to the chemical, physical, and biological constituents found in water and its suitability for a particular purpose.

Water resources. Supply of water in a given area or basin interpreted in terms of availability of surface and underground water.

Water supply system. All storage reservoirs, pumps, pipes, and works required for providing water of a desired quality to the different sectors of consumption.

Water table. That surface in an unconfined groundwater body at which the pressure is atmospheric. It defines the top of the saturated zone.

Water table aquifer. An aquifer containing water under atmospheric conditions.

Water yield. Total runoff from a drainage basin through surface channels and aquifers.

Well capacity. Maximum rate at which a well will yield water under a stipulated set of conditions, such as a given drawdown.

Well completion. Techniques used to control horizontal underground movement of injected fluids from a well and to maintain the integrity of over- and underlying layers.

Well, disposal. Well used for the disposal of polluted or drainage water brines, etc.

Well field (mine field). Several production cells capable of supplying a given feed to a process plant.

Well, fully penetrating. Well that extends through the whole saturated depth of an aquifer and is constructed in such a manner that water is permitted to enter the well throughout its length.

Well, partially penetrating. Well in which the length of water entry is less than the thickness of the saturated aquifer that it penetrates.

Well radius, effective. Horizontal distance from the axis of a well.

Yield of aquifer (economic). Maximum rate at which water can be artificially withdrawn from an aquifer in the foreseeable future without continuously lowering the water table, depleting the supply, or altering the chemical character of the water to such an extent that withdrawal at that rate is no longer economically possible.

Yield, optimal. Amount of water that can be withdrawn annually from an aquifer or from a basin according to some predetermined criterion of optimal exploitation.

Yield, safe. Amount of water (in general the long-term average amount) that can be withdrawn from a groundwater basin or surface water system without providing undesirable results.

Zone of saturation. That part of the lithosphere in which the pores are completely filled with water.

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4. PROPOSED OPERATIONS

4.1 DESCRIPTION OF ORE BODY

4.1.1 Physical shape and areal extent

Roll-type mineralization is present at the Irigaray site in the Wasatch Formation in units designated by WMC as the Upper Irigaray sandstone (UISS) and the Lower Irigaray sandstone (LISS). The UISS is the thickest and economically most important. Figure 4.1 shows the areal extent of mineralization of the UISS.

4.1.2 Mineralogy and geochemistry

Uranium has been deposited in the reducing environment of the ore roll front as uraninite, an oxide of uranium, and coffinite, a silicate. The content of calcite, CaCO_3 , ranges from 1 to 3%, and pyrite, FeS_2 , is generally less than 0.5%. In contrast to many uranium deposits of similar origin, no molybdenum mineralization has been found at the Irigaray site to date. Arsenic and selenium are present within and adjacent to the uranium mineralization. Barite, BaSO_4 , is found with the uranium mineralization.

4.2 AMENABILITY TO SOLUTION MINING

Pilot-scale testing has been performed on the Irigaray deposit to determine its amenability to and the feasibility of recovering uranium by solution mining techniques. During the course of testing, data were collected on (1) solution circulation rates as a function of well spacing, completion methods, and lixiviant composition; (2) characteristics of the solution produced as a function of lixiviant composition; and (3) sustained well field and process plant operation.

The first test period lasted for 11 months, beginning in November 1975 and continuing until October 1976. During this period, testing was conducted on three adjoining patterns in Section 5, designated 5I7, and 5I7X, and 5I7S (Fig. 4.2). Restoration tests have been conducted at the 5I7 site.

Results from the 5I7 test to demonstrate the feasibility of solution mining are shown in Table 4.1. The data suggest that the well spacing (injection to production) best suited for the Irigaray deposit is near 12 m (40 ft). Because of limited injection flows and economic considerations, the proposed production cell configuration will be a seven-spot pattern (six injection wells around a central recovery well). However, both well spacing and pattern may vary depending on geohydrological conditions.

A pilot-scale test is being conducted in Section 9 at the site (Fig. 4.4) to develop design criteria for the proposed production-scale solution mining operation.

4.3 WELL FIELD

4.3.1 Description and location

Uranium will be mobilized by injecting a leach solution (ammonium bicarbonate) and an oxidizing agent (hydrogen peroxide) into the ore body through injection wells and recovered by pumping the uranium-rich solution to the surface through nearby production or recovery wells. Figure 4.3 is a simplified cross section of a solution mining unit. The numbers of injection wells and recovery wells and their spacing depend on the hydrologic characteristics of the host rock. The initial well pattern to be used at the Irigaray site is called a seven-spot — six injection wells surrounding one central recovery well (Fig. 4.4, inset) — and is based on economic factors and limited injection flow rates. The distance between the injection and recovery wells will be about 12 m (40 ft). The seven wells are called a production cell. A number of production cells operating in one area constitute the well field. The applicant's proposed mining and drilling schedule is shown in Fig. 4.1.

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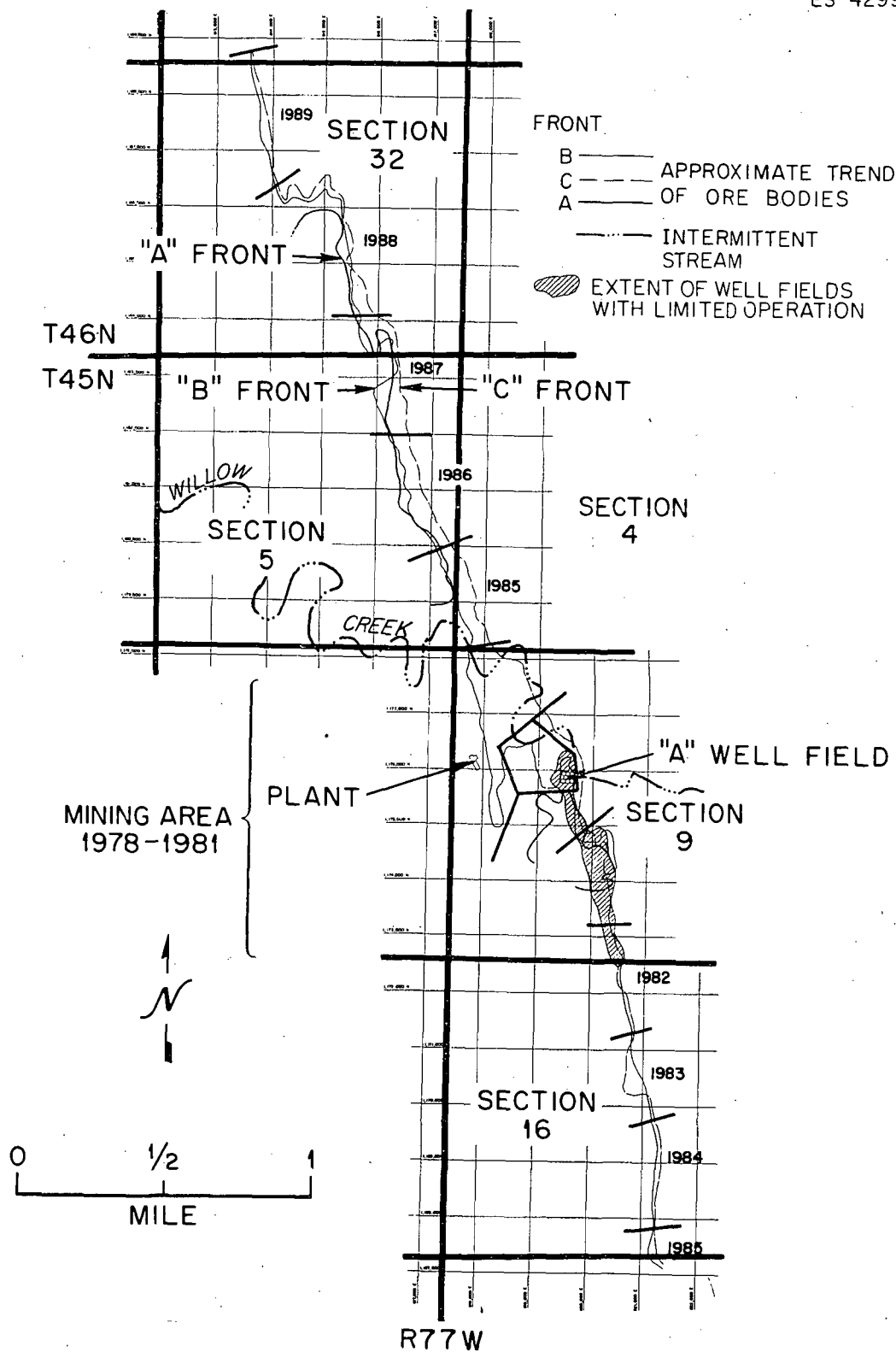


Fig. 4.1. Potential mining and drilling schedule for the Irigaray site. Source: Modified from ER, Fig. 4-1.

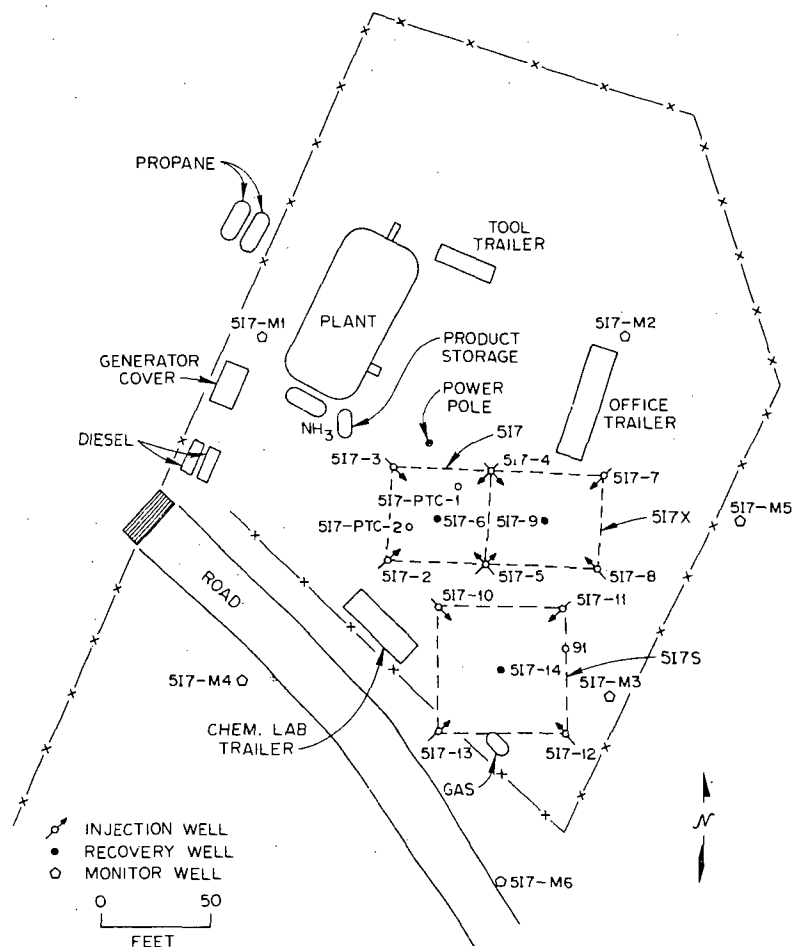


Fig. 4.2. 517 Irigaray research and development test layout. Source: ER, Fig. 2-7.

Table 4.1. Results from 517 pilot-scale test

Test	Surface area of test site (ft ²)	Duration of test (days)	Approximate percentage of U ₃ O ₈ recovered ^a
517	1600	107	35
517X	2000	104	50
517S	3250	94	30 (approx)

^a Test was only operational in nature; it was not intended to effect optimum recovery.

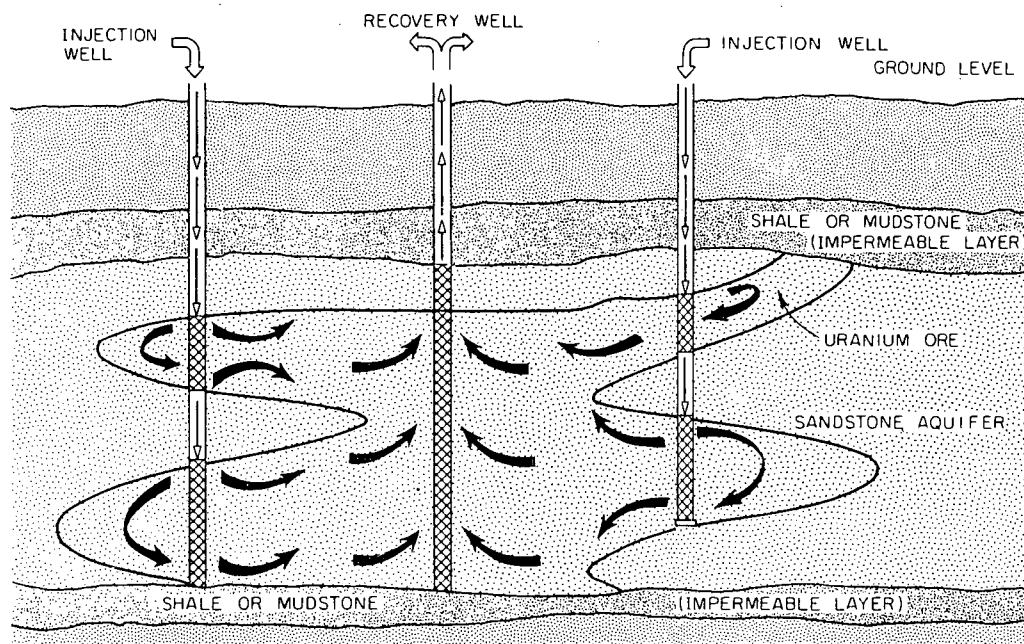


Fig. 4.3. Cross section of a typical uranium roll front deposit and the solution mining unit. Source: Modified from ER, Fig. 2-2.

The existing well field A (pilot-scale test area) is located in Section 9, T45N, R77W (Fig. 4.4). Proposed well fields for subsequent mining are also indicated in Fig. 4.4.

4.3.2 Well completion

Wells are drilled with a standard exploration-type water drill rig using a conventional bit and an inorganic drilling mud. The wells are usually 10 cm (4 in.) in diameter. The hole is logged (gamma, resistivity, etc.) to pinpoint the mineralized zones and the depths where open or screened holes are needed. The well is then cased. The bottom of the casing is assembled as shown in Fig. 4.5.

Cement is then pumped into the casing and through cementing holes into the annulus above the cement basket. Water is used to force most of the cement out of the casing and bring the cement level in the annulus to the surface. The well is then shut in and checked for leaks, and the cement is allowed to harden. After hardening, the cement remaining in the casing is drilled out along with the plug. The part of the well below the casing is then cleaned by circulating water, "produced," and steam-cleaned. Underreaming is used when the injectivity is not acceptable.

A cap is put on the injection well so that fluid can be injected into the open interval. Recovery wells are equipped with a down-hole pump suspended on a 1-in. pipe, which brings recovered solution to the surface.

4.3.3 Injection and production rates and pressures

Injection and production flow rates are maintained to produce a balanced flow from the operating well field.

Based on the hydraulic conductivity of the ore zone (Sect. 2.6.2.3), injection rates per well are expected to be 4 to 5 gpm at a pressure of 50 to 120 psi. Total injection rate in one production cell could be as much as 30 gpm. These figures are based on pilot-scale experience. Localized variations of the hydraulic characteristics in the ore body might increase or decrease selected injection rates. Other factors that may affect the maximum injection pressures and flow vs pressure relationships are hole interval, binding of the injection well bore, and the quality

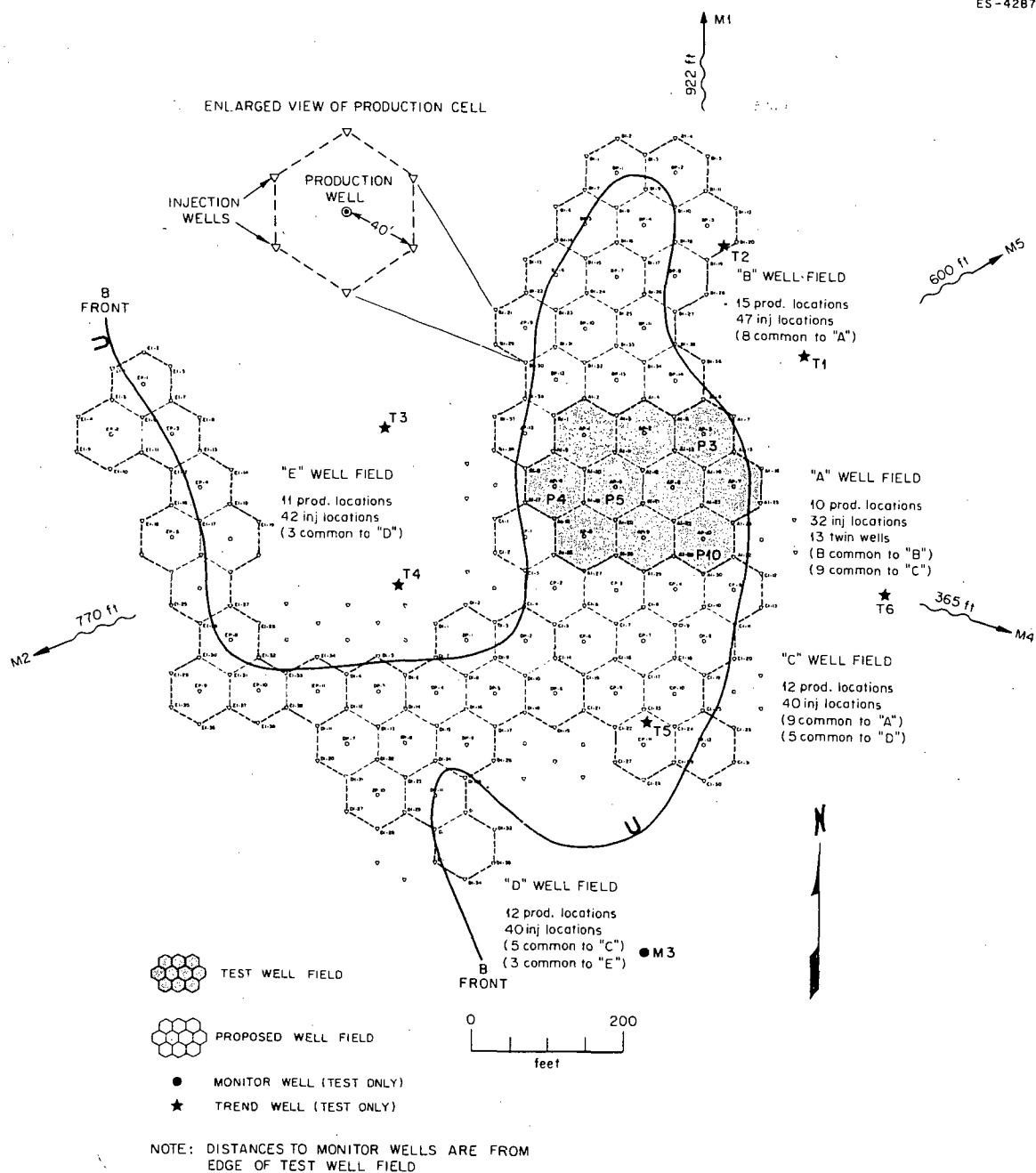


Fig. 4.4. Well field locations for the initial mining unit and pilot-scale test in Section 9. Source: Modified from ER, Fig. 2-10.

WELL COMPLETION

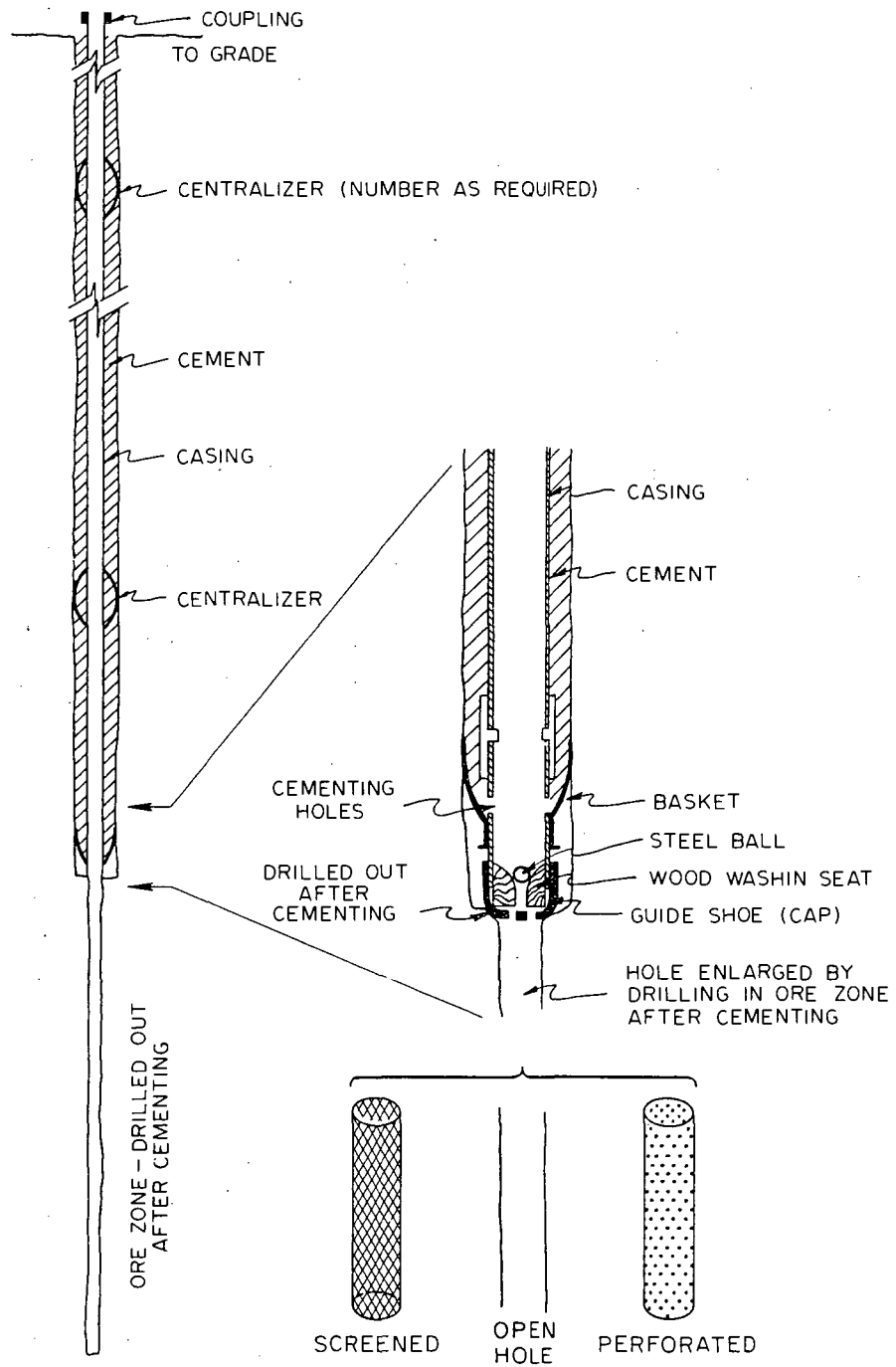


Fig. 4.5. Diagram of well completion methods. Provided by the applicant.

of well completion. The injection pressure is limited by the fracturing pressure of the formation, which is about 140 psi. Successful leaching of uranium could be markedly impeded if fracturing occurred.

Recovery wells will be pumped at a rate planned to confine the leach solution to the production cell or well field. Specific production rates from recovery wells are expected to range from 12 to 15 gpm based on a 3 to 1 ratio of injection wells to recovery wells.

4.3.4 Operating plans and schedules

4.3.4.1 Well field and plant

The recovery building shell has been constructed. It presently contains the pilot-scale test equipment, operating at a 100-gpm capacity under Nuclear Regulatory Commission Source Material License SUA-1204. The applicant proposes plant start-up at a capacity of 500,000 lb/year of U_3O_8 (800 gpm) in the fall of 1978. Well field drilling is planned to stay approximately four to five months ahead of the mining operation.

4.3.4.2 Mining operation

Proposed annual progress of the mining and drilling operation is shown in Fig. 4.1. The specific plan will be to start at the existing well field A and B in Section 9 and follow the ore body south toward Section 16 and develop 12 ha (30 acres) of well fields through 1981.¹ In the future, mining operations may move northward along the roll fronts through Sections 4, 5, and 32. As the mining operation moves away from the site of the present plant, other recovery plants may be required in the future.

4.3.4.3 Restoration

Restoration will begin after a well field has been mined out and the mining operation has moved far enough away [a distance of three production cell widths approximately 73 m (240 ft)], so there will be minimal interference with the restoration operation. For specifics, see Sect. 5.1.

4.4 RECOVERY FACILITY

4.4.1 Buildings: construction and appearance

According to the applicant, the Irigaray plant building will house a 500,000-lb/year recovery plant. The site and core building have been designed to permit expansion to a 1,000,000-lb facility either by replication of the currently planned recovery system or by the use of satellite systems (see Sect. 3.2.4.2).

The process building covers 2230 m² (24,000 ft²) and is 91 m (300 ft) long, 24 m (80 ft) wide, and 6 m (20 ft) high except for a raised section that is 12 m (40 ft) high, 24 m (80 ft) wide, and 12 m (40 ft) long to accommodate the ion exchange columns.

The building is a standard steel structural framed unit, covered with prepainted 24-gage steel sheets, and has fiberglass-insulated walls and ceilings. The floors are a minimum of 15 cm (6 in.) of reinforced concrete with central drain and sump systems to reclaim all plant liquids used in processing and washing. The structure is designed to be expandable to accommodate modifications or process changes during the life of the plant. As mining progresses, new floors and foundations can be prepared elsewhere. The skid-mounted process units and the building can then be moved to that location.

Attached to the process building is a combined office, warehouse, and analytical laboratory of 446 m² (4,800 ft²).

Well field control buildings will be located in each well field. The buildings will typically be 18 m (60 ft) long and 18 m (60 ft) wide. The size may vary slightly depending on the number of wells serviced by each building. Floors and pump mounts are constructed of reinforced concrete. The floor is equipped with drains and sumps to control wash water and spills.

Septic systems have been built to State-approved plans for the process building to handle sanitary and laboratory wastes. Power is supplied by the Rural Electrification Administration on specially built power lines to meet service requirements. Water is supplied by onsite wells

drilled specifically to supply plant and process water. The buildings are heated by propane space heaters to prevent freezing of equipment. The office, warehouse, and laboratories are served by a central heating and air conditioning unit to provide the required temperature levels to maintain comfort.

4.4.2 Process equipment

This discussion is centered on process components that produce or control effluents during operation and/or accidents. Figure 4.6 is a schematic representation of the applicant's recovery process.

4.4.2.1 Lixiviant sorption circuit

In the WMC lixiviant sorption circuit, the pregnant lixiviant solution will flow from the production wells to the uranium extraction column, then through the lixiviant solution makeup unit to the calcium control unit, and back to the ore zone through the injection wells. The production well pumps are centrifugal-type submersible electric pumps mounted at the bottom of the wells and will produce flows of 12 to 15 gpm at each production well. Flow rates will be limited to this range by manual control valves in the well field control buildings.

The production wells and control building will be connected by solution collection lines of polyvinyl chloride (PVC) and/or rubber pipe. The lines will be above ground except at road, ravine, and creek crossings, where suitable culverts or supports will be constructed. Above-ground piping simplifies leak detection and repair. According to the applicant, operation at planned flow rates should prevent pipeline freezes during cold weather.

At the well field control building, the uranium-rich lixiviant solution will pass through a manual flow control valve and a flowmeter into a surge tank (approximately 12,000 gal). It will be pumped to the main processing plant via the main trunk pipeline (PVC pipe) into another surge tank. The pregnant lixiviant solution will then pass through the uranium sorption column, where the complexed uranium displaces chloride ion from the ion exchange resin. The uranium-depleted solution will flow to the lixiviant makeup unit, where additional ammonia and carbon dioxide will be injected to reconstitute the ammonium bicarbonate concentration.

As a result of ammonium bicarbonate reconstitution, precipitation of calcite (CaCO_3) would occur. To prevent scale formation in pipes or plugging of injection wells, the calcite will be separated from the leach solution prior to recycling the lixiviant to the well field.

Calcite precipitation will be done in a large tank in which the lixiviant solution will remain long enough to permit calcite crystals to grow and settle. The product will be transferred to an external calcite storage pond.

The reconstituted lixiviant solution will be recycled to the well field. Surge tanks and PVC trunk pipelines will be used to transfer the solution to the well field control buildings. The solution will be pressurized prior to injection, metered, fortified with oxidant (0.25 to 1.0 g of hydrogen peroxide per liter of solution), and fed to the injection wells through rubber or PVC pipe.

4.4.2.2 Resin transfer circuit

Periodically a fixed quantity of uranium-loaded resin will be transferred from the sorption circuit to the elution circuit and a like quantity of eluted resin will be transferred in the opposite direction. The uranium-loaded resin will be flushed to remove contaminant solids, and the eluted resin will be washed to remove unabsorbed elution chemicals. These washing steps will minimize chemical communication between the sorption and elution circuits. A portion of the wash water waste will be used for process water, while the remainder will be sent to a liquid waste pond.

4.4.2.3 Elution and precipitation circuit

The elution column will receive uranium-loaded resin from the uranium extraction column. An eluant containing ammonium bicarbonate and ammonium chloride will elute the uranium complex from the resin. Hydrochloric acid will then be added to this eluate to decompose the complex and to drive off carbon dioxide (CO_2), converting the uranium to its uranyl form. The uranyl ion will be precipitated with ammonia to form ammonium diuranate (ADU). A thickener unit will be used to separate the ammonium diuranate slurry from the solution. The slurry will then be transferred to the drying and packaging unit for final processing.

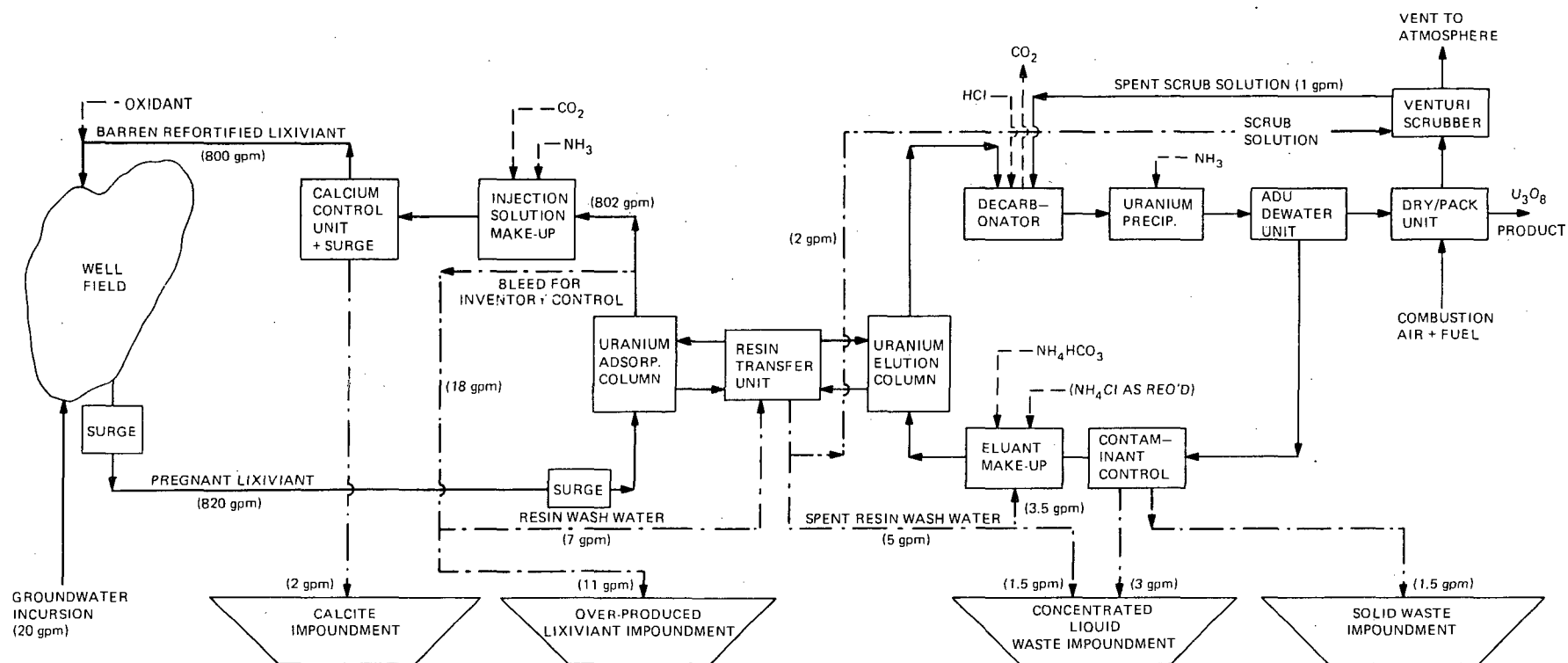


Fig. 4.6. Schematic diagram of the applicant's uranium recovery process, showing approximate volume flow rates. Source: Modified from ER, Fig. 2-9.

The barren solution from the thickener will be reformed in chloride and bicarbonate ion before it is recycled to the elution column. If sulfate or vanadium levels increase above pilot-scale observations, vanadium adsorption on activated carbon or sulfate precipitation utilizing barium salts will be used to reduce their levels in the circuit. Vanadium-saturated activated carbon and barium sulfate would then be produced as solid wastes.

4.4.2.4 Drying and packaging unit

The ammonium diuranate slurry will enter a propane-fired kiln, where it will be dried and converted to U_3O_8 product (yellow cake). Upon cooling, the U_3O_8 will be packaged in drums. Airborne effluents from the drying and packaging unit operation will be controlled by Venturi scrubbers. Spent scrubber solution will be recycled to the elution precipitation unit to recover any particulate U_3O_8 .

4.4.2.5 Wastewater treatment unit

Uranium recovery process liquid wastes consist mainly of ammonium chloride and carbonate solutions. They may contain sufficient radium, uranium, and other dissolved solids to warrant isolation from surrounding surface and groundwaters. Wastewater treatment is discussed in Sect. 4.6.2.

4.4.2.6 Chemical storage tanks

Onsite storage facilities will be maintained for chemical agents and fuels involved in mining and restoration operations. Corrosive or flammable liquids and pressurized gases will be stored away from buildings in tanks and pressure vessels meeting ASME standards. Materials to be stored would include liquified anhydrous ammonia (30,000 gal tank), liquified carbon dioxide (20,000 gal tank), concentrated hydrochloric acid (35 wt % HCl), hydrogen peroxide (50%), propane (5000 gal tank), diesel fuel (3000 gal), and gasoline (3000 gal).

Prefabricated fiberglass surge tanks will be employed in the recovery system to maintain flow to the uranium extraction column during temporary curtailments in production and injection flows, as indicated in Fig. 4.6.

4.4.3 Process operation

The WMC recovery plant is designed to produce 500,000 lb of U_3O_8 per year. The flow rate of lixiviant through the plant will be adjusted so that the scheduled yellow cake production can be met with the available heads grade or uranium concentration. The design plant flow rate is 800 gpm. The applicant's pilot-scale operating experience suggests that a plant flow rate of 800 gpm will be sufficient to maintain initial plant production.

At the well field, a sufficient number of injection and production wells will be maintained to provide for the flow requirements of the plant. Only a portion of all the wells in a well field would be in operation at any time. This will allow continuous operation, since new production cells could be brought on line as mined-out cells are retired. Also, production would not be affected by maintenance operations such as injection well cleaning.

4.4.4 Operating plans and schedules

Plant startup is anticipated for the fall of 1978. The plant's life expectancy is up to ten years or until mining operations require relocation of the recovery plant.

4.5 PLANT MATERIALS BALANCE AND FLOW RATES

The estimated volume flow rates for an 800-gpm plant to produce 500,000 lb of U_3O_8 per year are shown in Fig. 4.6. The anticipated chemical feed rates are listed in Table 4.2. The chemical feed ranges in Table 4.2 reflect the wide range of operating conditions that are possible. The introduction of sulfate precipitation and/or vanadium adsorption for contaminant control would reduce both the rate of bleed from the elution and precipitation circuit and the consumption of ammonium chloride and water.

Assuming 100% recovery of uranium from the lixiviant solution, the plant would be expected to operate on an average heads grade of at least 143 ppm (as U_3O_8) in the lixiviant to maintain scheduled production.²

Table 4.2. Estimated chemical feed rates for WMC
Irigaray uranium recovery process
500,000 lb/year production

Compound	Feed rate	
	Pounds per hour	Tons per year
Lixiviant chemicals for 800 gpm injection		
Carbon dioxide (CO ₂)	75–225	325–985
Ammonia (NH ₃)	40–120	175–525
Hydrogen peroxide (H ₂ O ₂) (50%)	75–250	325–1100
Elution and precipitation reagents for 4.5 gpm total eluant bleed		
Ammonium bicarbonate (NH ₄ HCO ₃)	35–100	150–440
Ammonium chloride (NH ₄ Cl)	75–200	325–875
Hydrochloric acid (35% HCl)	25–70	110–305
Ammonia (NH ₃)	5–20	22–90
Fuel		
Propane	20–60	90–260

4.6 WASTES AND EFFLUENTS

4.6.1 Liquid waste sources

The major effluent to be generated during solution mining and the subsequent groundwater restoration processing will be liquid wastes. A small volume of sanitary waste will also be generated.

Maximum water volumes affected in a solution mining operation of this scale under normal conditions, as estimated by the applicant, are summarized in Table 4.3 along with the bases for these estimates. The largest volume of effluent will be generated by groundwater restoration operations. This is discussed in Sect. 5.1.4.1.

The second major source of liquid waste will be well field overpumping. Here, more water is withdrawn from the well field than is injected. Overpumping helps to confine the lixiviant solution to the ore zone being mined. It will also serve to supply the wash and process water in the uranium recovery plant. This volume will be minimized by balancing the operational flows.

Another source of liquid waste will be associated with routine injection well cleaning to maintain necessary lixiviant flows. Present treatment to clean the injection well bore includes the withdrawal of about 10 well bore volumes to remove residual solids from the formation and well prior to resuming injection. Alternative well cleaning methods to reduce effluent volumes for this operation are being investigated in the applicant's pilot-scale tests.

Other sources of process liquid wastes will be the spent resin wash water and the eluant circuit bleed respectively. Alternative methods of contaminant control are under pilot-scale investigation by the applicant to reduce the rates of waste sources. Overproduced solution could be successively used for resin wash water and eluant makeup prior to being discharged as waste. Neither source will represent a major consumptive use of water. The remaining water requirement for sanitary use and monitor well sampling will be approximately 1 gpm.

4.6.2 Liquid waste disposal

Liquid wastes generated in mining and restoration processes will vary in composition and volume. Uranium recovery process liquid wastes, groundwater restoration liquid wastes, and sanitary wastes will be handled by separate systems.

4.6.2.1 Liquid wastes from mining

Uranium recovery process liquid wastes will consist of ammonium chloride and carbonate solutions. They will contain uranium and daughter products, including radium, and dissolved solids warranting isolation from surrounding surface and groundwaters.

Table 4.3. Estimated volumes of liquid effluents^a

Estimated volumes of liquid wastes (in acre-feet per year) associated with 500,000-lb/year solution mining production facility (800 gpm)

Source ^b	Acre-feet per year
1. Overproduction of the well field (basis: 1% of design production rate of 800 gpm for 500,000-lb/year facility)	14.6
2. Well cleaning to maintain injection flows (basis: 10 acres land on seven-spot configuration, 40-ft spacings with 1500 gal per well twice a month required to accomplish cleaning)	5.5
3. Resin wash water for contaminant control (basis: field test data indicate a bleed of ≤ 7.0 gpm is required for control, or ≤ 10.5 acre-ft/year)	Included in item 1
4. Eluant bleed for contaminant control (basis: field test data indicate a bleed of ~ 4.5 gpm will be required)	Included in item 1
5. Plant and well field sanitary water use (basis: estimated consumption rate of $\sim 2,000$ gpd)	2.1 ^c
6. Monitor well sampling (basis: withdrawal of ~ 200 gal per well is necessary to obtain a representative sample and 50 wells sampled twice monthly)	0.9
Affected volume from mining operations (items 1, 2, and 6)	21.0

^a Exclusive of groundwater restoration activities.

^b All sources are presumed to be radioactive except for item 5.

^c Goes to sanitary waste field.

As indicated in Table 4.3, approximately 21 acre-ft of this waste would be generated annually. Since the net annual evaporation rate in the Wyoming area is about 3.5 ft per year, solar evaporation ponds covering at least 6 acres could handle this liquid waste volume indefinitely.

The WMC solution mining process is still in the developmental stage. Future process developments may lead to decreased liquid waste volumes. On this basis, the applicant proposes the construction and use of the evaporation ponds listed in Table 4.4 to serve the dual function of liquid waste storage and concentration.

Table 4.4. Evaporation ponds for liquid wastes

Type	Number	Dimensions (ft)	Capacity (acre-ft)		Freeboard surface area (acres)
			Freeboard	Total	
Calcite waste	1	100 X 250 X 6	2.7	4.4	0.78
Low TDS waste	1	250 X 250 X 6	6.3	9.9	1.72
High TDS waste	1	250 X 250 X 6	6.3	9.9	1.72
High TDS waste	2	160 X 390 X 6 each	6.4 each	10.0 each	1.75 each
Total			28.1		7.72

Figure 4.7 shows the locations of the proposed ponds. Although the calcite waste pond is designed primarily for solids containment, it will also serve as an evaporation pond, since a liquid seal will be maintained over the solids. The ponds should have sufficient capacity for liquid wastes from the recovery plant.

Figure 4.8 shows the details of pond construction as proposed by the applicant. The calcite pond and waste ponds will be constructed as rectangular basins excavated in relatively flat areas on high ground. A gravel bed and a system of perforated pipes will be placed under the base of each pond to collect seepage and serve as a leak detector. A thin layer of soil will

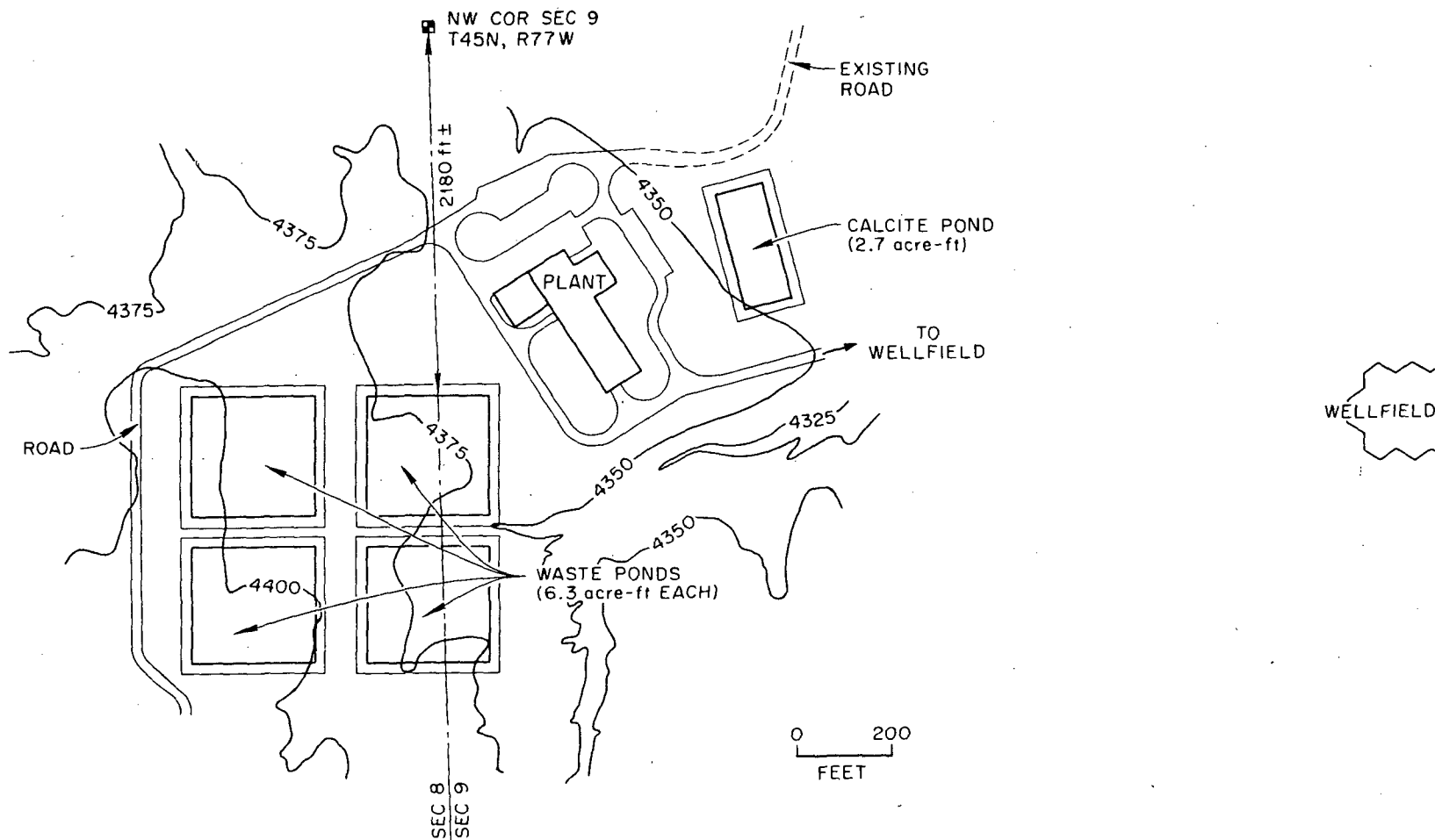
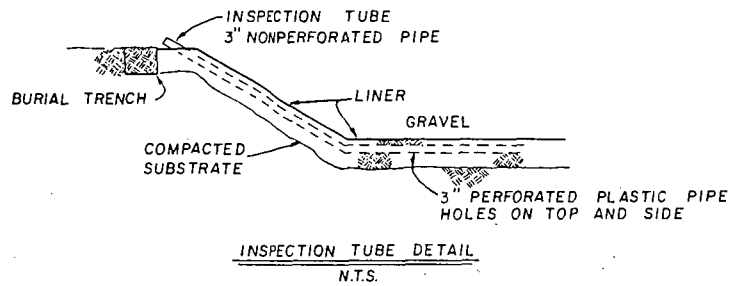
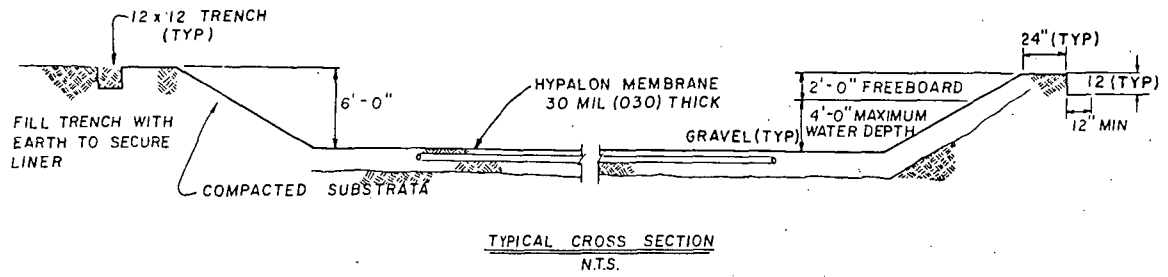


Fig. 4.7. Locations of evaporation ponds for process plant liquid wastes at the proposed Irigaray site. Provided by the applicant. Note: The revised dimensions of the waste ponds are shown in Table 4.4.



MODEL RESERVOIR
 AREA = 1.75 ACRES CAPACITY = 6.3 ACRE FT.

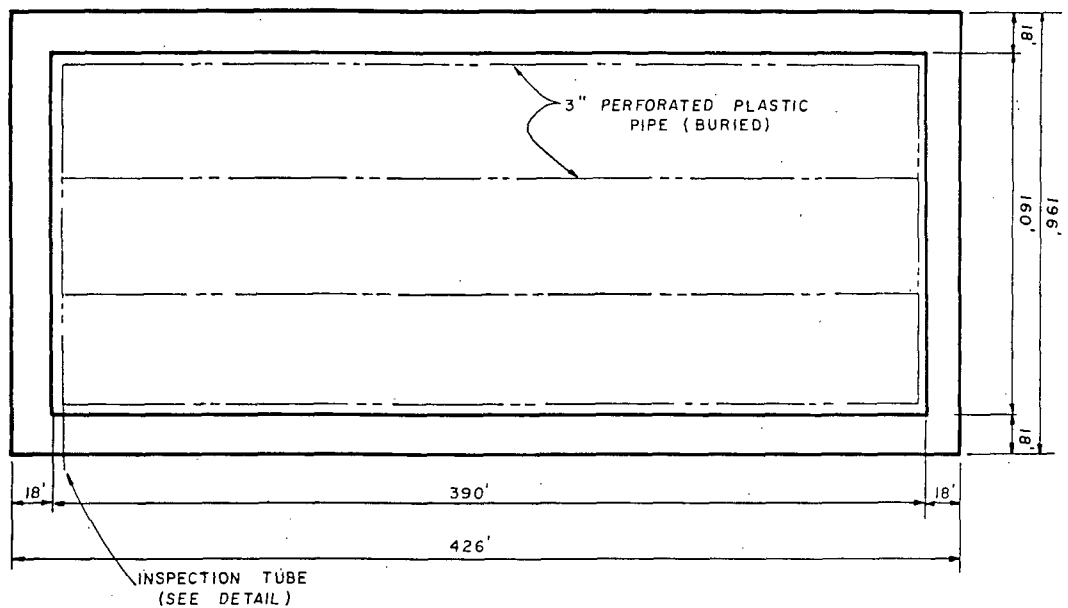


Fig. 4.8: Pond construction detail.

be placed over the gravel and will be covered by an impermeable polyethylene liner. A thin layer of soil may also be placed over the liner to protect it from mechanical and weather damage. In normal operation at least 0.6 m (2 ft) of freeboard will be maintained in each pond. The plastic liner will normally preclude any seepage from the pond. However, should the liner fail, process wastes would seep into the gravel and piping underlying the pond. The presence of water and process chemicals in the leak detection system will readily indicate a leak. In this event, the contents of the leaking pond will be pumped to an adjacent pond to permit repair of the liner.

4.6.2.2 Liquid wastes from groundwater restoration

Restoration wastes are discussed in Sect. 5.1.4.

4.6.3 Solid waste sources

Solid wastes will be generated from three principal sources in the recovery process: (1) the calcium removal unit, (2) supplemental contaminant control incorporated in the elution and precipitation circuit of the recovery process, and (3) liquid waste concentration by evaporation during impoundment. Additional solid wastes will be produced in conjunction with the water treatment methods utilized to accomplish aquifer restoration. The latter would generally be similar to the solid wastes produced in the uranium recovery process.

Calcite (CaCO_3), which will be removed prior to injection of the refortified lixiviant, will be the principal solid waste produced in the solution mining process. Contaminants will be coprecipitated with the calcite prior to lixiviant reinjection. According to the applicant, the precipitated calcite could contain from 500 to 1200 pCi of radium-226 per gram (ER, p. 37). This corresponds to about 95% removal of the radium-226 that may be mobilized by the proposed lixiviant. The applicant estimated that for each pound of U_3O_8 recovered, 2 lb of calcite will be produced. Thus less than 500 tons of calcite would be generated per year that could contain about 0.5 Ci of radium.

Another source of solid wastes could be associated with supplemental contaminant control methods for sulfate and vanadium, as indicated in Sect. 4.4.2.3.

A third source of solid wastes from the recovery plant would be crystallized materials resulting from evaporative concentration of impounded waste solutions. These products would consist primarily of assorted ammonium and alkaline earth salts (e.g., ammonium chloride, ammonium sulfate, calcium carbonate, radium sulfate). The staff estimates that on the order of 500 tons per year of such material may be generated and would contain an indeterminate quantity of naturally radioactive materials.

Additional solid wastes will result from daily operations. These will include such items as used filters, contaminated hardware, and other disposable items.

4.6.4 Solid waste disposal

The solid wastes generated by mining and subsequent aquifer restoration could contain uranium, thorium, radium, and other toxic materials in varying amounts. Therefore, isolation of solid wastes will be necessary. The applicant plans to temporarily store these wastes in lined ponds under a liquid seal. A maximum of five years accumulation of the calcite wastes will be permitted prior to removal from the site. This will be a license condition. The applicant will transport these wastes to an active uranium mill tailings impoundment for disposal. Other radioactive or toxic wastes accumulated in the evaporation ponds will be removed and transferred to an active mill tailings impoundment as necessary (as ponds fill) or at the time of site reclamation. The staff recommends that any transportation method used for such wastes have provisions for minimizing both liquid and dust releases to the environment. The staff also recommends that contract arrangements for the disposal of such solid wastes be obtained and maintained by the applicant and the operator of the licensed tailings pond.

All other contaminated solid wastes (e.g., spent resin, filters, hardware) will be disposed of offsite in a licensed burial ground or active tailings pond.

4.6.5 Atmospheric emissions

Atmospheric emissions from the proposed solution mining process will originate from three principal sources: (a) the uranium recovery process area, (b) the calcium removal unit, and

(c) waste ponds. To reduce atmospheric releases within the uranium recovery process area, process components will be enclosed or vented where practicable. Ventilation and emission controls will be maintained at levels necessary to ensure safe working conditions and insignificant environmental impacts. In the plant building, there will be two principal atmospheric emission sources: the calcium removal unit (tanks) and the product drying and packaging unit.

According to the applicant, the drying and packaging unit atmospheric release will consist of (1) by-products of combustion (1,000,000-Btu/hr product drying unit), (2) volatilized solution residuals (about 0.75 to 1.25 lb of barren eluant per pound of ammonium diuranate feed), and (3) U_3O_8 fines generated during product drying. The off-gases from the dryer will be scrubbed by a high-intensity Venturi scrubber (99.5 to 99.9% efficient) to reduce U_3O_8 losses to less than 1000 lb/year.

The storage ponds will also be a source of atmospheric ammonia, carbon dioxide, radon, and ammonium chloride emissions. The magnitude and composition of atmospheric emissions will be determined by the equilibria established between the prevailing evaporation rate, the feed rate, and the composition of solutions being impounded. Particulate emissions from impoundment areas will be minimized by a liquid seal over pond contents. The maintenance of a liquid seal on impoundments will be a license condition.

Radioactive atmospheric releases will originate in the ammonium diuranate drying unit, the calcium control unit, and the waste storage ponds. Releases of 1000 lb of U_3O_8 per year from dryer losses would correspond to a release of approximately 0.15 Ci of uranium-238 per year. A like amount of radioactivity release would be expected from the other natural uranium isotopes. Radium-226 mobilized during in situ leaching will coprecipitate with the calcite in the calcium control unit and will be deposited in the calcite storage pond. The staff estimates that about 1.4 Ci of radon-222 per year could be released from the calcite storage pond and calcium control unit as a result of decay of radium-226. Radon-222 mobilized from the ore zone during solution mining would be vented at the well field surge tanks. The staff estimates that approximately 76 Ci of radon-222 per year would be released from these tanks.

Table 4.5 contains a summary of the estimated emissions from each of the indicated sources. The cited estimates are based on the applicant's source composition and ambient temperature data and an assumed mean evaporation rate of 42 in./year.

Table 4.5. Estimated atmospheric emissions

Source	Emission rate ^a (thousands of pounds per year)				Radioactive releases ^b (Ci/year)	
	NH ₃	CO ₂	NH ₄ Cl	H ₂ O	U-238	Rn-222
Uranium recovery process facility (excluding the calcium control unit and waste storage ponds)	6-9	1500-3000	30-54		0.151	
Calcium control unit (basis: 1,000 ft ² of exposed solution surface containing 0.75 g NH ₄ , 1.5 g total CO ₃ , and 0.75 g Cl per liter)	2-4	6-9	0.06-0.09	390-470		0.04
Calcite storage pond (basis: complete evaporation of 2.04 gpm of supernate containing 0.75 g NH ₄ , 1.5 g total CO ₃ , and 0.75 g Cl per liter)	2.5-3.5	9-10	9.5-10.5	~8000		1.36
Liquid waste storage ponds (basis: 1 acre of exposed solution surface containing about 7.0 g NH ₄ , 1.0 g total CO ₃ , and 16 g Cl per liter)	9-11	7-8	27-31	~9300		
Well field surge tanks						76

^aBased on data supplied by applicant. Net evaporation rate of 42 in./year used in estimating releases.

^bStaff estimates.

REFERENCES FOR SECTION 4

1. Wyoming Mineral Corporation, Application for In Situ Permit to Mine for the Irigaray Site, April 12, 1978.
2. W. C. Larson, "Nomograph for In-Situ Uranium Leaching," *Eng. Min. J.*, September 1977, p. 159.

5. RESTORATION, RECLAMATION, AND DECOMMISSIONING

This section discusses the measures that will be taken to return the mining area to its original use after mining has been completed. Restoration techniques will be applied to all contaminated groundwater. Reclamation will be conducted on all disturbed surface areas. Decommissioning of all structures will be accomplished when the project has been completed. A performance bond is required by the State of Wyoming for both reclamation and restoration.

5.1 RESTORATION

Restoration is defined as the returning of affected groundwater to a condition consistent with its premining use (or potential use) upon completion of leaching activities. Restoration is intended to reduce the concentration of toxic contaminants remaining in the groundwater to acceptable levels. Although restoration technology is currently in the developmental stage, test results to date indicate generally that satisfactory levels of restoration can be achieved, with the possible exception of the ammonia parameter.¹

Currently, the most widely used restoration technique is groundwater sweeping. This technique involves the pumping of contaminated groundwater from the mineralized zone which then causes surrounding (uncontaminated) groundwater to flow through the affected area. The contaminated groundwater is eventually displaced by uncontaminated groundwater, thereby restoring the affected area. This technique has also been successfully demonstrated on contaminated groundwater in the oil industry.² Although a number of companies have demonstrated the feasibility of the groundwater sweeping technique on small test areas, it has not yet been tried or demonstrated on a production scale. Other groundwater restoration techniques involving chemical treatment methods and/or groundwater recycling are also under study by the industry and the U.S. Bureau of Mines.³

5.1.1 Restoration criteria

With continued sweeping over a sufficiently long term the affected mining zone will approach its original condition. However, the consumptive use of water, the disposition of solid wastes, and additional costs must be optimized against groundwater condition if solution mining is to be a viable technique for recovery of uranium resources. In line with this, the staff evaluation of the applicant's proposed restoration procedure is based on the requirement that any affected groundwater must be returned to a chemical condition consistent with its potential premining use.

The staff has recognized two water quality zones within the ore-bearing aquifer. The zones are defined as follows:

1. Mining zone — the area within the mineralized (ore deposit) portion of the aquifer. The perimeter of this zone is defined as one well spacing (approximately 40 ft) either beyond the outer injection wells or the limit of the ore deposit to be mined. At the Irigaray site, groundwater (as determined from the highest concentrations in wells) within this zone naturally contains excessive concentrations of radium-226 (144 pCi/liter vs 5 pCi/liter), arsenic (0.10 mg/liter vs 0.05 mg/liter), and selenium (0.73 mg/liter vs 0.01 mg/liter) compared with drinking water standards (Table 2.9). The quality of the groundwater is such that the water is unfit for either domestic or livestock consumption. Groundwater within this zone will be affected by in situ leaching operations.
2. Containment zone — the area, in the ore-bearing aquifer, from the perimeter of the mining zone to the nearest monitor well. The perimeter of this zone is defined by a line connecting the monitor wells surrounding the well field. Trend wells may be placed within this zone. At the Irigaray site, groundwater quality in this zone (excluding wells placed in mineralized areas) is generally suitable for drinking water. However, it is anticipated that water quality may be degraded in portions of this zone during solution mining operations.

Because the groundwater in each of these zones is of different quality, each zone will require specific restoration criteria. The groundwater quality can be such that the water will meet standards for either drinking water or livestock watering purposes, or the natural quality may preclude its use for either animal or human consumption. Where the

premining quality of the groundwater meets either drinking water or livestock watering standards, the appropriate established State or Federal criteria will be used to establish maximum permissible chemical concentrations for restoration purposes. If the premining groundwater chemistry exceeds either set of the criteria, the staff believes that a return to within +20% of the baseline concentrations of each toxic element or complex ion would be a reasonable basis for establishing restoration criteria. If there are no applicable criteria, a level should be selected for restoration that is consistent with public health and safety.

The applicant's proposed lixiviant consists of ammonia carbonate/bicarbonate; residual ammonia concentrations will be present. Ammonia is discussed in detail in Sect. 6.3.2.2.

5.1.2 The applicant's restoration demonstration test

As discussed in Sect. 4.2, the 517 test pattern was leached as part of the pilot-scale test program to determine the feasibility of recovering uranium. A restoration demonstration was initiated on a part of the 517 test area in May 1977, and reports have recently been submitted by the applicant.^{4,5}

Average preleaching (Column A) and postleaching groundwater quality (Column B) are shown in Table 5.1. These values were obtained from a single sampling of wells and reflect average concentrations rather than fluid chemistry for any specific well. The applicant used the affected mining zone in the vicinity of well 517-3 (Fig. 5.1) for the restoration demonstration tests. According to the applicant, these tests involved approximately 142 m³ (37,400 gal) of affected groundwater. The applicant's restoration demonstration was designed to provide preliminary evaluation of three restoration techniques: (1) groundwater sweeping, (2) water recycle (use of reverse osmosis unit), and (3) chemical treatment.

Groundwater sweep test

The applicant's groundwater sweep test involved the removal of affected groundwater from a part of the 517 test pattern. A hydraulic fence was used to isolate the restoration test area from the rest of the pattern, which permitted surrounding generally uncontaminated groundwater to flow into the leached zone thereby removing and replacing the affected groundwater. Approximately 1710 m³ (450,000 gal) of groundwater were pumped during this phase of the restoration test. As shown in Table 5.1 (Columns C and D), this operation did lower the concentrations of most radioactive and toxic constituents.

Reverse osmosis unit test

Water removed from the aquifer during the groundwater sweep test [approximately 1710 m³ (450,000 gal)] was conveyed to a pond for storage. This water was used as feed for the testing of the reverse osmosis (RO) unit. At the start of the RO demonstration, natural evaporation had reduced the volume of water in the ponds to approximately 836 m³ (220,000 gal). This water was pumped to a surge tank, the pH was adjusted to 5.5, and the water was then pumped at high pressure to the RO unit. Approximately 670 m³ (176,000 gal) of permeate (clean water) and 170 m³ (44,000 gal) of concentrate were produced during the RO unit test. The performance of the RO unit is shown in Table 5.2, Column B. These results indicate that the unit is capable of producing water suitable for reinjection (recycling) into the aquifer.

Clean water recycle test

The applicant initiated a clean water recycle test in the vicinity of well 517-3 (Fig. 5.1). A small five-spot pattern was drilled with wells 517-3 and 517-6, 3A and 2A, serving as injection wells. Well 6A was used as the recovery well. The ponded permeate from the RO test [approximately 670 m³ (176,000 gal)] was injected via the four perimeter wells and pumped out through the central recovery well. Conductivity of the injected solution was maintained at a low level (650-700 micromhos/cm), and the injection rate was balanced with the recovery rate (8.0-8.5 gpm) during the test. The final levels of analyzed constituents are shown in Table 5.2, Column C. These results indicate that the clean water recycle method can probably reduce levels of the constituents listed, except for ammonia, more efficiently than groundwater sweeping.

Chemical restoration test

Both the groundwater sweep and clean water recycle tests were ineffective in reducing the concentration of residual ammonia. The applicant designed a chemical restoration test to demonstrate the enhanced removal of residual ammonia (NH₄⁺) from the aquifer. This test involved the

Table 5.1. Water quality during restoration testing

Units are ppm except as noted

Constituent	Column A Preleaching groundwater quality ^a	Column B Postleaching groundwater quality ^b	Column C Postleaching groundwater quality — Well 517-3	Column D Groundwater quality after sweep test — Well 517-3	Column E Postrestoration testing of groundwater quality
Ammonia	<1.0	235	180	123	27 (as N)
Arsenic	<0.0025	0.021	0.033	0.017	0.02
Barium	0.12	0.069	0.09	0.03	0.05
Bicarbonate	139	805			0.60
Boron	0.16	0.283	8.3	0.26	0.11
Cadmium	<0.05	0.014	0.30	<0.002	0.002
Calcium			58.5	13.5	37.8
Calcium carbonate	232		616	445	
Carbonate			4.2	4.7	
Chloride	10.75	524	531	229.9	159
Chromium	0.0135	0.002	<0.002	0.004	0.005
Copper	0.019	0.22	0.215	0.041	0.035
Fluoride			2.75	4.10	2.4
Iron			2.15	0.65	0.04
Lead	0.0035	0.110	0.32	0.058	0.015
Magnesium			19.5	5.4	3
Manganese	0.12	0.97	0.784	0.15	0.022
Mercury	0.0028	<0.0002	0.0002	<0.0002	0.0018
Molybdenum			<0.02	0.42	0.12
Nickel	0.018	0.218	1.79	<0.2	0.2
Nitrate			4.92	1.24	0.2
Nitrite			2.76	0.151	
Potassium			8.14	2.9	
Selenium	0.013	1.75	1.02	0.339	0.01
Silicon			5.3	3.3	
Silver	<0.005	0.015	<0.002	<0.005	0.002
Sodium			308	210.8	97
Sulfate			270	233	105
Vanadium			<0.05	0.21	0.33
Zinc	0.003	0.22	0.218	0.02	0.02
Total dissolved solids	793	1324	1302	712	460
pH, standard units			7.94	8.14	9.0
Conductivity, μ mhos/cm			3300	1950	
Uranium	0.098	24.4	18	12.3	<1.0
Ra-226, pCi/liter	26.8 \pm 5.2	371 \pm 5.6	478 \pm 9	105 \pm 10	18.4
Th-230, pCi/liter			640 \pm 21	1.5 \pm 0.9	
Gross alpha, pCi/liter	168 \pm 11	22815 \pm 296	12317 \pm 288	5412 \pm 177	
Gross beta, pCi/liter	164 \pm 19	21043 \pm 441	5374 \pm 115	2052 \pm 85	

^a Average of analyses for a single sampling from five wells at the 517 test site.^b Average of analyses for a single sampling.

Table 5.2. Concentration of selected constituents after completion of restoration demonstration tests

Constituent (ppm)	Initial ^a	Column A Groundwater sweeping	Column B Reverse osmosis ^b		Column C Clean water recycle	Column D Chemical treatment	Column E Residual TDS reduction
			Concentrate	Permeate (clean water)			
Ammonia (NH ₄ ⁺)	180	123	54	3	120	120	35
Chloride (Cl ⁻)	531	230	686	26	160	2800	159
Carbonate (CO ₃ ⁻)	397	267	300	4	40	40	60
Uranium (U ₃ O ₈)	18	12	43	<1	2	1	<1
Conductivity, micromhos/cm	3300	1950	3237	149	1400	9000	880

^aConcentration prior to initiation of restoration tests.^bTest of reverse osmosis unit.

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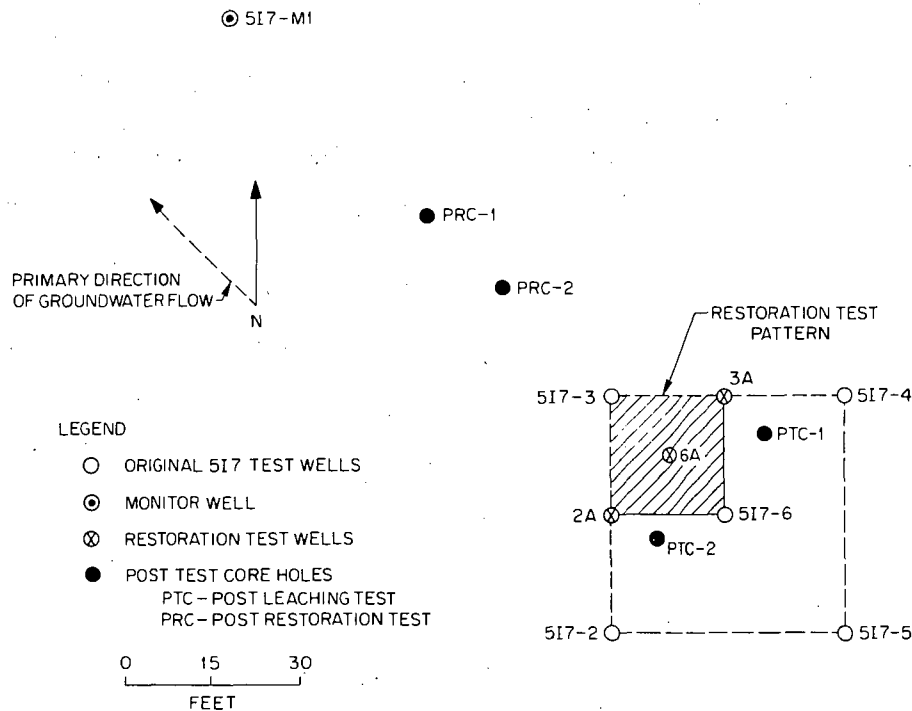


Fig. 5.1. Location of the 517 restoration demonstration well sites.

(1) circulation of a concentrated salt (Ca²⁺, Na⁺, and/or Mg²⁺) solution through the formation to elute the ammonia from clays, and (2) removal of the ammonia from the solution in a surface treatment plant. Test results showed that ammonia was released from the clays as indicated by an initial increase in the concentration of ammonia from less than 120 ppm (Table 5.2, Column C) to 230 ppm in the produced fluid during this phase of the test. After further treatment the chemical restoration test was terminated when ammonia reached the level of 120 ppm, as shown in Table 5.2, Column D.

Residual total dissolved solids (TDS) reduction test

The final method tested by the applicant involved the addition of an RO unit to the well field, water treatment circuit. Groundwater in the test area after the chemical restoration test was recycled through the RO unit. The permeate (clean water) was recycled through the aquifer, and the concentrate was discharged into a waste pond. The resultant groundwater quality after completion of this test is shown in Column E in both Table 5.1 and 5.2. Most constituents have

been reduced to preleaching levels or below accepted criteria, although ammonia (35 ppm) remained well above baseline.

In addition to the above experiments the applicant has conducted similar experimental pilot-scale tests near Bruni, Texas, and Grover, Colorado (ER, Appendix A). In general these restoration demonstration tests also indicate that restoration can be achieved using a combination of the techniques described above. From the various restoration demonstration tests, the applicant has developed a restoration program for the Irigaray site.

5.1.3 The applicant's restoration program

After mining has been completed in a given area, activities will be initiated to return the affected groundwater to the premining quality. The applicant's proposed restoration plan will be implemented on a sequential basis using a water recycle treatment process. Restoration will begin after the first well field has been mined out and the mining operation has moved far enough away so there will be minimal interference between concurrent mining and restoration operations.

Sequential restoration of the groundwater in a well field will be conducted concurrently with ongoing mining activities rather than at the termination of all mining operations. The restoration treatment process will begin on a mined-out unit and will continue until the groundwater in that mined-out unit is restored to its premining quality. This sequence will be repeated as additional units are mined out and new well field areas are brought into production until mining operations are completed.

The restoration treatment will incorporate water removal (groundwater sweeping), water treatment, and reinjection processing steps (Fig. 5.2). When a mining unit has been depleted of uranium and a buffer zone established, restoration will be initiated. The residual leach solution in the mined-out unit, which is usable, will be pumped out and reinjected into a new mining area. Natural groundwater from the new mining area will be pumped back into the mined-out unit. After most of the residual leach solution has been removed, the groundwater will be pumped from the mined-out area, treated, and then reinjected on a continuing basis. Treatment will include running the water through a hardness removal step (cold lime softening) and a reverse osmosis unit for additional removal of various contaminants if required to achieve established restoration water quality criteria. Prior to reinjection of this water into the mined-out aquifer, it will be chemically adjusted by the addition of ions such as calcium or magnesium to enhance the removal of ammonia adsorbed on clays in the mined ore zone before reinjection. This solution will be circulated with ammonia removed at the surface and replaced with an alkaline earth cation. This process will be repeated until the contaminated groundwater in the mined-out unit has reached a selected ammonia level. Then the RO unit will be placed in the circuit and operated until all ions have reached selected levels. The applicant estimates that the withdrawal of at least five pore volumes will be required to reach this point. Modifications in the application of the above restoration techniques may be appropriate as experience is gained to achieve the best overall results.

5.1.4 Wastes from aquifer restoration

5.1.4.1 Liquid waste

The quantity of liquid waste generated by the applicant's proposed aquifer restoration process (Sect. 5.1.3) will depend on the affected aquifer volume and the characteristics of the host rock.

The applicant will mine a maximum of 20 ha (50 acres) under the initial licensing action. This area will be divided into multiple well fields that will be mined and restored separately. The staff estimates, as a worst case, that the entire thickness of the host sandstone will be affected by in situ leaching. The resulting aquifer volume (pore volume) will be approximately $420,000 \text{ m}^3$ (340 acre-ft) for each 4-ha (10-acre) well field area. The applicant estimates that at least five pore volumes [approximately $2 \times 10^6 \text{ m}^3$ (1700 acre-ft)] will have to be cycled through the field to effect restoration. Under the sequential restoration process (Sect. 5.1.3), approximately one pore volume or 20% of the total $2 \times 10^6 \text{ m}^3$ (1700 acre-ft) will be exchanged, with groundwater from a new, unmined, 4-ha (10-acre) area. The other four pore volumes, approximately $1.7 \times 10^6 \text{ m}^3$ (1360 acre-ft), would receive reverse osmosis (RO) treatment and be circulated through the mined-out 4-ha (10-acre) area. Approximately $2.5 \times 10^5 \text{ m}^3$ (205 acre-ft) or 15% of the water receiving RO treatment will be released as a concentrated brine. This wastewater will be discharged to evaporation ponds. The applicant estimates that additional ponding may be necessary for restoration wastes (ER, p. 117).

The waste production rate and required ponding area will be functions of the number of units undergoing restoration and the time required to process the necessary volume of liquid. Assuming a one-year timetable for the treatment and/or circulation of five pore volumes, the staff

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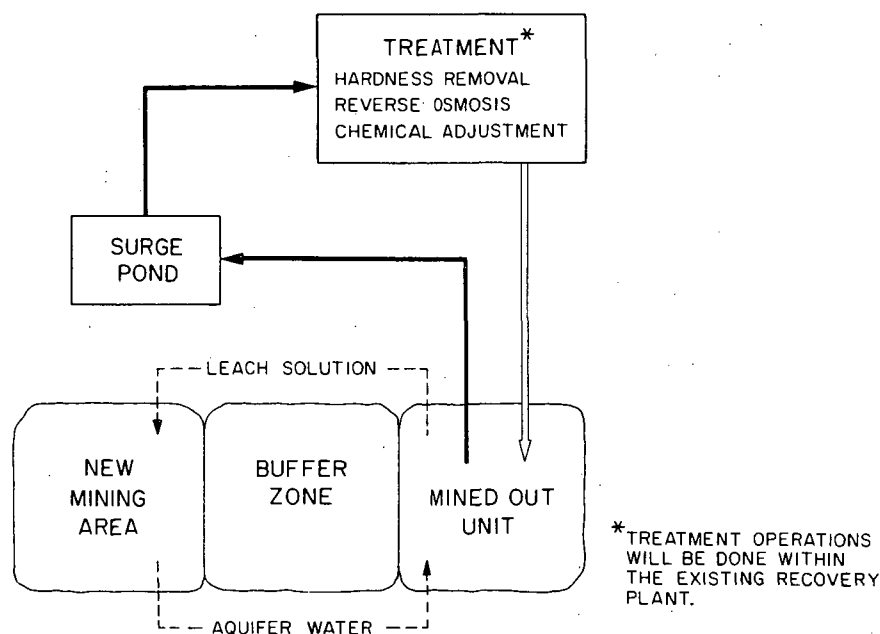


Fig. 5.2. Diagram of applicant's proposed restoration method for the Irigaray project.

estimates the necessary surface area of evaporation ponds to be about 24 ha (58 acres)* per 4-ha (10-acre) area undergoing restoration. A reduced restoration rate would decrease the waste production rate and required pond area. The applicant is presently evaluating potential sites for restoration evaporation pond(s).

The chemical treatment pumping of five times the affected aquifer volume through the mined area will sweep out the major portion of the contaminant chemical species from the mined area. However, various amounts of contaminants may be left in the formation as ions absorbed on clays and sands. Reduction of contaminant concentrations in the water may cause gradual desorption of the ions from the clays and sands back into the water until equilibrium is obtained. This will be checked by postrestoration sampling. Should these concentrations exceed the pre-established water quality criteria, further restoration work would be necessary. This additional work may increase the volume of waste generated by the applicant's proposed restoration process.

5.1.4.2 Solid waste

According to the applicant, the reverse osmosis unit will produce a brine with a dissolved solids content of 15 g/liter (ER, p. 175). The brine will contain primarily salts such as ammonium chloride and sodium sulfate and will have a pH of about 6. The brine will also contain concentrations of radium exceeding 100 pCi/liter and small quantities of uranium, calcium, magnesium, selenium, arsenic, and other trace contaminants. As water evaporates from the brine, these chemicals will precipitate from solution as solid waste. Additionally, some calcite wastes will also be produced by the lime water-softening process.

The staff estimates that the maximum quantity of solid wastes resulting from the evaporated brine during restoration of a 4-ha (10-acre) mining area will be approximately 4200 tons. However, the applicant also reports a TDS of 1324 ppm in the prerestoration mine water at the 517 test site (Table 6.1). If these solids were concentrated in 15% of the original liquid volume, the TDS content would be 9 g/liter, which would result in about 3000 tons of solid waste. In addition, the TDS content of the groundwater that is being restored will decrease during restoration activities. Therefore, the final quantity of solid wastes should be less than 3000 tons. The quantity of solid waste will be dependent on the amount of liquid waste. Any increase in liquid waste volume will result in an increase in solid waste.

Disposal of restoration solid waste will be accomplished as described in Sect. 4.6.4.

* Assumes a net evaporation rate of 1.1 m (42 in.) per year.

5.1.5 Staff recommendations.

The applicant has demonstrated that the various proposed restoration techniques can be used to reduce the concentrations of radioactive and toxic constituents in affected groundwater. There are, however, two areas which need further evaluation to determine the applicability of the applicant's proposed techniques for production-scale mining. First, the use of reverse osmosis units for industrial wastes is in a developmental stage.⁶ The effectiveness and practicality of this unit on a large-scale restoration operation need to be established. Secondly, a primary area of concern is the potential environmental impact of ammonia. The remaining concentration of ammonia after completion of restoration by the applicant may result in ammonia migration and/or its possible conversion to nitrate and nitrite which will migrate.

The ammonia problem is present only with the use of an ammonium bicarbonate leach solution. The applicant proposes to restore the groundwater to an ammonia concentration of 20-50 ppm.⁷ No present standard exists for ammonia concentration in groundwater. The staff recognizes that the proposed level of ammonia left in the groundwater may be controversial and that the applicant will be required to meet any ammonia standard promulgated later.

Currently, the applicant is examining alternative alkaline leach solutions for future use at the Irigaray site (ER, p. 107, ref. 7). Until the ammonia problem is resolved or alternative lixivants are developed, the staff proposes that limitations be placed on the use of ammonium bicarbonate leach solution by the applicant.

The applicant's proposed recovery plant will have an annual production of about 500,000 lbs of yellowcake. The staff estimates that this amount will require an annual well field area (production unit) of up to 4 ha (10 acres) to maintain the anticipated production over the five-year duration of the requested license; thus, a maximum well field of 20 ha (50 acres) would be required. The staff proposes to limit the mining of not more than 20 ha (50 acres) with an ammonium carbonate-bicarbonate lixiviant, which will allow multiple production units to be developed while production-scale restoration can be demonstrated. Accordingly, the following license conditions are proposed:

1. The use of an ammonium bicarbonate lixiviant will be limited to a maximum well field area of 20 ha (50 acres). This area will include the well field used for the 100 gpm pilot-scale test.
2. Restoration of the first production well field must be initiated upon completion of mining of the unit. This production unit should be sufficiently isolated from any further operating well field within the 20-ha (50 acre) area to ensure that restoration operations will not be compromised by ongoing activities.
3. Restoration of at least the first production well field must be completed prior to mining any area beyond the maximum 20 ha (50 acres) with an ammonium bicarbonate lixiviant.
4. The applicant must provide a plan that reflects these restoration requirements.

The staff recognizes the potential of a small risk from the residual ammonia. However a search of the literature by the staff indicates no significant risk to mammals from ingestion of water containing this concentration of ammonia (see Sect. 6.3.2.2). The ammonia is expected to be relatively immobile in the aquifer and remain within the mining zone. The possible conversion of this ammonia to nitrate (water quality standard of 10 ppm) appears unlikely under expected anaerobic conditions. These aspects are discussed in detail in Sect. 6.3.2.2.

The staff concludes that with the above restrictions the risk of leaving a small region of contaminated groundwater is more than offset by opportunity to (1) continue development of a new uranium mining technology that appears to offer significant environmental advantages over conventional mining methods and (2) develop and improve restoration techniques for solution mining on a production scale. This conclusion is reinforced by the much smaller surface impacts of solution mining compared with conventional uranium mining and milling methods.

5.2 DECOMMISSIONING

After completion of mining and groundwater restoration, all surface equipment (pipelines, tanks, etc.) will be disassembled and removed, and the plant building will be decommissioned. However, if the surface owner requests use of a structure as a ranch building after mining, the decontaminated structure will remain, pending regulatory approval. All wells will be sealed and plugged with concrete to within approximately 1 m (3 ft) of the surface. The casing will be cut off flush with the plug, leaving a hole about 1 m (3 ft) deep that will be backfilled with adjacent surface material. All waste and evaporation ponds will ultimately be filled, graded, spread with topsoil, and revegetated.

5.3 SURFACE RECLAMATION

All land disturbed by WMC activities will be reclaimed and revegetated. The reclamation plan has been tailored to the WMC site based on results of site-specific studies of soils and vegetation at the mining area. The studies were conducted in collaboration with the Wyoming Powder River Conservation District. The postmining land-use goal of the reclamation plan is to return the affected land to a productivity capable of supporting livestock grazing and to provide stable habitats for both game and nongame wildlife. To this end, only native species of proven range value have been chosen for revegetation. Wherever excavation is required, as for waste ponds, topsoil will be removed to the appropriate depth (based on Conservation District recommendations), properly marked as "topsoil," and placed in storage protected from wind and water erosion. Details of the reclamation plan, as described in the WMC mining plan,⁸ follow.

Initial surface preparation for seeding will be accomplished with a conventional disc harrow, and specific soil amendments, determined by tests of soil quality, will be added. Planting of seeds will be by drill. To enhance spring germination and survival, planting will be done in fall, after the cessation of warm weather but before freezing (generally October 1-15). Nine species of native grasses and five species of native shrubs have been selected for revegetation on the basis of palatability to livestock, suitability for wildlife habitat, drought resistance, and applicability to the WMC site. Table 5.3 details the species, seeding rate, and application methods to be used.

Table 5.3. Application rate and method of introduction of plant species for revegetation of Irigaray mine site

Species	Pounds of pure, live seed per acre	Plants per acre	Application method
Grasses			
Western wheatgrass (<i>Agropyron smithii</i>)	3.6		Drilling
Slender wheatgrass (<i>Agropyron trachycaulum</i>)	1.8		Drilling
Thickspike wheatgrass (<i>Agropyron dasystachyum</i>)	1.8		Drilling
Bluebush wheatgrass (<i>Agropyron spicatum</i>)	1.8		Drilling
Blue gramma (<i>Bouteloua gracilis</i>)	3.6		Drilling
Prairie sand-reed (<i>Calamovilfa longifolia</i>)	1.2		Drilling
Sand dropseed (<i>Sporobolus cryptandrus</i>)	1.2		Drilling
Green needle grass (<i>Stipa viridula</i>)	1.8		Drilling
Indian rice grass (<i>Oryzopsis hymenoides</i>)	1.2		Drilling
Shrubs			
Big sagebrush (<i>Artemisia tridentata</i>)		90	Direct planting on uplands
Silver sage (<i>Artemisia cana</i>)		60	Direct planting in draws
Four-winged saltbush (<i>Atriplex canescens</i>)	2.0		Drilling
Winterfat (<i>Eurotia</i>) (<i>Ceratoides lanata</i>)	1.0		Drilling
Rubber rabbitbrush (<i>Chrysothamnus nauseosus</i>)		60	Direct planting
Skunkbrush (<i>Rhus trilobata</i>)		60	Direct planting in draws
Total	21	270	

Source: Wyoming Mineral Corporation, Application for In Situ Permit to Mine for the Irigaray Site, submitted to the Wyoming Department of Environmental Quality, Land Quality Division, April 1978.

Because of their importance as food and cover for a variety of wildlife species, successful reestablishment of shrubs is a major goal of the reclamation plan. Direct planting of shrub seedlings with well-developed root systems will ensure their successful reestablishment, because such seedlings can better withstand grazing pressure and competition from grasses.

Approximately 2 tons per acre of natural prairie hay will be distributed over the reseeded area as mulch in an effort to prevent the introduction of agricultural crop and weed species into the reseeded areas. The mulch will be forced 1 to 2 in. into the surface with a hay crimper. Shrub seedlings will be planted following mulching.

Fences will be maintained around revegetated areas for at least two and perhaps three growing seasons. If consistent with the landowner's wishes, early grazing of the revegetated areas will be intermittent to reduce the initial impact. Irrigation of the reclaimed areas is planned only in case of drought conditions. Progress of the revegetation program will be included in the annual reports to the Wyoming Department of Environmental Quality.

The general restoration and reclamation timetable assumes that restoration of groundwater will occur one year after mining has ceased. Surface reclamation will begin approximately one year after restoration activities have been completed. A total of approximately 29 ha (70 acres) will be directly affected by the initial mining activities and will be revegetated over a 4-year period following completion of aquifer restoration. Peripheral areas, including ponds and plant facilities, will be revegetated over a 4-year period following completion of all activities. It is estimated that all land disturbed in connection with the initial mining activities will have been reclaimed and revegetated by 1990.

REFERENCES FOR SECTION 5

1. Discussions with Texas Water Quality Board personnel (now Texas Department of Water Resources), Austin, Texas, Jan. 17, 1977, and subsequent discussions with other offices.
2. L. G. McMillion, "Groundwater Reclamation by Selective Pumping," *Trans. AIME* 250: 11-15 (March 1971).
3. W. C. Larson, *The State of the Art of In Situ Leach Mining, FY 77*, prepared by Twin Cities Mining Research Center for the United States Department of the Interior, Bureau of Mines.
4. Wyoming Mineral Corporation, "Irigaray Restoration Demonstration Program, Final Report," Lakewood, Colo., Mar. 13, 1978.
5. Wyoming Mineral Corporation, "Irigaray Restoration Data Package," Lakewood, Colo., March 1978.
6. E. B. Besselievre and Max Schwartz, *The Treatment of Industrial Wastes*, 2d ed., McGraw Hill, New York, 1976, pp. 175-177.
7. K. R. Schendel, Wyoming Mineral Corporation, attachment to letter to L. C. Rouse, Nuclear Regulatory Commission, March 20, 1978, Docket No. 40-8502.
8. Wyoming Mineral Corporation, Application for In Situ Permit to Mine for the Irigaray Site, submitted to the State of Wyoming Department of Environmental Quality, Land Quality Division, April, 1978 (revised June 23, 1978).

6. ENVIRONMENTAL IMPACTS

Environmental impacts from a solution mining operation will result from both construction and operational activities. An attempt has been made to separate these two activities in the following discussions. In most cases, doing so proved difficult because development (construction) of some well fields will be concurrent with production (operation) from other well fields. The impacts from these activities are also quite similar. Therefore, assessment of many impacts associated with solution mining includes the combined effects of construction and operational activities.

Solution mining (in situ leaching) of uranium is a relatively new and developing technology. Operating experience as well as information on the subsurface environment is currently limited. Consequently, conservative assumptions and "worst case" examples have been used to assess many of the environmental impacts. Therefore, the magnitude of such impacts may be considerably smaller than those determined in this Statement.

6.1 IMPACTS ON AIR QUALITY

The proposed project could affect air quality near the WMC site by the formation of fugitive dust, the release of diesel emissions from drilling and construction equipment, and the release of atmospheric emissions from the recovery facility and waste ponds. Diesel emissions will be minor, of short duration, and should be readily dispersed.

Dust will be generated as a result of construction and drilling activities in connection with well field development. During project operation, disturbed areas on the roads and well fields will continue to be a source of fugitive dust. Wyoming's air quality regulations require that dust control measures be implemented for all potential sources of dust.¹ Adequate dust control measures, such as application of oil or water to graveled roads, wetting of exposed soil on well fields, and reseeded and stabilizing disturbed land, should minimize dust emissions. Localized degradation of air quality resulting from dust could occasionally occur at the WMC site on windy days, possibly causing the concentration of suspended particulates to exceed the State standard of $150 \mu\text{g}/\text{m}^3$ (24-hr maximum). Other than such occasional, localized episodes, fugitive dust from WMC activities should not significantly affect air quality.

Air quality at the site and environs could be affected during operation of the proposed project by atmospheric releases from the recovery facility and from the waste storage and treatment ponds. Nonradioactive emissions from the recovery facility will include combustion products from the propane-fueled project drying unit and volatilized solution residuals (primarily ammonia). Ammonia and ammonium chloride will be released from the ponds.

Nonradiological atmospheric releases from the combustion of propane will consist of hydrocarbons, nitrogen oxides, carbon monoxide, sulfur oxides, and particulates. The dryer has a relatively small capacity (1,000,000 Btu). Thus release of pollutants from combustion should be insignificant, and State and Federal ambient air quality standards for these pollutants (Sect. 2.6) are unlikely to be exceeded.

Estimated releases of ammonia vapors and ammonium chloride particulates from the recovery facility and waste ponds are detailed in Table 4.5. Particulate ammonium chloride formed over waste ponds should rapidly precipitate in the immediate vicinity of the ponds and should have no effect on air quality. Ammonium chloride particulates from the recovery facility should likewise not affect air quality beyond the immediate vicinity of the facility. An estimate of atmospheric ammonia concentrations resulting from release of ammonia vapors from the facility and ponds has been made using an atmospheric dispersion model. Atmospheric dilution factors were obtained using wind and stability data from Casper. Although the ponds and recovery facility will actually act as scattered and rather diffuse sources of ammonia, the model assumes all ponds to be one ground-level point source and, therefore, should result in conservative estimates of maximum ambient ammonia concentrations.

Maximum ammonia emissions from the ponds and recovery facility could total 12,500 kg (27,500 lb) of ammonia annually, or 0.4 g/sec. Using the point-source dispersion model, estimated maximum concentrations of ambient atmospheric ammonia could be $75 \mu\text{g}/\text{m}^3$ at 100 m (328 ft) from the ponds and facility. At 500 m (1640 ft) from the ponds and recovery facility, maximum ammonia concentrations should be about $5 \mu\text{g}/\text{m}^3$. By comparison, the recommended occupational threshold limiting value (TLV) for ammonia is $35,000 \mu\text{g}/\text{m}^3$ (ref. 2), and the threshold for ammonia odor is $37,000 \mu\text{g}/\text{m}^3$ (ref. 3). The lowest atmospheric concentration of ammonia known to affect vegetation is $1000 \mu\text{g}/\text{m}^3$, which produced effects on photosynthesis.⁴ There are no Federal or State ambient standards for atmospheric ammonia. Because anticipated ammonia concentrations in the vicinity of the ponds ($75 \mu\text{g}/\text{m}^3$ at 100 m) are over an order of magnitude below levels that affect vegetation and well over two orders of magnitude below the TLV, they should not have a significant effect on air quality.

6.2 IMPACTS ON LAND USE

Contact with the Johnson County Planning Office indicated that the project is compatible with the county-wide land use plan (Jerry Kuhaida, Oak Ridge National Laboratory, telephone communication, to Kenneth Gross, Johnson County Planning Office, August 11, 1978).

6.2.1 Grazing

Grazing will be restricted on the project area proper. A total of approximately 400 ha (1000 acres) may be involved over the life of the project. Approximately 24 ha (60 acres) of land will be removed from grazing during the limited 20-ha (50-acre) well field operation. This land has an average grazing capacity of 3.5 ha (9 acres) per animal unit month. Therefore a total of seven animal unit months will be removed from use, a loss of grazing capacity that would support about five cows per year. With successful reclamation (Sect. 5.2), this grazing land could be returned to its original capacity.

6.2.2 Transportation

The applicant estimates that about 80 km (50 miles) of roads will be constructed or improved to serve the WMC site over the life of the project (ER, p. 118). These could improve access for the local ranchers to parts of their properties. The relatively small increase in traffic associated with the WMC project should not adversely affect neighboring ranching activities.

6.2.3 Recreation

Hunting will be restricted on the WMC site, which will result in the removal of an area of about 25 km^2 (10 sq miles) from hunting. The abundance of excellent hunting area available in the region leads to the conclusion that this removal should not result in a significant impact.

6.2.4 Impacts on historic, archaeologic, and natural landmark sites

Fort Reno and Cantonment Reno are the only sites located in the vicinity of the WMC site that are listed in the National Register of Historic Places (Sect. 2.5.2). These two sites are over 8 km (5 miles) from the project boundaries and should not be affected by project activities. The Portuguese Houses site, which has been determined as eligible for inclusion in the Register, is also over 8 km (5 miles) from the WMC site and should not be affected by the proposed project. The Hoe Ranch, a site of some historic value that has not currently been determined as eligible for inclusion in the National Register, is within the boundaries of the WMC site. The ranch ruins, however, are not within the area to be mined and thus should not be impacted by project activities. The Wyoming State Historic Preservation Officer (SHPO) has been contacted regarding potential conflicts of WMC activities with State and local historic resources. Clearance for the project has been given (Appendix F).

An archaeological survey conducted by the Office of the State Archaeologist did not find archaeological resources in the area of the WMC site to be affected by mining (Appendix F). If any suspected archaeologic sites are discovered during project development, the office of the Wyoming State Archaeologist will be contacted before any disturbance of the site would occur. If future mining plans call for disturbance of a portion of the site not included in the previous archaeological survey, another survey will be conducted before activities on that area commence.

No natural landmarks exist in the region of the WMC site.

6.3 WATER

6.3.1 Surface water

6.3.1.1 Impacts of construction

Impacts to aquatic systems from WMC construction activities will derive primarily from the release of sediments, oil, and grease. Land clearing during construction will increase the rates of erosion and discharge of sediments. WMC used the Universal Soil Loss Equation to predict that, with the disturbance of 40 ha (100 acres) at any one time, soil loss will increase from the normal 14 tons per year to 20 tons per year (ER, p. 118). U.S. Geological Survey data (1972-74) for the Powder River at Arvada indicate that the existing load of sediments has varied from 4.4 tons per day to 83,700 tons per day, with an average of 9285 tons per day. Apparently, even if WMC's estimate of increased erosion were low by a factor of 10, the increased sediment released by WMC activity would constitute a negligible addition to the Powder River.

Most of WMC's activities should have a small or negligible impact on Willow Creek. In addition to erosion, land clearing can cause more rapid runoff to occur during rainstorms, which can accelerate scouring and erosion of stream channels. The discharge of eroded sediments and oil and grease from heavy equipment and drilling rigs could affect any biota inhabiting Willow Creek or the pools in its normally dry streambed. However, WMC's operation will disturb only 2% of the Willow Creek drainage area (400 ha out of 25,000 ha, or 1000 acres out of 96 sq miles). Therefore, the majority of WMC's activities should produce only minor localized impacts on Willow Creek.

WMC plans to conduct solution mining in the streambed of Willow Creek, and this activity has the greatest potential for adverse impact. WMC is currently developing engineering designs and methods to (1) protect pipes and equipment in the streambed from flooding and (2) prevent adverse impacts to downstream water quality.

According to WMC's mining plan operations in the streambed are scheduled to begin in 1982, and protective measures will be adopted prior to these operations. WMC has proposed several modifications of its operation for activity in the Willow Creek streambed.⁵ These modifications include installing wells at a dry season and constructing temporary dikes while mining is in progress to contain any spills. WMC has also indicated that a temporary diversion of the Willow Creek channel might be constructed. Because such a channel modification could cause erosion problems and long-term disturbance of the stream, NRC will review WMC's proposed control and mitigation measures prior to initiation of operations in this sensitive area.

If extensive placement of fill in the streambed is proposed, WMC may be required to secure a permit under Section 404(b) of the Federal Water Pollution Control Act Amendments from the U.S. Corps of Engineers. Information is required regarding the impact of dredged or fill materials on the aquatic environment, including potential effects on food chains, benthic organisms, and potential fish spawning areas. Section 8.1.5.3 indicates NRC staff recommendations concerning a baseline survey of the aquatic environment of Willow Creek. It is the responsibility of WMC to determine any additional monitoring that may be necessary to satisfy Section 404(b) permit requirements after consultation with the U.S. Army Corps of Engineers. Compliance with these requirements will be included in the NRC's review of the applicant's plans for Willow Creek.

6.3.1.2 Impacts from operations

WMC's project operations are designed to produce no discharge to surface waters. Under normal operating conditions, there should be no impact on surface waters. There is, however, a potential for accidental release of contaminated fluids, which is discussed in Sect. 7.1. In addition, normal well field operating conditions will result in localized groundwater contamination.

As the contaminated groundwater migrates through the aquifer, contaminating substances can be differentially adsorbed to clays and other materials. Presently, however, it is not possible to predict which constituents would be removed from the contaminated water movement through the aquifer. In addition to removal of contaminants by adsorption, the contaminated groundwater would also be diluted to some unknown extent by uncontaminated groundwater.

Due to the distance to the Powder River, contaminated groundwater from the initial 20-ha (50-acre) mining area would cause relatively minor adverse impacts to surface waters. Furthermore, the program of monitoring groundwater (Sect. 8.2.3) should reduce the probability of an uncontrolled excursion to a low level, and restoration should return any affected groundwater to its premining quality. These observations suggest that WMC can conduct solution mining with a low risk of adverse effects on the Powder River. Nevertheless, because knowledge of excursions and restoration is incomplete, a precautionary program for obtaining baseline water quality data for the Powder River is specified in Sect. 8.1.5.1.

6.3.2 Impacts on groundwater

6.3.2.1 Consumption

Maximum pumpage from the Wasatch Formation as a result of mining and restoration of 20 ha (50 acres) of well fields will be about 1000 acre-ft. This withdrawal of groundwater will occur over an extended period, and the impact of this pumpage is difficult to determine because of the limited available data on groundwater in the area and because of the complex geology (Sect. 2.7.1.2). Potential impacts, however, could include (1) temporary lowering of water levels in wells that are completed in the ore zone aquifer in the immediate vicinity of the well fields and (2) the lowering of water levels in wells completed in the alluvium overlying the Wasatch Formation, if leakage from the alluvium into the Wasatch Formation occurs as a result of pumping. The occurrence of these potential impacts should be readily identified by the applicant's monitoring of water levels.

6.3.2.2 Groundwater quality

Local groundwater quality will be lowered by in situ leaching of uranium. Potential groundwater quality impacts from the applicant's proposed operations are associated with (1) waste disposal ponds, (2) accidental leaks or spills of toxic liquids, (3) uncontrolled excursions, and (4) improper or incomplete groundwater restoration. The Upper Irigaray Sandstone will be the primary aquifer affected by in situ leaching. However, contaminated groundwater could also enter shallower and deeper aquifers in certain areas — especially from upward movement in the vicinity of the Powder River (see Sect. 2.6.2.2). Each of these potential impacts will be discussed below.

Waste disposal ponds

Liquid and solid wastes will be stored temporarily in polyethylene-lined ponds. Failure of the pond liners would permit some of the liquid wastes to seep into the ground. At the Irigaray site, this is expected to have an insignificant impact because of dry strata beneath the ponds. This type of accident is discussed in Sect. 7.2.1.

Leaks or spills

Accidental leaks or spills of toxic liquids could potentially infiltrate shallow aquifers and locally reduce groundwater quality. Accidental leaks and spills would probably not be of a sufficient volume to degrade significantly near-surface groundwater quality (see Sect. 7.1).

Excursions

Excursions of contaminated groundwater from the well field aquifer are possible because of large variations in aquifer permeability, less than optimal well spacings, and low pumping rates. The magnitude of an excursion and the degree to which the contaminants become attenuated once they have passed beyond the influence of the pumping well field is the primary and most difficult operational impact to predict at the Irigaray site. Consequently, worst case examples are used, and the magnitude of such impacts may be considerably less.

Initial concentrations of ammonia, bicarbonate, and hydrogen peroxide in the leach solution will range from 300-1500 ppm of ammonia, 1000-5000 ppm of bicarbonate, and 250-1000 ppm of hydrogen peroxide. As the leach solution circulates through the aquifer, many elements in addition to uranium will be oxidized and dissolved. Table 6.1 compares premining groundwater quality to postmining groundwater quality at the Irigaray 517 test site (see Figs. 1.2 and 4.2 for location). This leaching test consisted of four injection wells surrounding one recovery well and was conducted for 107 days. Longer periods of leaching over a much larger area could possibly result in higher concentrations of toxic substances in the groundwater. These concentrations, however, will depend on the initial concentrations of toxic substances in the ore zone and the extent to which they are mobilized by in situ leaching.

Elements associated with the ore zone: Uranium, arsenic, selenium, vanadium, and molybdenum were originally transported into the ore zone as complex anions in oxidizing groundwater having a slightly alkaline pH. The anions remained mobile until the oxidation potential (Eh) was reduced. This condition occurred at the Irigaray site and uranium, arsenic, selenium, vanadium, and molybdenum precipitated out of solution as relatively insoluble oxides (U, V), silicates (U, V), or native elements (As, Se). The molybdenum concentration was too low to form any minerals. During in situ leaching, these elements are expected to be remobilized by a similar, although more reactive, geochemical environment. In the event of an excursion, they will remain mobile as long as the groundwater remains oxidized.

Table 6.1. Comparison of premining groundwater and prerestoration groundwater quality, Irigaray test site 517

Analysis	Premining groundwater quality	Prerestoration production zone values
	(ppm)	(ppm)
As	< 0.0025	0.021
Ba	0.12	0.069
B	0.16	0.283
Cd	< 0.005	0.014
Cr	0.0135	0.002
Cu	0.019	0.220
Mn	0.12	0.97
Hg	0.0028	< 0.0002
Ni	0.018	0.218
Se	0.013	1.75
Ag	< 0.005	0.015
Zn	0.003	0.22
Pb	0.0035	0.110
U ₃ O ₈	0.098	24.4
NH ₃	< 1.0	235
Cl ⁻	10.75	524
	(mg/liter)	(mg/liter)
HCO ₃	139	805
Total dissolved solids	793	1,324
	(pCi/liter)	(pCi/liter)
Gross α	168 \pm 11	22,815 \pm 296
Gross β	164 \pm 19	21,043 \pm 441
Ra-226	26.8 \pm 5.2	371 \pm 5.6

Source: ER, p. 168.

Uranium occurs in the ore zone as the minerals uraninite and coffinite. During in situ leaching, uranium will be transported in solution as the uranyl dicarbonate complex $[\text{UO}_2(\text{CO}_3)_2 \cdot 2\text{H}_2\text{O}]^{2-}$. In the event of an excursion, uranium will remain mobile until the Eh is sufficiently lowered, at which time UO_2 (uraninite) or USiO_4 (coffinite) will begin to precipitate out of solution.

Arsenic occurs in the ore zone as either native arsenic or possibly arsenide minerals. During in situ leaching, arsenic will be transported in solution as the anion AsO_4^{3-} . In the event of an excursion, arsenic will be deposited as native arsenic if there is a decrease in the Eh.

Selenium occurs in the ore zone as native selenium and possibly as ferroselite. During in situ leaching, selenium will be transported in solution as the anion SeO_3^{2-} . In the event of an excursion, selenium will be deposited as native selenium or FeSe_2 (ferroselite), if the Eh is lowered at some distance from the well field.

Molybdenum occurs in the ore zone in very small concentrations. During in situ leaching, molybdenum will probably be carried in solution as the anion MoO_4^{2-} .

Substances injected into the aquifer: The concentrations of ammonia, bicarbonate, and chloride increase significantly in postmining groundwater at the Irigaray test site 517 (Table 6.1). Although chloride is not an essential part of the leach solution, large concentrations are injected into the aquifer as a result of elution of the ion-exchange resin.

The concentration of un-ionized ammonia (NH_3) and ammonium ion (NH_4^+) in the well field groundwater will equilibrate according to the pH. In general, the higher the pH, the more un-ionized ammonia will be present.⁶

At the surface and near-surface environment, with oxygen present, ammonia can be converted to nitrate and nitrite by bacteria. Some of the appropriate bacteria could conceivably be incorporated into the leach solution and then injected into the well field aquifer. Whether these bacteria, which normally thrive in acidic soils, would survive in the alkaline groundwater environment at the site is not known.

Other elements: Increases in the concentration of other elements in the groundwater as shown on Table 6.1 result from changes in the geochemical environment induced by in situ leaching.

Elements such as manganese, iron, and small amounts of boron occur in the ore zone in a variety of detrital heavy and authigenic minerals. Other elements which show increased concentrations in the groundwater (Table 6.1), such as cadmium, copper, nickel, silver, zinc, and lead, are not associated with any identifiable minerals. These elements probably occur at concentrations of less than a few parts per million within the rock and show no relationship to uranium mineralization.

Table 6.2 summarizes information regarding water quality criteria and toxicity for many of the constituents that might be released during an excursion. Criteria and standards for irrigation water, drinking water, and aquatic life, and the Wyoming Department of Environmental Quality criteria for wildlife and livestock are also included in Table 6.2. Two indications of toxicity of trace elements to aquatic organisms are derived from a data base assembled by Cushman et al.⁷

In general, the size, shape, and concentration of an excursion will depend on the following variables:

1. the effectiveness of pumping to confine and then remove these contaminants from the groundwater;
2. the direction of groundwater flow;
3. how mobile and physically and chemically reactive each substance is;
4. the geochemical characteristics of the aquifer, such as its capacity to dilute, disperse, and diffuse contaminants, and the adsorptive and ion exchange capacity of minerals in the aquifer;
5. the physical characteristics of the aquifer such as abrupt changes in permeability and porosity; and
6. how quickly the applicant detects the excursion and the methods that are used to remove these contaminants from the groundwater.

At the Irigaray site, hydrologic and lithologic characteristics of the aquifer are not known well enough to predict, and along what specific layers, the contaminants might travel. There is a possibility that fractures are present in the upper Irigaray sandstone. As reported by Grisak and Cherry,⁸ groundwater velocities in fractured rock (or channelized sands) can be orders of magnitude greater.

The shape of an excursion can be quite variable, as indicated by Legrade.⁹ Little is known, however, about the three dimensional shape of an excursion. The concentration of a continuous excursion will usually decrease with increasing distance from a well field until a quasi-equilibrium is reached between contaminants added to the excursion from leaching, and attenuation of the contaminants at the periphery of the excursion by physical and chemical mechanisms. At this point, the contaminated zone would remain somewhat stationary, although individual contaminants such as selenium, chloride, uranium, etc., would establish their own quasi-equilibrium at some unknown distance within the excursion. At the Irigaray site, however, a continuous excursion is not anticipated. Contaminants in the groundwater would therefore be expected to attenuate more rapidly as they travel down the hydraulic gradient toward the Powder River — about 5.6 km (3.5 miles) away. Furthermore, because normal well field production should remove some percentage of the mobilized ore-associated contaminants, concentrations of these elements in successive excursions would be expected to decrease.

Cations and ammonia are less mobile than the anions because of their tendency for the cations to be absorbed onto clays, especially montmorillonite. However, the distance each ion will travel during an excursion is not known. In situ leaching for uranium is a new and evolving technology. Past experience cannot always be used to predict future groundwater contamination problems because of the site-specific nature of these operations. Based on the preceding qualitative analysis, the staff concludes that some contaminants could potentially enter the Powder River through groundwater recharge. The concentration of these contaminants upon entering the Powder River, however, would probably be very low. The monitoring program for groundwater should ensure that any impacts from excursions will be minimal (Section 8.2.3).

Restoration

Groundwater restoration will include the following cycle: (1) groundwater removal, (2) treatment of the groundwater to remove contaminants, and (3) reinjection of the treated groundwater (see Sect. 5.1.3). Should restoration be incomplete for any mobilized constituents, groundwater quality will be degraded. As mentioned in Sect. 5.1.4, the use of an ammonium carbonate/bicarbonate leach solution may result in significant residual ammonia concentrations after restoration.

Table 6.2. Water quality criteria and toxic concentrations for potential contaminants from solution mining

All units in mg/liter, unless indicated otherwise

Parameter	Wyoming DEQ water quality criteria for wildlife and livestock ^a	NAS criteria for irrigation water ^b	Recommended limit for protection of aquatic life	Drinking water standard	Toxic concentrations ^c	
					Mean toxic concentration ^d	Lowest toxic concentration ^e
NH ₃ ^f			0.02 ^{b,g} (for un-ionized ammonia)	0.5 ^h		
Cl ⁻	2000			250 ^{i,j}		
SO ₄	3000			250 ^{i,j}		
Ag ⁻				0.05 ^{i,k}		
Al	5.0		5.0		18.9	0.07
As	0.2	0.1		0.05 ^{i,k}	13.6	0.022
B	0.5	0.75			900	0.69
Ba				1.0 ^{i,k}	1080	8.0
Cd	0.05		0.003–0.03 ^{b,g} 0.001–0.012 ^g (for hard water)	0.01 ^{i,k}	7.4	0.0009
Co		0.05			21	0.021
Cr	1.0	0.1	0.05 ^b –0.1 ^g	0.05 ^{i,k}	80.7	0.008
Cu	0.5	0.2		1.0 ⁱ	1.6	0.006
Fe		5.0	1.0 ^g	0.3 ^j	1235	0.02
Hg	0.01		0.05 ^g	0.002 ^k	0.2	0.003
Mn		0.2		0.05 ⁱ	2259	17
Mo		0.01			147	47
Ni		0.20		1.0 ^l	13.0	0.05
Pb	0.1	5.0	0.03 ^b	0.05 ^k	69.8	0.007
Se	0.05	0.02		0.01 ^k	11.2	1.0
U					36.2	1.7
V		0.1			27.3	4.8
Zn	25	2.0		5 ^j	7.9	0.0001
F	2.0	1.0		0.7–1.2 ⁱ		
Total dissolved solids	5000			500 ^{i,j}		
pH	6–9			6.5–8.5 ^j		
Ra-226, pCi/liter				5.0 ^j		
Gross α, pCi/liter				15.0 ^j		
Gross β, pCi/liter				1000.0 ⁱ		

^aData obtained from Wyoming Department of Environmental Quality, Land Quality Division, Guideline No. 4 (Revised), Nov. 9, 1976, p. 3-41.

^bData obtained from National Academy of Sciences, Environmental Studies Board, *Water Quality Criteria* 1972, EPA/R3/73-033, March 1973.

^cR. M. Cushman, S. G. Hildebrand, R. H. Strand, and R. Anderson, *The Toxicity of 35 Trace Elements in Coal to Freshwater Biota: A Data Base with Automatic Retrieval Capabilities*, Report ORNL/TM-5793, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1977.

^dMean of all concentrations (ppm) found to be lethal to fish in experiments lasting 96 hr or longer.

^eLowest concentration (ppm) found to be lethal to any aquatic organism.

^fThe toxicity of ammonia is discussed in detail in the text.

^gData obtained from U.S. Environmental Protection Agency, *Quality Criteria for Water*, EPA-440/9-76-023, 1976.

^hData obtained from World Health Organization, *European Standards for Drinking Water*, Geneva, Switzerland, 1961.

ⁱData obtained from U.S. Public Health Service, *Drinking Water Standards*, PHS Publication 956, 1962.

^jData obtained from "Proposed National Secondary Drinking Water Standards," *Fed. Regist.* 42(62): 17143-17147 (March 31, 1977).

^kData obtained from "National Interim Primary Drinking Water Regulations," *Fed. Regist.* 40(24B): 59566-59577 (Dec. 24, 1975).

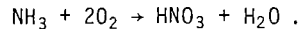
^lData obtained from T. Kirkor "Protecting public waters from pollution in the USSR" *Sewage Ind. Wastes*, 23(7): 938-940 (1951).

After WMC's mining operation, ammonia will be present in the Upper Irigaray Sandstone (UISS) in at least two states: (1) in solution and (2) adsorbed on clays and other minerals which form the aquifer. Restoration will remove ammonia from the groundwater; this will alter the equilibrium and cause some ammonia to be desorbed from bonding sites in minerals and clays. However, ammonia adsorbs tightly to clays, and WMC's restoration tests indicate that the desorption of ammonia proceeds slowly. Table 5.2, which shows the decline of ammonia during WMC's restoration tests, indicates that the rate of desorption declines as restoration progresses; that is, it becomes

increasingly difficult to remove ammonia from the aquifer. Because of this, WMC has proposed a maximum allowable value for ammonia in the 20-50 ppm (average) range.¹⁰ Ammonia concentrations of 20-50 ppm represent a substantial degradation of groundwater quality when compared with premining levels. In evaluating the significance of this degradation of groundwater quality, the staff considered (1) transformation of the contaminants; (2) mobility; (3) water quality standards for all forms of nitrogen for humans, livestock, and other organisms; and (4) water uses — past, present, and potential.

Transformations: Ammonia cannot be considered alone as a water quality constituent. In the presence of oxygen, nitrifying bacteria convert NH_3 to NO_2^- and NO_3^- . As mentioned in Sect. 6.3.2.1 it is difficult to predict whether nitrification will occur in the aquifer. A lack of oxygen, high pH, or other factors may inhibit formation of nitrites or nitrates.

The basic stoichiometry of the conversion process is



Several different paths and mechanisms may be involved, but all involve driving forces not available in the underground mining zone except under leaching conditions. Other formation constituents compete for the available oxidant even then, so only minimal nitrate formation would be expected. This fact is confirmed by reported data as shown in Table 5.1, Column C, where a total of 7.68 ppm of combined nitrate and nitrite have apparently been formed in the presence of 180 ppm of ammonia. Restoration techniques effectively remove this nitrate (Table 5.1, Column E).

After restoration the only oxygen available for ammonia conversion would be from air dissolved in the water returned to the aquifer. At one atmosphere pressure, the saturation value is 9 to 14 ppm of dissolved oxygen (dependent on temperature). If the water was fully saturated and 100% conversion to nitrate occurred, neither of which the staff considers likely, no more than 14 ppm of nitrate could be formed. When reported as nitrogen, this concentration amounts to only 3.2 ppm which is well below the allowable drinking water standard of 10 ppm for nitrate (as nitrogen).

Mobility: As noted previously, the presence of clays in the UISS should make ammonia relatively immobile. Ammonia can migrate through parts of the aquifer where absorptive capacity is saturated, but in parts of the aquifer that are unaffected by solution mining, ammonia should travel only short distances. Nitrite and nitrate, on the other hand, are relatively mobile and are expected to migrate with the flow of groundwater.

The large amounts of ammonia left in the mining zone, both in the groundwater and aquifer (sand and clays), and the subsequent difficulty in eluting this ammonia from the aquifer by groundwater sweeping indicates chemical exchange. The ability to elute ammonia from the aquifer by alkaline earths in solution confirms that a true chemical exchange is occurring.

From this evidence the staff concludes that any ammonia transported by the slowly moving groundwater will equilibrate with the sands and clays outside the mining zone. This exchange is probably with the calcium associated with the clay (approximately 15%) in the aquifer.

The overall effect will be to decrease the rate of ammonia transport and concentration in the groundwater system as it leaves the mining site. The applicant estimates the average groundwater flow as 5 to 8 ft per year. The staff estimate of a maximum flow is about a factor of 10 higher; however, exchange reactions with the aquifer will reduce the effective ammonia transport rate to less than 10 ft per year, although ions such as chloride and nitrate can be expected to move with groundwater velocity.

The staff concludes that this slow transport and effective dilution will make potential offsite consequences negligible but recommends continued monitoring as a precaution. Furthermore, the staff considers that the "restored" section of the 517 pilot test area provides a unique opportunity to study ammonia movement caused by groundwater flow and/or conversion to nitrate.

One week after completion of the TDS reduction experiment, the central recovery well showed 27 ppm of ammonia (as nitrogen). The injection wells, about 4.3 m (14 ft) distant, showed values below 0.5 ppm. Nitrate values were below 0.5 ppm. Groundwater flow is to the northwest of the "restored" plot (Fig. 5.1). Unrestored mined areas bound the "restored" region on the sides bounded by wells 2A, 517-6, and 3A. In addition, wells PRC-1, PRC-2, and M-1 lie about 12, 18, and 32 m (40, 60, and 105 ft) down gradient from the recovery well (No. 6A). The applicant has reported that the water in PRC-1 has contained small quantities of ammonia, but its present condition is unknown.

If the above described physical system is sampled for ammonia and nitrate routinely over a long time period, the staff believes that the relative importance of ammonia transport and nitrate conversion can be demonstrated.

As a license condition the applicant will be required to submit an experimental plan to demonstrate whether significant ammonia transport occurs and if nitrate is formed in the "restored" formation. The actual demonstration will be the responsibility of the applicant as a license condition.

Standards and criteria: Ammonia is identified as an objectionable constituent in water supplies, but it appears that rather little is known about the toxicity of ammonia to humans. The NAS⁶ recommends a low limit for NH_3 in public water supply stating:

- Because ammonia may be indicative of pollution and because of its significant effect on chlorination, it is recommended that ammonia nitrogen in public water supply sources not exceed 0.5 mg/liter.

With respect to livestock it appears that 40 ppm of ammonia in drinking water will not pose a hazard to cattle.¹¹ Ammonia is toxic to fish at low concentrations, and, as shown in Table 6.2, a very low limit for un-ionized ammonia is recommended for protection of aquatic life.

While there is uncertainty about nitrification in the aquifer, it is clear that nitrification will occur as soon as any water from the aquifer reaches the surface and is exposed to oxygen. Because nitrate and nitrite can cause methemoglobinemia in infants, NAS⁶ recommended as follows:

- On the basis of adverse physiological effects on infants and because the defined treatment process has no effect on the removal of nitrate, it is recommended that the nitrate-nitrogen concentration in public water supply sources not exceed 10 mg/liter.
- On the basis of its high toxicity and more pronounced effect than nitrate, it is recommended that the nitrite-nitrogen concentration in public water supply sources not exceed 1 mg/liter.

With respect to livestock, the NAS concluded "that all classes of livestock and poultry that have been studied under controlled experimental conditions can tolerate the continued ingestion of waters containing up to 300 mg/liter of NO_3N to 100 mg/liter of NO_2N ." Nevertheless, NAS⁶ recommended:

- In order to provide a reasonable margin of safety to allow for unusual situation such as extremely high water intake or nitrite formation in slurries, the NO_3N plus NO_2N content in drinking waters for livestock and poultry should be limited to 100 ppm or less, and the NO_2N content alone be limited to 10 ppm or less.

Water use: Water from the UISS aquifer is used predominantly for livestock watering. This aquifer is also the water source for the Irigaray ranch, although moderate levels of selenium are present (Appendix B, Table B-1, W-23). Natural radiological contamination is also present in many areas of the aquifer. It is difficult to predict future use of the UISS aquifer. Ranching seems likely to remain the predominant land use near WMC's operations, but uranium mining may greatly increase in the area. WMC's degradation of aquifer water quality would be initially limited to the mining zone [approximately 20 ha (50 acres) of well fields]. If nitrification occurs in the aquifer, those "downstream" portions of the aquifer into which nitrates and nitrites could migrate would also be degraded. Currently the water quality in these potentially affected areas is naturally degraded by the radioactive materials associated with uranium deposits. Thus, water from much of the areas to be affected is already unacceptable for public water supply.

Conclusions

The WMC's proposed action will degrade groundwater in the mining zone (Sect. 5.1.1). The extent of degradation depends significantly on an unknown factor: whether nitrates and nitrites are formed in the aquifer. Degradation would be limited to a relatively small area in which groundwater quality is already naturally degraded. If WMC leaves 20-50 ppm of NH_3 in the UISS aquifer, this groundwater would be unacceptable for human consumption due to (1) possible presence of nitrites and nitrates, (2) the odor of ammonia, and (3) potential toxicity of ammonia. The water would probably be marginally acceptable for livestock water, unless partial nitrification resulted in concentrations of nitrite-nitrogen greater than 10 mg/liter. Finally, if water from the contaminated aquifer reached any aquatic ecosystems (i.e., Powder River), it could adversely affect fish and other aquatic life. Livestock ponds filled with water from the contaminated aquifer would not support fish due to (1) ammonia toxicity, and (2) possible algal blooms stimulated by ammonia or nitrate.

The WMC's restoration does not pose a large or imminent threat to public health because the degradation of groundwater quality would occur in a small area where groundwater is currently not used for human consumption. Pumping from the contaminated area could probably be controlled or eliminated in the immediate future, and adverse impacts to public health, livestock, and aquatic life could be avoided in the near and mid-term. However, contamination of an aquifer under any circumstances is a serious matter because it is essentially irreversible. The restoration plan does involve potential risks, for example, in the event of unforeseen circumstances or perhaps at some future time. Thus, the proposed action is considered acceptable because of the small area involved and the extensive monitoring that will be undertaken.

6.4 MINERAL RESOURCES

Coal deposits underlying the Irigaray site are of limited quantity and are not considered presently to be economically recoverable. Any oil and gas that may exist beneath the site would be thousands of feet below the depths at which solution mining will take place and could not be affected by the proposed operation. Other minerals, such as zeolites, should not be affected because of the limited excavation involved. Solution mining should not interfere with later potential resource recovery at the Irigaray site.

Uranium recovery using the solution mining method may not be as efficient as recovery by conventional underground or open pit mining methods since the technology is in a developmental stage. However, solution mining is conducted on uranium deposits that may not be of sufficient mineral grade or quantity to be economically mined by conventional methods. Such deposits would be lost as a resource.

6.5 SOILS

The removal of natural vegetative cover from construction sites and much of the well field areas will expose surface materials to accelerated wind and water erosion. Soil compaction due to operation of drilling rigs and other equipment in the well fields will also increase erosion and sedimentation. Extensive destruction of the soil system characteristics (physical, chemical, and biological) is not anticipated since no stripping or excavation will occur during proposed project operations.

6.6 ECOLOGICAL IMPACTS

6.6.1 Impacts on the terrestrial environment

Impacts on terrestrial biota will accrue from vegetation disturbance and related loss of wildlife habitat during well field development as well as possible effects on wildlife from increased human activity associated with the project. Atmospheric emissions from the project have been discussed in Sect. 6.1 and will have no effect on terrestrial biota. All waste ponds will be fenced with sheep-tight fencing to prevent livestock and wildlife access. The ponds will also be flagged to discourage waterfowl use. There should be no significant adverse impacts on wildlife from wastes in the ponds. Traffic associated with the project may result in an increase in road-killed animals. Such losses, however, should not significantly affect local populations. Increased human activity may cause some wildlife species that are particularly intolerant of human presence to leave the immediate area. Because increased human activity will be limited to a small area around the recovery facility and the specific well field, this factor should not be significant.

Vegetation will be disturbed during development and operation of the proposed project in connection with construction of the recovery facility [2 ha (5 acres)], roads, and well fields. Well field development will produce the great majority of land disturbance. Drilling wells and subsequent maintenance activities will destroy natural vegetation present on the well fields and will involve an estimated 24 ha (60 acres) for the limited operation and may involve a total of 400 ha (1000 acres) over the lifetime of the project. WMC will reclaim and revegetate all land disturbed and is required to post a reclamation bond with the Wyoming Department of Environmental Quality.

Most of the land to be disturbed by well field development is within the sagebrush/grassland vegetation type, which is abundant and widely distributed over the entire Powder River Basin. Although wildlife will be displaced from the land disturbed, the animals that may be expected to occur on the sagebrush/grassland type are common and relatively abundant in the region of the site. The land that is disturbed will be lost as wildlife habitat until revegetation is accomplished. However, disturbance of about 400 ha (1000 acres) of the sagebrush/grassland vegetation type will not result in significant adverse impacts.

Disturbance of riparian habitat along Willow Creek and the Powder River could have a significant impact depending upon the extent of disturbance. Vegetation in riparian habitats is difficult to reclaim adequately,¹² and the vegetation type is not widely distributed in the region of the site. Furthermore, riparian areas near the site represent important habitat to a number of wildlife species including game species such as mule deer, sage grouse, and wild turkeys. Plans for the initial well field development should not include any riparian habitat along Willow Creek. However, because maps of the ore body show that it passes under Willow Creek and closely approaches the Powder River in Section 30 of the site, it is possible that future mining activities could involve riparian areas. The staff therefore recommends that disturbance in riparian habitats be kept to a minimum. In particular, the staff will require that trees and large shrubs, which could take over 100 years to be replaced, should not be destroyed. Vegetation along streams should not be removed because it stabilizes stream banks.

6.6.2 Impacts on endangered species

No endangered plant or animal species are expected to occur on the WMC site (Sect. 2.7). Of the wildlife species listed by the Wyoming Game and Fish Department as rare in Wyoming, only the milk snake would be likely to occur on the site. Construction and development of the proposed project should disturb only a small percentage of the habitat available for milk snakes on the site.

6.6.3 Impacts on aquatic environments

Potential impacts to surface aquatic environments through construction and operation of the WMC project are directly related to potential impacts on water quality, discussed in Sect. 6.3.1. Two aquatic environments are of concern: Willow Creek and the Powder River. Willow Creek has not been characterized ecologically except for the theoretical analysis presented in Sect. 2.9.2. Routine construction activities associated with the applicant's in situ mining operation near Willow Creek should have a negligible impact on aquatic biota that may be present during periods of flow (Sect. 6.3.1.1). Solution mining proposed within the Willow Creek streambed itself could potentially disrupt aquatic habitat that may be present. WMC is currently developing methods to minimize any adverse impacts (Sect. 6.3.1.1). As a condition to license consideration, the staff requires that WMC, prior to any solution mining in the Willow Creek streambed, submit and obtain approval of mitigating measures to be used at Willow Creek. Potential construction impacts on aquatic systems in the Powder River should not significantly affect aquatic biota (Sect. 6.3.1.1).

Potential impacts of solution mining operation on aquatic environments may result from accidental surface releases of contaminated fluids onsite to Willow Creek or the Powder River (Sect. 7.1) and from contaminated groundwater ultimately reaching the Powder River (Sect. 6.3.2.1). The probability of an event of such magnitude cannot be predicted accurately. Monitoring programs required as a condition to this license should reduce the probability of an excursion significantly affecting aquatic biota in the Powder River (Sect. 8.2.3).

6.7 RADIOLOGICAL IMPACTS OF ROUTINE OPERATIONS

6.7.1 Introduction

Estimates of radiation doses resulting from routine operations of the Irigaray solution mining and uranium recovery process facilities are considered in this section. Individuals living in the area of the Irigaray project will be exposed to the airborne radionuclides and the subsequent deposition of these materials on the land surface.

Estimates of radiation doses from the exposures involve many complex considerations. In the absence of complete information, estimates were made using the best current knowledge. Conservative assumptions were made where there was insufficient knowledge; for example, estimates of doses from atmospheric releases assumed exposure to contaminated air and ground 100% of the time with no shielding and consumption of food that was produced entirely at the location of dose calculation.

The radiological impact of the routine release of radionuclides during normal operations at the well field and processing facilities was assessed by estimating radiation dose commitments to individuals and population from the resultant exposure. Since radioactive materials taken into the body by inhalation and ingestion continuously irradiate the body until removed by processes of metabolism and radioactive decay, the estimate of the total dose an individual will receive from one year's intake is integrated over 50 years (remaining lifetime of the individual) and is called a dose commitment. All of the internal doses estimated in this report represent 50-year dose commitments. For those materials which have a short radioactive half-life or those, such as uranium, which are eliminated rapidly from the body, essentially all of the dose is received in the same year that the materials enter the body; that is, the annual dose rate is about the same as the dose commitment.

6.7.2 Airborne effluents

The release of radioactive materials to the atmosphere was assumed to be the principal mode of environmental contamination from the uranium solution mining and processing facility. Releases from solution mining will be substantially lower than those attributable to a conventional uranium mining-milling operation.

6.7.2.1 Models and assumptions

AIRDOS-II, a FORTRAN computer code,¹³ was used to estimate individual and population radiation doses resulting from continuous atmospheric release of airborne radioactive materials from the uranium mining and processing operation. Pathways to man include the inhalation of radionuclides in air, immersion in air containing radionuclides, exposure to ground and surfaces contaminated by deposited radionuclides, and the ingestion of food produced in the area.

The area around the operating facility was divided into 16 sectors. Each sector was bounded by radial distances of 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 10, 20, 30, 40, and 50 miles from the point of release. Factors used as input data were (1) human population (Table 6.3), (2) numbers of beef and dairy cattle, and (3) specifications as to whether each of the areas lying outside the facility boundary was used for producing vegetable crops or is a water area.

Table 6.3. Population distribution within 50 miles of the Irigaray project site

Sector	Population									
	0-1 mile	1-2 miles	2-3 miles	3-4 miles	4-5 miles	5-10 miles	10-20 miles	20-30 miles	30-40 miles	40-50 miles
N	0	0	0	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0	0	0	152
NE	0	0	0	0	0	0	1,813	0	0	7,194
ENE	0	0	0	0	0	0	0	0	0	797
E	0	0	0	0	0	0	0	0	0	175
ESE	0	0	0	0	0	0	0	200	0	86
SE	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	501	0
SSW	0	0	0	0	0	0	0	0	635	0
SW	0	0	0	0	0	17	0	0	0	0
WSW	0	0	0	0	10	0	0	272	0	0
W	0	0	0	0	0	0	0	0	572	0
WNW	0	0	0	0	0	0	173	0	0	0
NW	0	0	0	0	0	0	0	0	480	3,394
NNW	0	0	0	0	6	5	0	0	340	0
Total	0	0	0	0	16	22	1,986	472	2,528	11,798

A portion of the AIRDOS-II computer code¹³ is an atmospheric dispersion model (AIRMOD) which estimates concentrations of radionuclides in air at ground level and their rates of deposition on ground and surfaces as a function of distance and direction from the point of release. Annual average meteorological data for the site area are supplied as input for AIRMOD.

AIRMOD is interfaced with environmental models within the AIRDOS-II computer code to estimate doses to man through the various pathways. A terrestrial model, TERMOD,¹⁴ which estimates the radionuclide intakes via ingestion of radionuclides deposited on crops, soil, and pastures, is included. The intakes result from eating beef and vegetable crops and from drinking milk. The dose conversion factors for most radionuclides are based on ICRP-2¹⁵ and the report of the Task Group on Lung Dynamics for Committee II of the International Commission on Radiological Protection (ICRP).¹⁶ Methods used in estimating radiation doses have been published in a reference handbook, ORNL-4992.¹⁷

6.7.2.2 Atmospheric dispersion (meteorology)

In the absence of site-specific meteorological data for the proposed project, the staff used the meteorological data from the nearest weather station (Casper, Wyoming), approximately 1.13 km (70 miles) away, which should be quite similar to that of the project site. Values of χ/Q at the nearest residence (the Reculosa Ranch, where the highest individual dose occurred) was 2.31×10^{-8} sec/m³ for particulates and 3.67×10^{-8} sec/m³ for radon-222. The χ/Q values at the Irigaray Ranch were 5.65×10^{-9} sec/m³ for particulates and 1.26×10^{-8} sec/m³ for radon-222.

Atmospheric dispersion and deposition models and computations used are discussed in ref. 13.

6.7.3 Radiation dose commitments from airborne effluents

The radiation dose commitments from airborne effluents are based on the estimated emission rates shown in Table 6.4.

Table 6.4. Release rates for radionuclides from the well field and recovery plant

Radionuclide	Release rate (Ci/year)
Recovery plant	
U-238	1.5×10^{-1}
U-234	1.5×10^{-1}
U-235	7.0×10^{-3}
Th-230	2.6×10^{-3}
Ra-226	1.0×10^{-4}
Pb-210	1.0×10^{-4}
Bi-210	1.0×10^{-4}
Po-210	1.0×10^{-4}
Well field	
Rn-222	7.6×10^1

Source: Estimates based on information contained in *Environmental Report, Irigaray Project, Johnson County, Wyoming*, Docket No. 40-8502, Wyoming Mineral Corp., Lakewood, Colo., July 1977.

6.7.3.1 Maximum dose to the individual

Reculusa Ranch

The maximum annual dose commitments would be received by individuals living at the Reculusa Ranch, the nearest residence to the plant site. The ranch is 6.6 km (4.1 miles) west-southwest of the recovery plant and 7.1 km (4.4 miles) west-southwest of the initial well field (Fig. 6.1). The doses are shown in Table 6.5.

The highest organ dose is estimated to be 1.1 millirems per year to the lung resulting from the release of uranium from the yellow cake drying and packaging operation. As shown in Table 6.5, other organ doses and the total body dose are much lower. The contribution of the various radionuclides is shown in Table 6.6.

These predicted annual individual dose commitments resulting from the normal operations are only a small fraction of the present NRC dose limits for members of the public outside restricted areas, as specified in 10 CFR Part 20, Standards for Protection against Radiation. Table 6.7 presents a comparison of the predicted annual dose commitments to individuals from operations of the Irigaray Project with present NRC limits and can be compared with the future Environmental Protection Agency's (EPA) Radiation Protection Standard (40 CFR Part 190),¹⁸ which becomes effective for some uranium fuel cycle facilities in December 1979 and uranium mills in December 1980.

Irigaray Ranch

The maximum annual dose commitments are also shown for individuals living at the Irigaray Ranch, which is 7.1 km (4.4 miles) north-northwest of both the plant and well field. These dose commitments are shown in Table 6.8. The doses are about one-fourth of the similar doses received by individuals at the Reculusa Ranch and are also well below applicable standards.

6.7.3.2 Dose to the population

The annual dose commitments from the airborne effluents to the population living within 80 km (50 miles) of the operating facility are summarized in Table 6.9. The population total-body dose was 0.006 man-rem. The comparable dose from natural background in the area was 2.4×10^3

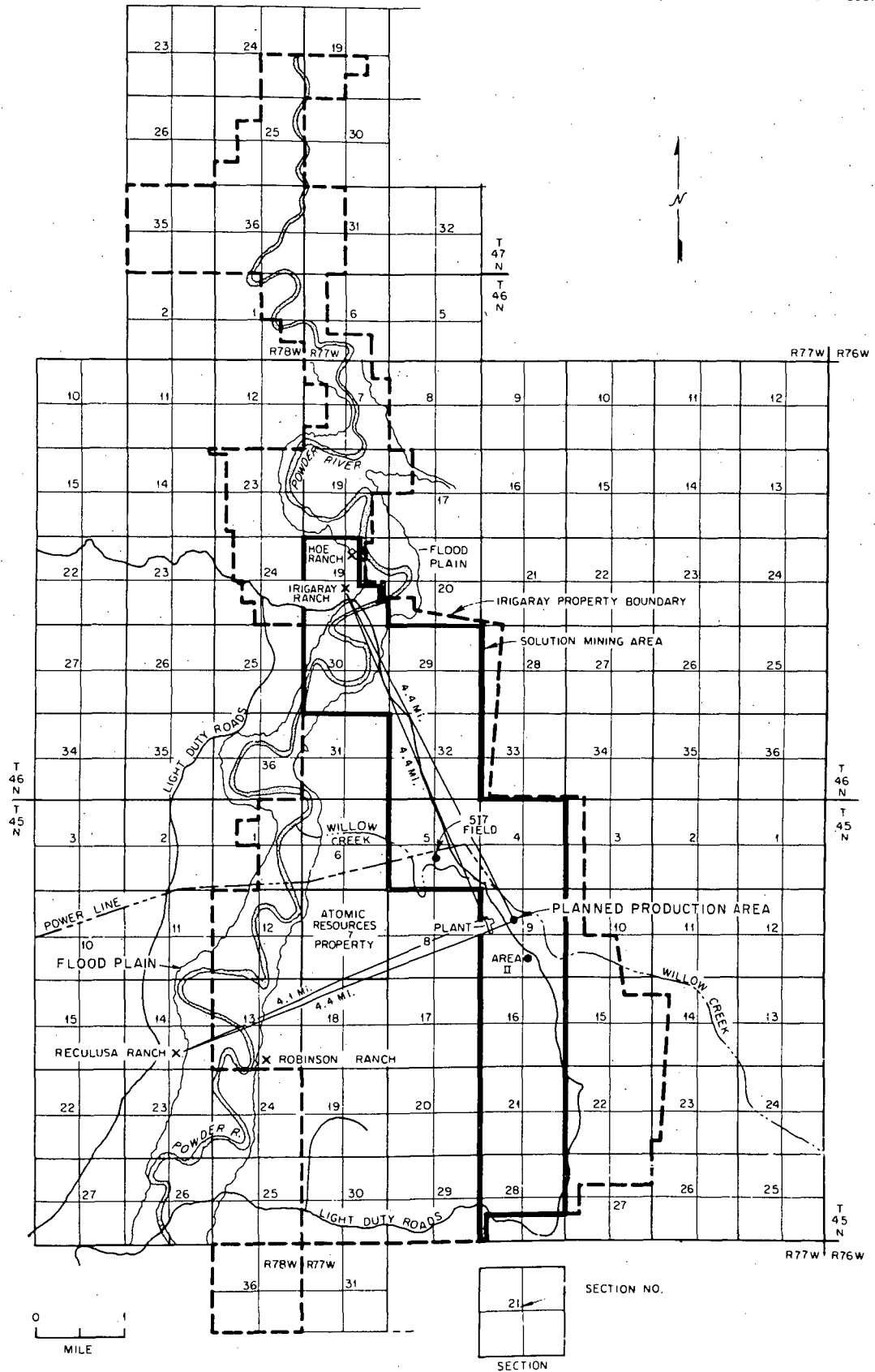


Fig. 6.1. Distances to nearest residences from the recovery facility and well fields.

Table 6.5. Estimated maximum annual doses from the airborne effluents to an individual living at the Reculosa Ranch^a

Figures are for 50-year dose commitments from one year of intake of radionuclides

Pathway	Maximum annual dose (millirems)				
	Total body	Bone	Lung	Kidney	Bronchial epithelium
Submersion in air	8.2E-5 ^b	1.2E-4	7.4E-5	6.5E-5	
Inhalation ^c	1.2E-3	2.7E-2	1.1	1.2E-2	8.9E-2
Ingestion ^d	5.0E-3	8.1E-2	5.1E-3	1.9E-2	
Exposure to ground	2.8E-3	4.5E-3	2.3E-3	1.9E-3	
Total	9.1E-3	1.1E-1	1.1	3.3E-2	8.9E-2

^aThe nearest residence to the plant and well field; located 4.1 miles west-southwest of the plant and 4.4 miles west-southwest of the well field.

^bRead as 8.2×10^{-5} .

^cDaily intake assumed to be 23 m³ of air.

^dDaily intake assumed to be 0.30 kg of beef and 0.25 kg of vegetables.

Table 6.6. Contribution of radionuclides to dose from airborne effluents at the Reculosa Ranch, the nearest residence

Radionuclide	Percent contribution			
	Total body	Bone	Kidney	Lung ^a
Po-210	0.1	< 0.1	0.8	< 0.1
Pb-210	0.2	0.4	1.2	< 0.1
Rn-222 ^b	5.4	2.3	16.6	7.8
Ra-226	3.2	2.6	0.9	< 0.1
Th-230	6.0	15.6	16.1	0.8
U-234	31.7	38.6	31.1	47.4
U-235	11.1	2.9	3.2	2.2
U-238	42.3	37.5	30.1	41.8

^aIncludes dose to bronchial epithelium.

^bIncludes dose from daughters Pb-214 and Po-218.

Table 6.7. Comparison of annual dose commitments to the nearest residence (Reculosa Ranch) with radiation protection standards

Receptor organ	Estimated annual dose commitments	Radiation protection standards	Fraction of standard
Present NRC Regulation (10 CFR Part 20)			
Total body	9.1E-3 millirems per year	500 millirems per year	1.8E-5
Lung	1.1 millirems per year	1500 millirems per year	7.3E-4
Bone	1.1E-1 millirems per year	3000 millirems per year	3.7E-5
Bronchial epithelium	4.5E-7 WL ^a	3.3E-2 WL ^a	1.4E-5
Future EPA Standard (40 CFR Part 190)			
Total body	9.1E-3 millirems per year	25 millirems per year	3.6E-4
Lung	1.1 millirems per year	25 millirems per year	4.4E-2
Bone	1.1E-1 millirems per year	25 millirems per year	4.4E-3
Bronchial epithelium	4.5E-7 WL ^a	NA ^b	NA ^b

^aRadiation standards for exposure to Rn-222 and daughter products are expressed in Working Level (WL). WL means the amount of any combination of short-lived radioactive decay products of Rn-222 in one liter of air that will release 1.3×10^5 mega electron volts of alpha particle energy during their decay to Pb-210.

^bNot applicable; 40 CFR Part 190 does not include doses from Rn-222 daughters.

Table 6.8. The estimated maximum annual doses^a from airborne effluents to an individual living at the Irigaray Ranch, 4.4 miles north-northwest of the plant

Pathway	Maximum annual dose (millirems)				
	Total body	Bone	Lung	Kidney	Bronchial epithelium
Submersion in air	2.1E-5 ^b	3.0E-5	1.9E-5	1.7E-4	
Inhalation ^c	3.1E-4	6.7E-3	2.6E-1	3.1E-3	3.1E-2
Ingestion ^d	1.3E-3	2.1E-2	1.3E-3	5.0E-3	
Exposure to ground	7.2E-4	1.2E-3	5.9E-4	5.0E-4	
Total	2.3E-3	2.9E-2	2.6E-1	8.8E-3	3.1E-2

^a50-year dose commitments from one year of intake of radionuclides.

^bRead as 2.1×10^{-5} .

^cDaily intake assumed to be 23 m³ of air.

^dDaily intake assumed to be 0.3 kg of beef and 0.25 of vegetables.

Table 6.9. Annual doses^a to the population from airborne effluents of the solution mining facilities

Organ	Population dose (man-rems)	
	Project effluents	Natural background
Total body ^b	5.76E-3 ^c	2.42E3
Lung ^d	1.39	1.51E4
Bone	4.31E-2	2.96E3

^aBased on 1970 population of 1.68×10^4 persons.

^bTotal-body dose from normal background from all sources for the State of Wyoming is 144 millirems per year (D. T. Oakley, *Natural Radiation Exposure in the United States*, ORP/SID 72-1, USEPA, 1972).

^cRead as 5.76×10^{-3} .

^dDose to lung includes dose to bronchial epithelium from Rn-222 daughters. With normal background conditions continuous exposure to the mean concentration (500-1000 pCi/m³) of Rn-222 in the air would deliver a dose of 500 to 1000 millirems per year to the bronchial epithelium (National Academy of Science - National Research Council, *The Effects on Populations of Exposures 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).

man-rems.¹⁹ The highest population organ dose of 1.4 man-rems was to the lung (includes dose to bronchial epithelium) and was only 0.009% of the similar dose resulting from area background. All population doses are quite low due to the relative isolation of the project facilities from the nearest residences and, additionally, to the fact that the population density for the area adjacent to the site is very low (only 16,819 persons living within 80 km (50 miles) of the project site).

6.7.4 Liquid effluents

There are no planned discharges of radioactive pollutants into uncontrolled areas of the Irigaray project and no anticipated seepage from waste ponds into the local groundwater.

The required groundwater monitoring and corrective action program should effectively contain any contaminated groundwater. Therefore, any adverse impact resulting from contaminated groundwater is expected to be minimal.

6.7.5 Occupational dose

The most significant exposure of project employees attributable to radioactive materials is expected to be associated with the yellow cake drying and packaging operations. These operations (if drying is incorporated in the process) will take place in a separate room in the recovery plant, and the equipment used will be designed to minimize the release of radioactive contamination to the room air. A recent review by NRC staff of exposure data at uranium mills, where similar drying and packaging operations are conducted, revealed that few drying and packaging operators exceeded 25% of the specified NRC limit for such exposure averaged over the year.²⁰ The limit for exposure to airborne natural uranium in the chemical forms encountered in the drying and packaging operations is not a radiation exposure limit but rather is based on the chemical toxicity of the element.

Worker inhalation of radon and its daughters is another potential exposure condition. The ventilation system in the recovery plant, designed to achieve ten air changes per hour, is expected to minimize this radiation exposure. Elevated radon concentrations may occur in the well field control buildings, but the occupancy factor should be low. It is expected that employee exposures should not exceed about 10% of the annual limit specified by NRC, again comparable to that encountered by some employees at uranium mills.

Exposure to external radiation is expected to be far below the maximum limits permitted by NRC regulations because of the nature of the material and the operations. The applicant will be required to perform periodic gamma radiation surveys, particularly adjacent to the resin columns, to assure that radium buildup does not occur and result in unnecessary radiation exposure.

The applicant's proposed air sampling program to assess airborne radioactivity concentrations to which employees may be exposed is given below:

1. A representative air sample shall be collected at least weekly at work stations in the calcining/packaging area to determine airborne uranium concentrations. Additional sampling, including breathing zone sampling, shall be conducted during cleanup and maintenance activities in the calcining/packaging area.
2. Monthly air samples shall be collected at other process and storage locations as appropriate to determine airborne uranium concentrations.
3. Quarterly sampling at selected process areas, including well field control buildings, shall be performed to determine radon or radon daughter concentrations. If quarterly values should exceed 25% of the applicable value in Appendix B of 10 CFR Part 20, the frequency of sampling at these locations shall be increased to monthly.
4. If the air sampling program reveals work locations where concentrations exceed 25% of the applicable value in Appendix B, Table I, Column 1, of 10 CFR Part 20, a program shall be established to determine time-weighted exposures of employees working at these locations and to establish such procedures specified by Section 20.103(b)(2) to maintain employee exposures as low as reasonably achievable.
5. Special uranium air sampling, supplementing the routine air sampling program, shall be conducted for cleanup and maintenance activities as appropriate.

6.8 SOCIOECONOMIC IMPACTS

The proposed project will require 60 employees during operation (ER, p. 184). Approximately 40 of these individuals are WMC employees working at the pilot-scale test facilities on the Irigaray site. Most of these employees currently reside in Buffalo. The 20 additional employees could result in an increase of 70 residents (3.5 persons per household) in the town of Buffalo. This small increase in population should be readily accommodated by the town of Buffalo. Therefore, no significant impact on the community is anticipated.

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7. ENVIRONMENTAL EFFECTS OF ACCIDENTS

Accidents in the operation of the Irigaray project can be minimized through (1) the proper design, manufacture, and operation of the process equipment, (2) adherence to adopted solution mining and radiation safety procedures, and (3) incorporation of a quality assurance program designed to establish and maintain safe operations in accordance with NRC Regulatory Guide 3.5. The NRC will maintain surveillance over the facility and its individual safety systems by conducting periodic inspections and by requiring reports of effluent releases and deviations from normal operations.

Accidents involving the release of radioactive materials or harmful chemicals have occurred in operations similar to those proposed by the applicant. Therefore, in this assessment, accidents that might occur during operation have been postulated and their potential environmental impacts evaluated.

Solution mining of uranium is currently developing. Operating experience is limited, thus restricting the application of probabilities of occurrence for most types of accidents. Where adequate information for realistic evaluations was unavailable, conservative assumptions were used to assess environmental impacts resulting from accidents. Thus the environmental effects of such accidents may be less than the potential effects determined by this assessment.

7.1 SURFACE ACCIDENTS

7.1.1 Surface pipe failures

The bulk of the piping at the Irigaray site will be surface piping to permit ready detection and repair of leaks. Polyvinyl chloride (PVC) and rubber piping will be used extensively to minimize corrosion and costs. This, however, introduces problems of low impact strength at freezing temperatures and gradual deterioration due to weathering. Pipe failures could result from vehicle and personnel movement near the pipelines and from freezing of the pipe.

7.1.1.1 Causes of leaks

In places, well field access roads will parallel or cross the main trunk pipelines. At crossings, a suitable pipeline casing protection will be provided. Vehicles may inadvertently slide off the road during icy or muddy conditions and hit the pipeline. Also, on passing another vehicle at a crossing, a vehicle may drive over the pipeline. Within the well field, vehicles and personnel may inadvertently break smaller injection or production lines.

During winter, temperatures at the Irigaray site will fall well below freezing. The salts in the lixiviant are too dilute to significantly lower the solution's freezing point. The applicant contends that freezing will be prevented by operating at relatively high flow velocities in the pipelines. However, the addition of thermal insulation to increase pipeline reliability during cold weather may be incorporated if needed.

Flow interruption in cold weather may result in the freezing and possible cracking of lines. Occasionally leaks can be expected in normal operations as a result of defective materials, construction practice, chemical degradation, vibration, or stress. The applicant will be required to document pipe breaks that result in any significant release to the surface. A report describing the nature of the event and corrective actions taken will be made available for review by NRC inspectors.

7.1.1.2 Estimated releases

Breaks in trunk lines will be detected by low-flow and low-pressure alarms installed by the applicant, probably limiting such spills to a worst-case loss of 12,000 gal (complete drawdown on a surge tank). Since the barren lixiviant solution grossly resembles irrigation water containing ammonia fertilizer (ER, p. 161), the immediate chemical effect of such a spill would be small. However, with the pregnant lixiviant containing 150 ppm U_3O_8 and 370 pCi/liter of radium-226, a 12,000-gal spill would release approximately 4,550 μ Ci of uranium and 16.8 μ Ci of radium-226 to a localized area. The area affected by such an event would be readily identified and decontaminated.

Leaks in production or injection well field lines would generally be smaller. However, should an unobserved leak develop in a line from a production well operating at 10 gpm, up to 2 hr (the period between flowmeter readings) may pass before the leak is detected. A total of 1,200 gal containing 455 μCi of uranium and 1.68 μCi of radium-226 could thereby be released to the surface of the well field. It, too, would be readily identified and decontaminated, resulting in an insignificant environmental impact.

7.1.2 Failure of chemical storage tanks

At the Irigaray project, chemical storage facilities will be maintained both inside and around the plant building and in the well field area. Leaks from tanks within the plant building will be collected by the building sump and pumped to an appropriate receiving tank.

External tanks will be of two types: (1) pressurized gas storage tanks and (2) liquid storage tanks. Pressurized gases such as ammonia, propane, and carbon dioxide are used in the plant. Leaks in ammonia tanks may present a short-term toxic hazard to personnel at the facility. Carbon dioxide leaks would present no apparent hazard. Both ammonia and propane tank leaks could result in the occurrence of an explosion and fire (Sect. 7.1.3).

Liquid storage tanks will contain concentrated hydrochloric acid, hydrogen peroxide, production and injection surge fluids, gasoline, and diesel fuel. Fiberglass, stainless steel, and carbon steel tanks will be used to store the appropriate fluids (Sect. 4.4.2). All external storage tanks will be diked or bermed to contain a minimum of twice the specific tank's capacity. If a leak or rupture occurred in a liquid storage tank, readily accessible shutoff valves would be closed and pumps turned off to prevent additional fluid loss. The failure would be repaired and the affected area cleaned up. Storage liquid releases to the environment would be insignificant.

7.1.3 Explosions and fire

Explosion(s) and/or fires at the Irigaray plant would be unlikely due to the limited use of combustible materials in the operations. The bulk of the plant construction and equipment is made of metal, fiberglass, polyvinyl chloride, or concrete. Fire sources would be limited to waste receptacles, electrical equipment, and fuel storage tanks. An adequate supply of properly serviced and appropriate portable fire extinguishers will be maintained at the site at all times. Personnel will be adequately trained in fire prevention and fire fighting techniques to limit and confine any fire that might occur. All electrical equipment will be properly wired and grounded in accordance with the National Electric Safety Code (ANSI C2). Diesel fuel and gasoline storage tanks will be properly labeled ("No Smoking," etc.) and will be diked or bermed.

Hydrogen peroxide storage tanks will be designed with pressure release vents to prevent the buildup of pressure within the vessels should unexpected oxidation occur (excessive heat, combustible material in contact with contents, etc.). The only other potential explosive sources on the site would be the ammonia and propane gas storage tanks, maintained in the open. Should either of these types of tank rupture releasing their contents, the concentrations in the vicinity of the tanks would not remain within the explosive limits of the respective gases (16% - 27% in air for ammonia and 2 - 10% in air for propane), due to their rapid dispersion. The environmental impacts from such occurrences are expected to be insignificant.

7.1.4 Tornadoes

The probability of occurrence of a tornado in the 1° square in which the Irigaray site is located is very low. Using the closest available data, the probability is approximately 3×10^{-4} per year.¹ The area is categorized as Region 3 in relative tornado intensity.² For this category, the wind speed of the "design" tornado is 390 km/hr (240 mph), of which 310 km/hr (190 mph) is rotational and 80 km/hr (50 mph) is translational. None of the structures are designed to withstand a tornado of such intensity.

The nature of the operation is such that little more could be done to secure the facility with advance warning than without it. Accordingly, a "no warning" tornado was postulated. Because the yellow cake product has the highest specific activity of any material handled at the recovery plant and because as much as 17.5 tons (approximately one truckload) of product may be accumulated prior to shipment, the tornado was assumed to lift 1588 kg (3500 lb) of yellow cake.

A conservative model, which assumed that all the yellow cake is in respirable form, was used for the dispersion analysis.³ The model assumed that all of the material was entrained as the vortex

passed over the site. Upon reaching the site boundary, the vortex dissipated, leaving a volume source to be dispersed by the trailing winds. The material was assumed to be in a source representative of the velocities of the tornado and to be dispersed through an arc of 90° containing the maximum population density in the vicinity of the site. Because of the small particle sizes assumed, the settling velocities was assumed to be negligible.

On the basis of this model, the maximum exposure would occur at a distance of about 4 km (2.5 miles) from the recovery plant, where a dose to the lung of 4.6×10^{-5} millirem would result. The maximum annual lung dose to the nearest residence, 6.6 km (4.1 miles) from the recovery plant was 3.8×10^{-5} millirem. The 50-year lung dose commitment as a function of distance is plotted in Fig. 7.1.

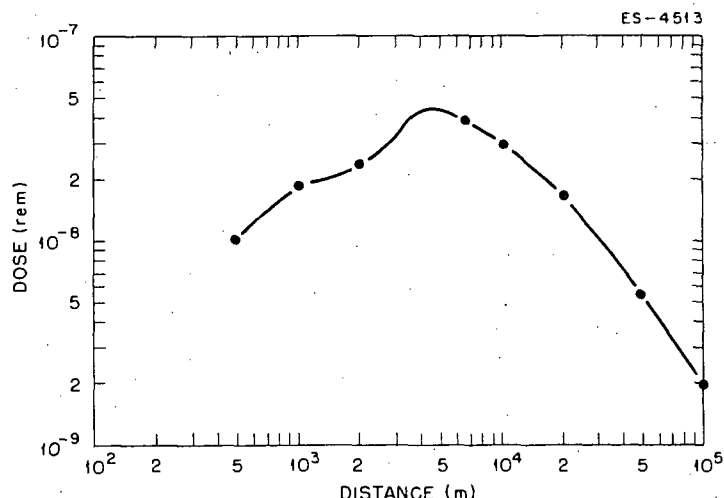


Fig. 7.1. Fifty-year lung dose commitment as a function of distance.

7.2 SUBSURFACE ACCIDENTS

7.2.1 Waste pond leakage

The description, size, and location of waste ponds are discussed in Sect. 4.6. The volume of liquid waste seeping into the ground through a ripped or corroded polyethylene liner would depend on the area exposed to infiltration and the time elapsed until repairs are made. Such leaks will be detected by a monthly monitoring program. Upon detection, liquid wastes from the leaking pond will be pumped to adjacent ponds, and the damaged plastic liner will be repaired. As a worst case, all four liquid waste ponds could develop leaks, and seepage into the ground could occur for one month without detection. As the liquid waste infiltrates into the ground, the variable lithologies below the pond will very slowly disperse the liquid waste, thereby limiting its mobility to a localized area around the ponds.

The effect of seepage will be mitigated by several factors: (1) The seepage will be passing through soils containing clays. Such clays (especially montmorillonite clay) have a cation exchange capacity of about 100 milliequivalents per 100 g of clay.⁴ The clays will absorb radium, ammonium ion, and other toxic compounds contained in the seeped liquid. (2) The seepage would have to traverse several hundred yards to reach Willow Creek. The dispersion of the seepage over this distance will aid in the absorption of toxic elements by the soil materials. The result of these effects is to reduce the volume and later the composition of the wastes, so that the impact on Willow Creek would be insignificant.

7.2.2 Failure of well casing

A casing failure in a production or recovery well could permit injected leach solution or the uranium-rich leach solution to escape into units overlying the Upper Irigaray sandstone. The

applicant reports that there is no water above the Upper Irigaray sandstone, except for a perched water table in the Willow Creek area. Therefore most leakage resulting from a failed well casing would seep into dry strata. The leakage would migrate down dip until it seeped from an outcrop or infiltrated a perched aquifer.

The applicant states that such failures would usually occur during the initial operation of a newly completed well due to improper completion. Close monitoring of injection flow and pressure will allow early detection of such a leak.

During normal operations, injection well pressure and flow rate will be monitored every 2 hr. Marked increases in flow rate at constant pressure would indicate a leak. Under such conditions the leakage rate would equal the flow rate increase over the normal value for the well. If the incremental changes are small, the leak might not be detected until lixiviant showed up at the shallow monitor well.

In the case of early leak detection, relatively small volumes of solution (1,000-10,000 gal) would be involved. Detection by a shallow monitor well would indicate a large spill. No practical method exists for reclaiming the dry strata contaminated by such a leak. However, the overall effect of such a leak would be small and comparable to a waste pond leak (see Sect. 7.2.1).

7.2.3 Well field excursions

Well field excursions are considered as potentially normal events during operation. As such, they have been discussed in Sect. 6.3.2.2. Considering the degree of monitoring for detection and the corrective actions that will be implemented to mitigate such events, the staff has concluded that such occurrences would result in minimal environmental impacts.

7.3 TRANSPORTATION ACCIDENTS

Transportation of materials to and from the Irigaray site can be categorized under three headings: (1) shipments of yellow cake from the plant to a uranium hexafluoride conversion facility, (2) shipments of process chemicals (nonradioactive) from suppliers to the project, and (3) shipments of naturally radioactive solid wastes from the site to existing tailings ponds or a licensed solid waste repository.

7.3.1 Shipments of yellow cake

The applicant proposes to ship the yellow cake product by truck to a uranium hexafluoride conversion plant. Refined yellow cake product is generally packaged in 0.208-m³ (55-gal), 18-gauge drums holding an average of 364 kg (800 lb) and classified by the Department of Transportation (DOT) as type A packaging (49 CFR Parts 171-189 and 10 CFR Part 71). It is shipped by truck an average of 2200 km (1370 miles) to a conversion plant, which will transform the yellow cake to uranium hexafluoride for the enrichment step of the light water-cooled reactor fuel cycle. An average truck shipment contains approximately 45 drums, or 16 metric tons (17.5 tons) of yellow cake. Based upon an annual production of 227,000 kg (500,000 lb) of yellow cake, approximately 15 such shipments will be required annually.

From published accident statistics,⁵⁻⁸ 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: collisions, noncollisions, and other events. Collisions involve interactions of the transport vehicle with other objects, whether moving vehicles or fixed objects. Noncollisions are accidents in which the transport vehicle leaves the transport path or deviates from normal operation in some way, such as by rolling over on its top and side. Accidents classified as other events include personal injuries suffered on the vehicle, records of persons falling from or being thrown against a standing vehicle, cases of stolen vehicles, and fires occurring on a standing vehicle. The likelihood of a truck shipment of yellow cake from the Irigaray site being involved in an accident of any type during a one-year period is approximately 0.03 to 0.05.

The ability of the materials and structures in the shipping package to resist the combined physical forces arising from impact, puncture, crush, vibration, and fire depends on the magnitude of the forces. These magnitudes vary with the severity of the accident, as does the frequency with which they occur. A generalized evaluation of accident risks by NRC classifies accidents into eight categories, depending upon the combined stresses of impact, puncture, crush, and fire. On the basis of this classification scheme, conditional probabilities (i.e., given an accident, the probabilities that the accident is of a certain magnitude) of the occurrence of the eight accident severities were developed. These fractional probabilities of occurrence for truck

accidents are given in Column 2 of Table 7.1. In order to assess the risk of a transportation accident, it is necessary to know the fraction of radioactive material that is released when involved in an accident of a given severity. Two models are postulated for this analysis, and the fractional releases for each model are shown in Columns 3 and 4 of Table 7.1. 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 fraction (loss) for Model I and Model II, the expected fractional release in any given accident is approximately 0.45 and 0.03 respectively.

Table 7.1. 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).

For Model I and Model II, the quantity of yellow cake releases to the atmosphere in the event of a truck accident is estimated to be roughly 7400 kg (16,200 lb) and 500 kg (1100 lb) respectively. Most of the yellow cake released from the container would be deposited directly on the ground in the immediate vicinity of the accident. Some fraction of the released material, however, would be dispersed to the atmosphere. Expressions for the dispersal of similar material to the environment based on actual laboratory and field measurements over several years have been developed.⁶ 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 failed in an accident. Assuming that the wind speed is 5 m/sec (10 mph) and that 24 hr are available for the release, the environmental release fraction is estimated to be 9×10^{-3} . Assuming insoluble uranium, all particles of which are in the respirable size range, and a population density of 160 people per square mile characteristic of the eastern United States,⁹ 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-rem to the lungs for Models I and II respectively.

A recent accident (September 1977) involving a commercial carrier, carrying 50 steel drums of uranium concentrate, overturned and spilled an estimated 6800 kg (15,000 lb) of concentrate on the ground and in the truck trailer. Approximately 3 hr after the accident, the material was covered with plastic to prevent further release to the atmosphere. Using the above formula and values of wind speed for a fractional airborne release for this 3-hr duration of release, approximately 56 kg (123 lb) of U_3O_8 would be released to the atmosphere. The consequence of this accident would be a 50-year dose commitment to the general population of 11 man-rem for a population density of 160 people per square mile. The consequences 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. This dosage can be compared to a 50-year integrated lung dose of 19 man-rem from natural background.

The applicant has committed to submit to the NRC an emergency action plan for yellow cake transportation accidents. This emergency action plan is intended to assure that personnel, equipment, and materials are available to contain and decontaminate the accident area. Submittal of this plan will be a license condition.

7.3.2 Shipments of chemicals to the site

Truck shipments of anhydrous ammonia to the Irigaray site, if involved in a severe accident, could conceivably result in an environmental impact. Approximately 36 shipments of anhydrous ammonia will be made annually in 5,000-gal tank trucks from Cheyenne, Wyoming, a distance of approximately 250 miles from the site.

The annual amount of anhydrous ammonia shipped in that form is approximately 7,600,000 tons. About 26% of the ammonia produced is shipped by truck. Assuming that the average truck shipment is 21 tons, approximately 93,000 truck shipments of anhydrous ammonia are made annually. From Department of Transportation accident data, there are about 140 accidents per year involving truck shipments of anhydrous ammonia.¹⁰ For an estimated average shipping distance of 250 miles, the resulting accident frequency is roughly 4.3×10^{-6} per mile. According to DOT data, an average release of 1,700 lb of ammonia resulted from approximately 80% of the reported incidents. Injury to the general public occurred in roughly 15% of the reported incidents involving a release. The injured were mainly the drivers (17 persons).

The probability of an injury to the general public resulting from an accident involving an average shipment of anhydrous ammonia is roughly 4.8×10^{-7} per mile (3×10^{-7} per kilometer). This is an overestimate for shipments in the Powder River Basin, which has a very low population density. Accepting this estimate, the likelihood of an injury to the general public from shipments of ammonia to the proposed site would be about 5×10^{-3} per year.

7.3.3 Shipment of naturally radioactive solid wastes

Low-level naturally radioactive solid wastes generated during the applicant's solution mining operations will be transported by truck to a licensed tailings pond (Sect. 4.6.4). Because of the low radioactive concentration involved, these shipments are considered to have minimum potential for significant effects as a result of transportation accidents. The applicant's emergency action plan (Sect. 7.3.1) can be initiated should unusual circumstances occur.

REFERENCES FOR SECTION 7

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8. J. L. Russell, "An Evaluation of Risk Models for Radioactive Material Shipments," in *Proceedings of the 4th International Symposium on Packaging and Transportation of Radioactive Materials, September 22-27, 1974, Miami Beach, Florida*, Report CONF-740901, 1974.
9. U.S. Bureau of the Census, *Statistical Abstract of the United States; 1976*, 97th ed., U.S. Government Printing Office, Washington, D.C., 1976.
10. Unpublished incident reports, 1971-1975, Office of Hazardous Materials, Department of Transportation.

8. MONITORING PROGRAMS AND OTHER MITIGATING MEASURES

8.1 PREOPERATIONAL SURVEYS

This section discusses the surveys conducted by the applicant to document the preoperation characteristics of the site environment.

8.1.1 Hydrological surveys

The applicant conducted one-time sampling in the Powder River at two locations (see Sect. 2.6.1). No sampling was done for Willow Creek. In addition, the applicant will initiate an expanded surface water sampling program that includes additional sampling points on the Powder River and Willow Creek (Fig. 8.1).

Groundwater sampling by the applicant was initiated for private wells in the area in 1974 (see Sect. 2.6.2.4). Onsite groundwater sampling has been conducted in association with the development of the two pilot-scale test operations (see Sect. 2.6.2.4). Additional groundwater sampling will be conducted in well field areas as discussed in Sect. 8.1.5.2.

8.1.2 Meteorological survey

An onsite weather station was established by the applicant in September 1975 to record temperature, precipitation, relative humidity, and wind speed and direction. Insufficient time has elapsed to collect a representative data base (minimum of five years of record).

8.1.3 Ecological surveys

A baseline ecological study was conducted for the applicant on T44N, R77W, just south of the Irigaray lease area, from late November 1974 to mid-April 1975 (Appendix C). The study consisted of transect trapping for rodents and visual counts of other terrestrial vertebrate species. Vegetation studies consisted of determination of vegetative cover by stratified sampling in three 10-ha plots. The study did not include sampling of aquatic habitats.

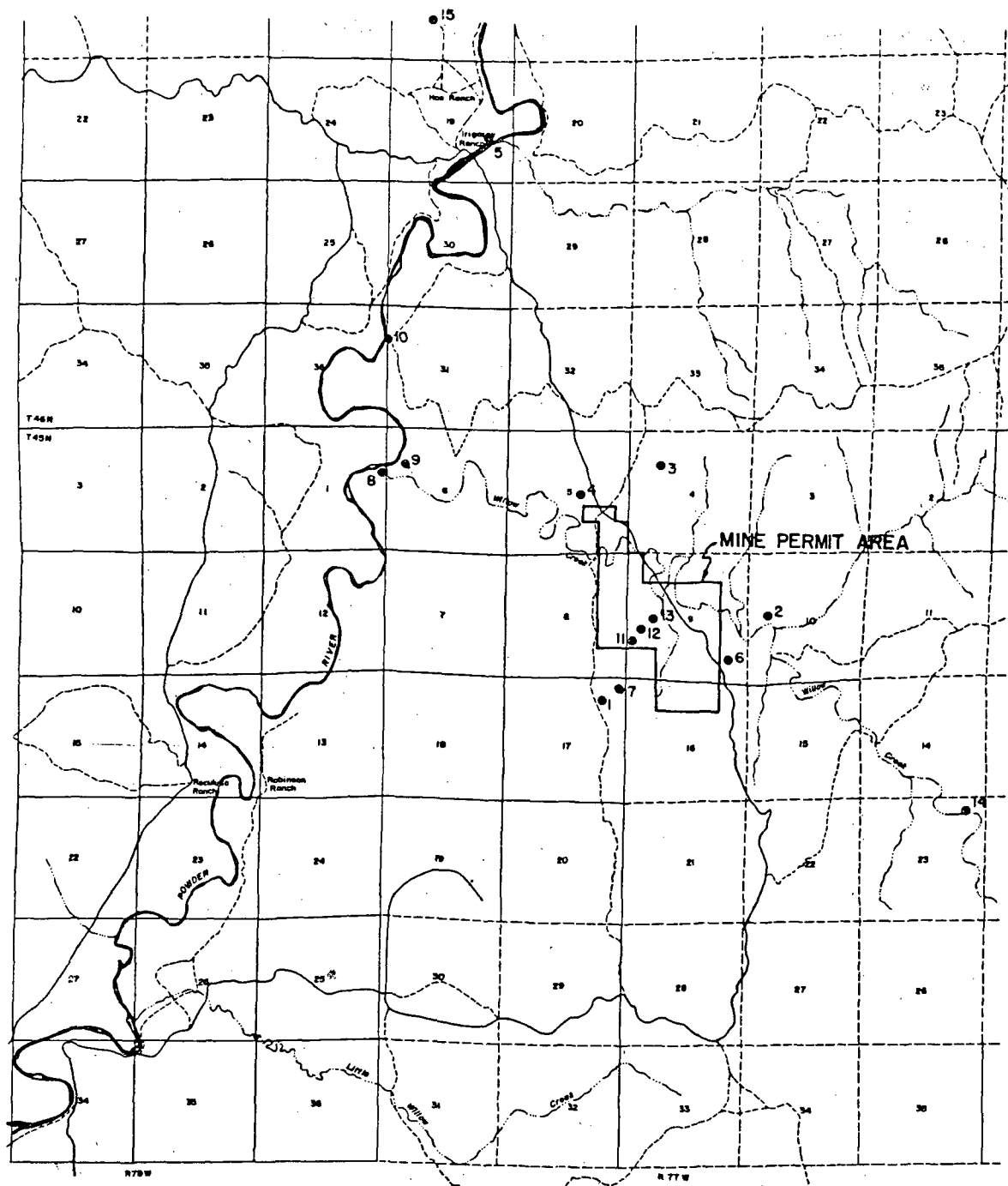
8.1.4 Radiological surveys

The applicant collected samples of soils and vegetation from the immediate site environment in November 1976. Additional soil and vegetation sampling has been conducted at ten sample points, as shown in Fig. 8.1. The results of the subsequent analyses for radioactivity and selected radionuclides are given in Table 8.1.

The applicant has also determined the radioactivity in the ore zone aquifer where solution mining will be conducted. The groundwater contained 63 ± 8 pCi/liter of radium-226, 3.4 ± 1.2 pCi/liter of thorium-230, and about 4 mg/liter of natural uranium. This water exceeds the drinking water standard of 5 pCi/liter for radium.¹ Measurements of groundwater in the same aquifer formation outside the mineralized zone showed values reduced by more than an order of magnitude.

Recent water samples from the Powder River obtained by the State of Wyoming Department of Environmental Quality and analyzed for radium-226 by U.S. EPA Region VIII in Denver are shown in Table 8.2. They indicate that radium-226 concentrations in the Powder River may be lower than the levels measured by the applicant, which are shown in Table 2.8. Variations may be due to the time of sampling, analytical techniques employed, and/or sampling techniques used.

Willow Creek, an intermittent stream on the site, was not sampled. No discharges to surface waters are planned by the applicant during project operations.



LEGEND:

SURFACE WATER SAMPLE SITES - 5, 8, 9, 10, 14

SOIL AND VEGETATION SAMPLE SITES - 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, 15

AIR SAMPLE SITES - 1, 2, 3, 4, 5, 11, 12, 13

1 1/2 0 1 MILE

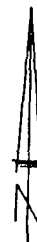


Fig. 8.1. Radiological baseline and monitoring sample points. Source: Wyoming Mineral Corporation, Application for In Situ Permit to Mine for the Irigaray Site, submitted to the Wyoming Department of Environmental Quality, Land Quality Division, April 1978 (revised 6/23/78).

Table 8.1. Radiological baselines for soil and vegetation as provided by the applicant

Sample point	Total uranium ($\mu\text{gU/g}$)	Radium-226 (pCi/g)	Gross α (pCi/g)
Soil			
1	0.48	0.71 ± 0.06	15 ± 2
2	0.42	0.54 ± 0.05	18 ± 3
3	0.56	0.89 ± 0.10	9.3 ± 4.0
4	0.31	0.57 ± 0.08	5.8 ± 1.5
5	0.24	0.51 ± 0.05	5.4 ± 1.6
6	0.42	0.29 ± 0.05	5.2 ± 0.9
7	0.29	0.43 ± 0.04	3.9 ± 0.8
8	0.50	0.53 ± 0.05	4.3 ± 0.9
10	0.61	0.54 ± 0.05	29 ± 2
Vegetation			
1	0.12	0.15 ± 0.02	1.4 ± 0.7
2	0.15	0.13 ± 0.03	1.8 ± 0.7
3	0.11	0.22 ± 0.03	1.0 ± 0.4
4	0.17	0.22 ± 0.04	2.4 ± 0.8
5	0.04	0.04 ± 0.02	0.4 ± 0.1
6	0.11	0.15 ± 0.04	1.5 ± 0.6
7	0.06	0.85 ± 0.31	1.0 ± 0.5
8	0.03	0.09 ± 0.03	3.9 ± 0.8
10	0.15	0.06 ± 0.02	1.7 ± 0.5

Table 8.2. Dissolved radium-226 concentrations in the Powder River

Station	Location	Radium 226 (pCi/liter)
PR-1	Powder River upstream from Willow Creek	0.20
PR-2	Powder River downstream from Willow Creek	0.25
PR-3	Powder River at Interstate 90 bridge	0.36
PR-4	Powder River at Arvada	0.48
PR-5	Powder River north of Arvada	0.45

Samples collected by D. Harp, Wyoming DEQ, June 7-8, 1977.

8.1.5 Staff recommendations

An effective monitoring program should be initiated with preoperational monitoring and continue throughout the operational and postoperational phases of a project. The locations of sampling points and the data obtained during preoperational monitoring or surveys must be sufficient to characterize the existing environment. Operational (and postoperational) monitoring should indicate any changes from preoperational values and initiate measures to reduce or mitigate environmental impacts. On this basis, some aspects of the applicant's preoperational monitoring for the proposed operation are deficient, and the staff makes the following recommendations.

8.1.5.1 Surface water baseline

Wyoming Mineral Corporation's preoperational monitoring of surface waters consisted of chemical analyses at two stations on the Powder River; the results are summarized in Table 2.8. These data, however, do not adequately define baseline water quality conditions in the Powder River. The NRC staff recommends that WMC pursue as soon as possible an expanded baseline survey of surface water quality near its facilities. In addition to the two stations already established, WMC should sample at a third station located farther downstream from the Irigaray Ranch near

WMC's northern property boundary. Currently, WMC's "downstream" station is located at the Irigaray Ranch. As discussed in Sect. 6, if a lixiviant excursion occurred, the direction of groundwater flow might bring contaminated groundwater to the Powder River somewhere near the Irigaray Ranch. Later sampling at this station might not fully reveal contamination of surface waters. Thus a sampling point farther downstream is necessary. The water quality of the Powder River should be sampled quarterly for one year. The water quality in Willow Creek should be sampled during the period of spring flow. Constituents and characteristics that should be sampled for are listed in Table 8.3. In presenting the results, the dates of sampling, analytical techniques, and numbers of samples taken should be specified. A review of the first year's sampling results will be made to determine the need for additional baseline monitoring.

Table 8.3. Physical and chemical parameters for baseline survey of surface water and groundwater^a

Ammonia (as NH_4)	Gross alpha and beta	Potassium
Arsenic	Hardness (as CaCO_3)	Radium 226
Barium	Iron	Selenium
Bicarbonate (HCO_3)	Lead	Silica
Boron	Magnesium	Silver
Cadmium	Manganese	Sodium
Calcium	Mercury	Sulfate
Carbonate (as CO_3)	Molybdenum	Total dissolved solids
Chloride	Nickel	Thorium 230
Chromium, hexavalent	Nitrate (NO_3)	Vanadium
Conductivity	Nitrite (NO_2)	Uranium (U_3O_8)
Copper	pH	Zinc
Fluoride		

^a Discharge should be determined for surface water; water level should be determined for groundwater.

8.1.5.2 Groundwater baseline

The establishment of groundwater baseline is a prerequisite for both the groundwater monitoring program and identification of restoration requirements for a uranium in situ leaching operation. Therefore, considerable importance is placed on the establishment of a baseline which thoroughly characterizes the site premining groundwater environment. This objective can be attained only when detailed information is available on the hydrogeologic environment at the site (see Sect. 8.2.3.1).

Groundwater baseline procedures have been developed and approved by the State of Wyoming. The permit and license to mine approved by the State requires that water quality data for each production well field be submitted to the State for review 60 days prior to planned injection of leach solution in the well field. The applicant must receive the approval of the State to proceed with leaching operations in each well field. The staff recommends that baseline determination for the proposed mining units should be conducted initially as follows:

Sample points

Sample points will consist of monitor wells and wells located within the proposed well field. Each monitor well, including surrounding shallow and deep monitor wells, should be sampled for baseline groundwater quality determination. A minimum of one well per each 0.8 ha (2 acres) of well field should be sampled to determine the initial baseline in well fields (mining zone). These wells should be randomly distributed within the planned production unit, and the sampled wells should be identified for future reference. In addition to the establishment of baseline, sample wells in the well field area will be used during restoration verification and monitor wells will be used during operational monitoring.

Sampling frequency

For the initial production units, sampling should include a minimum of three water samples from each monitoring and designated production unit well. These samples should be obtained at intervals of no less than two weeks.

Sample parameters

A list of parameters for analysis during baseline determination is shown in Table 8.3. As a basis for verification of restoration, the applicant should maintain a quality control procedure for

the sampling and analytical methods to be used during all phases of the project. To ensure that a representative sample of formation water is obtained, it is recommended that at least one bore hole volume be withdrawn before sampling. Furthermore, the sample for laboratory analysis should not be drawn until the electrical conductivity of the well water has stabilized. Proof of stabilization may be defined as no significant change in electrical conductivity for three successively drawn preliminary samples. During operation, selected parameters will be analyzed as part of the operational monitoring program (see Sect. 8.2.3.4).

Baseline sampling and analysis will establish the chemistry of groundwater and provide the necessary values to determine the quality of the groundwater. As discussed in Sect. 5.1, available groundwater chemistry data from the Irigaray site indicate the presence of two distinct areas. Groundwater within the mineralized portion of the host aquifer is generally unfit for consumption because of high concentrations of natural radioactivity and possibly other toxic elements (e.g., arsenic and selenium). In nonmineralized areas of the host aquifer, groundwater is generally of a quality that is suitable for either domestic or livestock use. The staff also recognized that the values obtained during baseline establishment are subject to considerable variation as a result of sampling procedures, analytical methods, and the natural variability of the groundwater both spatially and temporally. However, as the proposed limited operation develops, additional hydrogeologic data will become available. This data will be made available to the appropriate agencies, and refinements to the groundwater baseline program can be made within the hydrogeologic framework of the specific site.

8.1.5.3 Ecological baseline

Mining activities in the Willow Creek streambed, scheduled to begin in 1982, could potentially have adverse impacts on any biological communities downstream (Sect. 6.3.1.1). The NRC staff recommends that WMC undertake a survey of Willow Creek between the Powder River and the mining area to determine if significant biological communities exist there. Such a survey would assist WMC in developing optimum procedures to control and mitigate impacts of activity in the streambed and would provide a baseline for comparison if impacts are suspected following mining activity. Surveys should be performed (1) during the period of spring streamflow, (2) in midsummer, and (3) during the fall. Because the flow of Willow Creek is intermittent, these surveys need not be elaborate. Surveys should determine (1) the concentration of suspended sediments, (2) the presence of streamflow and/or temporary pools (Sect. 2.9.2), (3) the abundance of aquatic organisms, and (4) the presence or absence of suitable habitat for fish spawning.

8.2 OPERATIONAL MONITORING

8.2.1 Waste pond monitoring

During operation, all liquid and solid waste streams will be contained in lined ponds (Sect. 4.6.2). As shown in Fig. 4.8, the waste ponds will be underlain by a leak detection system. The inspection tubes for these ponds will be monitored weekly for the presence of liquid. The waste pond monitoring program will meet the requirement of the State of Wyoming.

8.2.2 Radiological monitoring

Solution mining eliminates the radioactive tailings that are generated in conventional uranium mining and milling operations. To produce 500,000 lb of yellow cake from 0.15% uranium ore by usual mining and milling methods would generate about 170,000 dry tons of radioactive waste.² The same production from a solution mining operation is expected to produce about 1% as much waste (see Sect. 4.6.3). The wastes from solution mining operations will be stored in evaporation ponds for later transfer to an active mill and tailings pond (Sect. 4.6.4).

The applicant's environmental monitoring program, as modified by the staff, will continue throughout all phases of operations. The radiological monitoring program is shown in Table 8.4. The applicant's sampling program will also enable better estimates of radon releases from well field surge tanks. These activities will be license conditions.

The sampling frequency and the number of sampling locations may be changed in the future due to changing environmental and demographic patterns. Such modifications will be subject to approval by the NRC.

Table 8.4. Operational radiological monitoring program^a

Environmental element	Sampling location	Sampling frequency	Type of measurement
Air	Yellow cake dryer stack	24-hr sample, weekly	Uranium
Surface water	Surface impoundments ^b and affected drainage	Quarterly, following precipitation event	Uranium, Ra-226, Th-230, Pb-210, suspended solids, sediment
Air	Well field surge tanks	Monthly	Rn-222 or radon daughters
Air	Air quality monitoring sites	24-hr sampling at monthly intervals	Ra-226, Th-230, uranium
Soils, vegetation	At the air quality monitoring sites	Annually	Ra-226, Pb-210

^aThe monitoring program will be specified in the license. In addition the water quality in the ore zone aquifer will be monitored as discussed in Sect. 8.2.3.

^bStock watering ponds.

8.2.3 Well field monitoring

Well field monitoring procedures will define an area of containment for leachate injected during the mining operation. Well field monitoring will be the surveillance technique for initiating corrective actions in the event of leachate migration. It will be effected through the use of monitor wells and may be supplemented by trend wells installed by the applicant for production control purposes. The specific well field monitoring program has been specified in the mine permit application and approved by the Wyoming Department of Environmental Quality.

8.2.3.1 Monitor wells

Monitor well location involves both surface spacing and subsurface placement in order to effectively determine the containment of the leach solution. On the surface, wells will be spaced around the perimeter of the well field so that any migrating leach solution (excursion) will be detected. Subsurface emplacement involves the location of monitor wells in the aquifers above and below the production zone aquifer. The locations of monitor wells should be optimized to assure that the injected leach solution is effectively confined to the production zone.

The applicant proposes to place monitor wells no closer than 120 m (400 ft) from the limit of mineralization and no further than 305 m (1,000 ft) from the well field (ER, p. 141). The State of Wyoming desires that monitor wells should not be located more than 60 m (200 ft) from the perimeter of the production area (well field) or if trend wells are used, at distances no greater than 120 m (390 ft).³

Monitor wells must effectively act as a control to contain the leach solution within the production zone to minimize environmental impact. To accomplish effective containment, a number of factors must be considered in the surface spacing of monitor wells. These include the following:

1. Site geological and hydrological variations must be evaluated, including (a) local variations in groundwater flow rates and direction, (b) local variations in permeability or zones of significant hydraulic conductivity, and (c) presence of subsurface geologic features (channels, clay lenses, facies changes, etc.).
2. Monitor wells should be spaced so that their respective zones of influence overlap.
3. Monitor wells should be located at a distance from the well field so as not to intercept normal operating fluid flows: (a) the zone of influence during monitor well sampling must be considered, and (b) sufficient distance should be available so that trend wells can be installed for normal operational controls.

The State of Wyoming's monitor well location requirement will be adhered to by the applicant until further site-specific data have been developed and evaluated.

8.2.3.2 Trend wells

Trend wells may be drilled within the monitor well ring at the operator's discretion. These wells would be for production control and will not necessarily be analyzed for the same parameters as required for monitor wells. Changes in the water quality of samples from trend wells would not signal the need for corrective action by the operator. Rather, they would initiate a production evaluation by the operator to determine the cause of this occurrence. Appropriate adjustment action by the operator would then take place. The staff believes that the use of trend wells by an operator will reduce the potential for leach solution to migrate to a monitor well. Therefore, their use is recommended but not required.

8.2.3.3 Shallow and deep monitor wells

These wells will be installed to permit monitoring of the aquifer or dry formation immediately above or below the confining mudstone or shale that overlies or underlies the mineralized formation. These wells should be placed within the well field area, and a minimum of one shallow and one deep monitor well for each 2 ha (5 acres) of well field is recommended.

8.2.3.4 Monitor well sampling

Monitor wells will be sampled every two weeks during project operations. The permit and license to mine approved by the State of Wyoming Department of Environmental Quality requires for each routine sampling water level measurements in the wells and groundwater sample analyses for conductivity, chloride, alkalinity (as calcium carbonate) and sulfate. Excluding sulfate, the analyses of these parameters will serve as "lead indicators" to establish the presence of a potential leachate excursion. The indicators were selected on the basis of relative mobilities in the aquifer and laboratory results are to be available within 48 hours of the sampling.

8.2.3.5 Upper control limit

An upper control limit (UCL) will be used to indicate a deviation in groundwater chemistry from the baseline concentrations. This deviation would indicate that migration (excursion) of lixiviant may be occurring and would initiate the appropriate corrective action(s). For the lead indicators identified above (Sect. 8.2.3.4), the permit and license to mine approved by the State established the UCL's as 15 percent above baseline for total alkalinity, 10 percent above baseline for conductivity and 5 ppm above baseline for chloride. If a biweekly monitor well assay exceeds the UCL values for two indicators, sampling will be repeated within 48 hours. If the second analysis shows that two parameters have again exceeded the UCL, an excursion status for the well will be established and appropriate correction action initiated. The permit requires notification of the State of the excursion status within 48 hours.

8.2.3.6 Corrective actions

A corrective action procedure will ensure the containment of the leach solution. For maximum effectiveness, the corrective action requires consideration of a number of factors including (1) spacing of monitor wells (Sect. 8.2.3.1), (2) relative mobilities of the various contaminants, (3) uniform measurement and reporting procedures, and (4) response measures consistent with the detected release.

If an excursion is verified, the plant supervisor will have several alternative methods for containing and correcting the migration of leach solution. The principal corrective action

procedures are overpumping, reordering the pumping balance of the well field, reducing or stopping injection, ceasing both injection and recovery pumping, injecting a solution of reduced concentrations, establishing a water fence, or the beginning of restoration procedures. These methods may be applied locally to a few wells within a cell, to the entire cell, to several cells, or to the entire well field as the situation dictates. Current corrective action methods are described as follows:

1. Overpumping. This method involves adjusting pumping so that the rate of flow into the injection wells is exceeded by the flow from the recovery wells. The net result is a general inward movement of native water.
2. Reordering. This is a variation of overpumping in that different ratios are applied to different areas in the well field. Hence the inward movement of native water may be emphasized at one point or another. Reordering may further include direct pumping from one part of the field to another.
3. Reducing injection. This is the second way to adjust the ratio of recovery flow to injection flow. At the same time it reduces the amount of leach solution introduced into the production zone in the vicinity of the wells concerned.
4. Ceasing pumping. This method stops both the injection and recovery flows. Exclusive of the effects of natural forces (e.g., natural migration of groundwater), which are orders of magnitude less, this should retard the further migration of leach solution beyond the established boundaries.
5. Beginning restoration. This step can be utilized when all other efforts have failed to halt the migration of leach solution beyond the farthest allowable limits.

As part of the corrective action procedure, the operator may be required, by the drilling of a detection well(s), to locate the extent of migration beyond the monitor well. Detection wells would be necessary if a public water supply may be affected or should a prolonged excursion occur. The detection well(s) would be sampled during corrective action to verify that the excursion is being controlled and/or corrected.

The applicant will be required to report in writing to the NRC within 30 days after an excursion has been detected. The report will describe the corrective action taken and an evaluation of the results achieved. If corrective action is continuing at the time of the report, a subsequent report shall be filed that describes and evaluates the final results. (Depending on the nature of the event, the NRC may require periodic reporting on the status of the corrective action.) The applicant will also notify the appropriate Wyoming State agency in accord with their requirements.

8.2.3.7 Postrestoration monitoring

After completion of restoration of the first production well field, the applicant will be required to conduct a postrestoration monitoring program. This program will be used to evaluate the effectiveness of the proposed restoration plan. The staff recommends the following: a minimum of two wells to establish baseline in the mining zone, a minimum of two monitor wells in the direction of maximum hydraulic conductivity, and a minimum of two trend wells (if used) to form the basis for postrestoration monitoring. If trend wells are not used, then at least two wells should be drilled between the well field and monitor well for this purpose. These wells should be sampled quarterly to evaluate restoration effectiveness.

Using the results of the experimental plans for the 517 test area discussed in Sect. 6.3.2.2 as a basis, the applicant will provide a postrestoration monitoring program prior to the beginning of restoration. This monitoring will be required as a license condition.

8.2.3.8 Postmining monitoring

After mining and restoration have been completed in other mining units, the applicant will sample every 45 days for a six-month period to verify restoration stabilization.

The staff recommends that at least one monitor well per production unit, and a shallow and a deep monitor well from a production unit, be made available for monitoring use throughout the duration of the licensing period. Annual sampling and analysis should be conducted on each of the wells.

8.2.3.9 Record keeping and reporting

All officially transmitted monitor well records will be prepared at the WMC office in Denver and returned to the Irigaray site for reporting requirements and site cumulative records. Required reporting will be to both the State of Wyoming and NRC unless otherwise specified.

8.2.4 Ecological monitoring

The WMC's plans for hydrological monitoring and erosion control measures should prevent the release of sediments or other constituents harmful to biota. The ecological baseline discussed in Sect. 8.1.5.3 will determine if significant biological communities exist in Willow Creek. The results of that survey will be reviewed to determine the need for an operational ecological monitoring program. Until this is completed, if significant releases of sediments or other constituents occur, WMC should undertake an ecological survey of Willow Creek or the Powder River in order to assess the extent of any damage to biota.

REFERENCES FOR SECTION 8

1. U.S. Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," as amended by 41 FR 28402, July 1976.
2. M. B. Sears et al., *Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing "as Low as Practicable" Guides - Milling of Uranium Ores*, Report ORNL/TM-4903, vol. 1, May 1975, p. 135.
3. Wyoming Department of Environmental Quality, Land Quality Division, "Guideline to Apply for an In Situ Recovery Mining Permit," June 1, 1978, p. 9.

9. UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

9.1 AIR QUALITY

The unavoidable impacts of solution mining activities upon the air quality in the area will be minimal. Some increase in suspended particulates from vehicular traffic on roads will occur, but the resulting impact upon the air quality will be minor. The anticipated small chemical emissions from the recovery facility and evaporation ponds will have a negligible impact on the air quality of the area.

9.2 LAND USE

There will be a temporary change in land use of about 29 ha (70 acres) from livestock grazing to mineral extraction during the limited project operations as proposed by the staff (Sect. 5.1.5). Ranchers will be inconvenienced by changes in land-use patterns.

The project area is presently of low potential for intensive recreation use and development, and no unique scenic or natural features are present. There are no existing recreation facilities within the project area. For these reasons, it is considered unlikely that any significant adverse environmental impacts will occur, except some loss of hunting opportunities.

9.3 WATER

9.3.1 Surface water

Some local deterioration of water quality may occur, although no surface discharges are planned during project operations. Additionally, removal of protective vegetative cover and other soil disturbance will cause increased sedimentation during development and mining activities.

9.3.2 Groundwater

Approximately 1.2×10^6 m³ (1000 acre-ft) of groundwater will be permanently removed from the aquifer, mostly during restoration activities. Some project-induced degradation of groundwater quality may occur. This loss will be in addition to localized naturally contaminated groundwater.

9.4 MINERAL RESOURCES

No unavoidable adverse effects on mineral resources are expected, other than the extraction of the uranium. In addition to the environmental effects of solution mining of uranium discussed herein, other subsequent and related impacts will occur, the kind and intensity of such impacts being dependent on disposition of the refined ore. Assuming that the uranium will be used to fuel steam-electric systems, the environmental effects associated with the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transport of radioactive materials, and management of radioactive wastes are relevant to the proposed project. The nature of these environmental effects is presented within the scope of the AEC report entitled "Environmental Survey of the Uranium Fuel Cycle" and in NUREG-0116 "Supp. 1 to WASH-1248," October 1976.¹

9.5 SOILS

The alteration of near-surface soil characteristics which have developed over long periods of geologic time cannot be avoided. Disturbance of soils may lower the natural soil productivity to some degree because of soil compaction and accelerated erosion.

Soil disturbance on the 29 ha (70 acres) used for the recovery process building site, evaporation ponds, and well fields cannot be avoided. The soil disturbance will not be severe, since only a few inches of soil material will be affected. A total of 400 ha (1000 acres) may be disturbed over the life of the project.

9.6 ECOLOGICAL

9.6.1 Terrestrial

Vegetation on approximately 400 ha (1000 acres) may be disturbed over the life of the project; about 29 ha (70 acres) will be disturbed during the limited operation proposed by the staff. Plant species composition and diversity will be altered due to the disruption of the natural vegetation and subsequent revegetation.

Loss of habitat for most wildlife populations on disturbed areas will occur as a result of project operations. Habitat removal is expected to be temporary.

9.6.2 Aquatic

Some minor impact on the aquatic system is expected. This impact will primarily result from increased sedimentation caused by well field operations.

9.7 RADIOLOGICAL

Radioactive emissions from excavated ore will not result from solution mining. The local environment will continue to be shielded by earth materials overlying the radioactive ore deposits. However, some small increase in the level of radioactivity is expected from emissions from the recovery plant and well field facilities.

9.8 SOCIOECONOMIC

No unavoidable adverse socioeconomic impacts on the local community are expected.

REFERENCE FOR SECTION 9

1. "Environmental Survey of the Uranium Fuel Cycle," U.S. Atomic Energy Commission, Directorate of Licensing, Fuels, and Materials, WASH-1248, April 1974 and Supp. to WASH-1248, October 1976.

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

10.1 THE ENVIRONMENT

10.1.1 Surface elements

The short-term increases in suspended particulates and chemical emissions associated with project activities are expected to have no effect upon the long-term quality of the atmosphere in the project area.

Project operations will cause a short-term reduction in carrying capacity of the local grazing resource and some reduction in hunting opportunities.

Well field development will result in not over 20 ha (50 acres) of vegetative cover lost during the limited operation proposed by the staff (Sect. 5.1.4).

Waste ponds, pipelines, access roads, and plant buildings will occupy only a small portion [2 to 4 ha (5 to 10 acres)] of the site.

Proposed monitoring and mitigating measures will assure that minimal short-term effects from project operations will occur.

After reclamation there should be no long-term effects on surface productivity.

10.1.2 Underground effects

The extraction of uranium (short-term usage) will not preclude extracting other minerals of current or future economic importance at a later date.

The short-term extraction of groundwater at up to $1.2 \times 10^6 \text{ m}^3$ (1000 acre-ft) during the limited operation, mostly during well field restoration, should not adversely affect other users of the aquifer.

Restoration of the mined aquifer region to the available level of use prior to mining has not yet been completely demonstrated. Restoration techniques are under test. If unsuccessful, the mined aquifer region (mining zone) would be unavailable for irrigation or stock water wells. This zone is currently contaminated due to natural radioactivity. With the addition of contaminants from solution mining, however, this would represent a long-term impact for about 20 ha (50 acres) of aquifer area.

10.2 SOCIETY

No significant short-term or long-term impacts on the local communities can be expected from this project, since it will not be a large factor in the local economy.

11. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

11.1 LAND AND MINERAL RESOURCES

After reclamation, no land resources are considered lost.

The uranium produced is irreversibly and irretrievably lost when used to produce power from a nuclear reactor.

11.2 WATER AND AIR RESOURCES

Water used in the project, primarily during aquifer restoration, is recycled to the atmosphere for distribution elsewhere. The aquifer will eventually become recharged from natural sources. Air is self-cleaning of pollutants at the low concentrations expected. The displacement of these resources is small in comparison with the benefits derived from the mined uranium.

11.3 VEGETATION AND WILDLIFE

These resources are renewable, and while some irreversible and irretrievable commitment is required, it is relatively small. Reclamation will require a commitment of human and financial resources for an undetermined period of time.

11.4 MATERIAL RESOURCES

Irreversible and irretrievable commitments of construction materials will be made for well completions, plant buildings, and other activities.

Chemicals and reagents used during solution mining will also not be recoverable for reuse. The fuels used for vehicles, heating, and plant processing will also be irretrievably committed.

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

12. ALTERNATIVES

12.1 MINING ALTERNATIVES

Selection of a mining technique to recover a mineral resource is based upon several complex and interrelated factors, including (1) the spatial characteristics of the deposit (size, shape, and depth), (2) the physical (or mechanical) properties of the mineral deposit and surrounding geological structure, (3) groundwater and surface water conditions, (4) economic factors, including ore, grade, comparative mining costs, and desired production rates, and (5) environmental factors, such as preservation and reclamation of the environment and the prevention of air and water pollution. The two most commonly used methods for mining uranium deposits are open-pit (surface mining) and underground mining. Other mining methods, such as solution mining (in situ leaching and bore hole), are currently in the developmental stage.

12.1.1 Open-pit mining

Open-pit mining is used for relatively shallow ore deposits. A pit is created when the overburden and topsoil overlying the ore body are removed to permit mining of the ore. The overburden and topsoil are stored and stabilized to meet future reclamation requirements. The mining depth is determined by economic factors: the point where the cost of mining a ton of ore is equal to the market value plus profit. To recover the uranium, the extracted ore must be processed in a mill (Sect. 12.2).

Although the applicant has initially decided to use in situ leaching methods to mine the ore, the eventual use of open-pit mining has not been precluded. As additional data are gathered during the development drilling that precedes solution mining activities, the applicant will be evaluating the economic viability of using other mining methods, such as open-pit mining, for ore extraction.¹ The decision to use alternative mining methods will be dependent on encountered ore grade and thickness, geological configurations, and other relevant decision parameters. Applications will be submitted to appropriate licensing authorities for necessary approval if any decisions are made to implement alternative mining methods.¹

The environmental impacts associated with uranium open-pit mining operations are well documented.²⁻⁵ For example, the Bear Creek open-pit mining and milling project located in the Powder River Basin has a comparable U_3O_8 production rate and will disturb about 650 ha (1600 acres) of surface area, with up to 1000 gpm (2000 acre-ft per year) of local groundwater being removed during pit dewatering for approximately 15 years.³ Long-term impacts are primarily associated with changes in topography resulting from overburden dumps and pits which remain after mining operations are completed. Since conventional milling methods must be used to process the ore, measures to alleviate the short-term and long-term environmental impacts associated with the disposal of mill tailings must be determined and evaluated. Because more mill and mine personnel would be needed for a conventional milling/open-pit mining operation (compared to solution mining), more significant socioeconomic impacts would occur. Open-pit mining (as shown by the Bear Creek example) would disturb a much larger surface area and completely alter the underlying geologic material. Additionally, the proximity of the ore deposits to the Powder River could result in more significant impacts to the river from open-pit mining and milling activities.

Many alternatives exist for the reclamation of uranium surface mines. Generally, overburden and topsoil are stored in dumps during mining, with the overburden being used to refill the pit (perhaps partially) and the surface being shaped to a rolling topography with slopes ranging from 0 to 30%. Salvaged topsoil is then distributed over the contoured surface. The restored surfaces are revegetated with plant species, using the necessary fertilizers and soil amendments to ensure plant growth. Precautions are taken to stabilize the soil against erosion and to provide watershed protection.

12.1.2 Underground mining

Underground mining is the method generally used for deeper, relatively high-grade ore deposits in structurally stable host rock. Basically, a vertical mine shaft is constructed to the depth of the ore body, with horizontal tunnels being utilized to remove the ore. Air shafts ventilate

the mine, and extensive dewatering facilities are usually required. After mining operations have ceased, the equipment and buildings at the mine shaft and the mining equipment are removed. Air shafts and the mine shaft are sealed (probably with concrete), covered with topsoil, with the area being revegetated with appropriate plant species to stabilize the soil.

The applicant has rejected the underground mining alternative due to geologic conditions and economic factors (ER, p. 190). The relatively low-grade ore and the nature of the host sandstone rock at the Irigaray site make this alternative impractical for the present. To recover the uranium, the ore must be mill-processed (Sect. 12.2).

12.1.3 Solution mining (in situ leaching)

A general discussion of solution mining (in situ leaching) is presented in Sect. 3, while specific details of the applicant's proposed activities are addressed in other sections of this Statement. As noted throughout this document, in situ leaching is a developing technology and considerable variation exists from one operation to another.⁶

In situ leaching is a relatively new technique for uranium extraction on a commercial scale, with both operational and environmental considerations being very site specific. The disposal of waste solutions and/or contamination of the aquifers represent the major areas of environmental risk which must be examined carefully.

Uranium deposits which are small, isolated, and unsuitable for mining by other methods may be recovered by in situ leaching under the following general conditions:

1. The ore is generally horizontal and is confined by impervious layers such as shales, siltstones, or mudstones.
2. The ore is in a saturated stratum below the static water table.
3. The ore body must possess suitable mineralogic and hydraulic properties, that is, adequate permeability and amenability to chemical leaching.
4. A maximum recovery of the acidic or alkaline leach solution is possible. A primary impact of concern involves the possibility of incomplete recovery of the leachate.

The applicant conducted pilot-scale testing on the Irigaray deposit to ascertain the feasibility of uranium recovery by solution mining, concluding that, initially, utilization of in situ leaching was the most suitable mining alternative. However, according to the applicant, the mining plan is a "living plan"; that is, the plan will change as changes in environmental, economic, or regulatory circumstances are altered.¹ Initially, the applicant proposes a solution mining facility utilizing an ammonium bicarbonate and hydrogen peroxide lixiviant. As pointed out in Sect. 12.1.1, the applicant may later use open-pit mining techniques.

12.1.3.1 Alternative leach solutions

Both alkaline and acidic leach solutions may be used in uranium in situ leaching operations depending on formation constituents. An acidic lixiviant generally results in higher concentrations of mobilized constituents, such as selenium, arsenic, vanadium, and molybdenum, which may be present in the ore. The use of an alkaline leach solution may result in a lower uranium recovery rate than if the acidic lixiviant is used; however, lower mobilized concentrations of other ore constituents would result. Additionally, alkaline lixiviants are favorable for ore deposits having high carbonate content; such ores will neutralize substantial quantities of an acid lixiviant, increasing operating costs.

The applicant has determined that an alkaline leach solution is the better lixiviant for extracting uranium from the Irigaray ore deposits (ER, p. 107). An alkaline lixiviant could include a sodium, magnesium, calcium, or ammonium carbonate/bicarbonate solution as the mobilizing reagent in the presence of an oxidant (hydrogen peroxide). Because test results indicate that ammonium bicarbonate is suitable as a mobilizing compound, the applicant will utilize an ammonium bicarbonate and hydrogen peroxide lixiviant. However, as is the case for alternative mining methods, changes in the environmental, economic, and regulatory climate may require changes within the solution mining alternative. The applicant has indicated that it may apply for permission to change lixiviant chemistry within the first two-year period of operations.¹

12.1.3.2 Comparison of impacts of in situ leaching of uranium with underground and open-pit methods

Impacts associated with in situ leaching of uranium are generally less severe than the impacts associated with conventional open-pit and underground uranium mining. Environmental advantages of the in situ leaching method include the following:

1. minimal surface disturbance,
2. less solid wastes, no mill tailings,
3. less air pollution compared with conventional uranium mining and milling,
4. minimal surface subsidence from in situ leaching,
5. possible restoration of the mine site to an "unrestricted use" status within a relatively short time, providing that the solid wastes are removed from the site or are otherwise restricted from contaminating the surface and subsurface environment, and
6. smaller radiological releases than in conventional mining and milling, particularly the release of radon-222.

Socioeconomic advantages of in situ leaching include the following:

1. ability to mine a lower grade of ore,
2. a minimum capital investment,
3. less risk to the miner,
4. short lead time before production begins, and
5. lower manpower requirements.

The primary disadvantage of in situ leaching of uranium is groundwater contamination, which however, does not imply that conventional uranium mining necessarily has an advantage in regard to groundwater pollution. On the contrary, in situ leaching may prove to have a less severe impact on groundwater than does conventional mining. Nevertheless, excursions of leach solution from the well field aquifer have the potential to enter surface waters and to contaminate nearby well water. To confine the leach solution and mobilized ore zone elements to the well field aquifer, the operator must maintain a proper balance between injection and production. In the event of an excursion, monitor wells must be adequately spaced and screened to detect the advancing contaminant plume. These wells can be properly placed only if the hydrologic characteristics of the aquifer are adequately known. If an excursion is detected, the operator has the choice of implementing one or more methods to reduce its impact on the groundwater, such as stopping the entire operation and then pumping all wells. Some of the contaminants, however, will invariably escape the influence of the pumping wells and will travel in the direction of the groundwater flow. This impact is unavoidable and in most cases negligible, considering the potential for most aquifers to attenuate contaminants as they move away from the source.

12.2 MILL PROCESSES REQUIRED FOR AN ALTERNATIVE OPEN-PIT OR UNDERGROUND MINE

There are eight main steps in the milling of uranium ore from open-pit or underground mines. They are (1) crushing of ore (primary), (2) grinding of ore (secondary), (3) production of water-ore slurry (sometimes combined with grinding), (4) leaching of ore, (5) separation of leach liquor from tailings (waste), (6) concentration and purification of leach liquor, (7) precipitation of uranium from leach liquor, (8) drying and calcining of precipitate to form U_3O_8 .

The manner in which these steps are accomplished is ore- and site-specific. Decisions are based on process economics plus the costs of controlling chemical and radiological effluents to water, air, and land.

Crushing and grinding prepare run-of-mine ore for slurry formation and reduce the overall particle size so that efficient contact is made with the reagent that dissolves the uranium.

Leaching reagents are dependent on ore characteristics. Basic ores are leached with bicarbonate-carbonate solutions, while acid consuming ores are leached with sulfuric acid. In each case an oxidant is added to the leach liquid.

The separation of the leach liquor (which contains over 90% of the uranium in the ore) from the undissolved waste (tailings) can be accomplished by filtration, or countercurrent decantation.

The leach liquor is then concentrated and purified using ion exchange resins or solvent extraction.

The final step in the process is precipitation of the uranium from acid solution by the addition of ammonia or hydrogen peroxide. The precipitate is then filtered, washed, dried, and calcined to U_3O_8 .

The solution mining project proposed by the applicant avoids steps 1 through 3 by leaching the ore in situ. In addition, no tailings are generated, and the gross quantity of solid waste expected in solution mining is about 1% of that remaining from the above alternatives.

12.3 ALTERNATIVE METHODS FOR WASTE MANAGEMENT

12.3.1 Introduction

For the purposes of this section, waste management is defined as the disposition of the solids and waste leach solutions following extraction (separation) of the uranium-bearing solutions and aquifer restoration activities. Engineering techniques to control pollutants from waste storage during both operational and postoperational stages of a conventional uranium milling project have been demonstrated. Such techniques are applicable to the control of liquid and solid wastes produced by a solution mining (in situ leaching) project. Because no tailings are generated by the in situ leaching process, the surface area required for storage of wastes would be significantly less than the area needed for the retention of tailings generated by processing the same ore by conventional mining and milling. In addition, waste disposal methods technically or economically infeasible for large-scale tailings facilities may be viable for the smaller quantities of wastes produced by in situ leaching. The method chosen for the control of solution mining wastes must match the unique characteristics of each facility and minimize potential environmental effects. The staff has examined alternatives considered by the applicant in preparing this section. Alternatives presently available or feasible (i.e., potentially available with existing technology and within legal constraints) are described in Sect. 12.3.2 and evaluated in Sect. 12.3.3.

Each alternative waste management plan has been evaluated against the following set of performance objectives developed by the staff and designed to ensure that potential public health hazards that otherwise could occur in the operation of the project are avoided or minimized. These criteria have been established for conventional uranium mill tailings disposal methods and are applied, where appropriate, to the methods proposed for this project.

Siting and design

1. Locate the waste isolation area remote from people so that population exposures would be reduced to the maximum extent reasonably achievable.
2. Locate the waste 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 the seepage of toxic materials into the groundwater system would be eliminated or reduced to the maximum extent reasonably achievable.

During operations

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

Postreclamation

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

12.3.2 Viable alternatives

Alternative 1: Onsite disposal using calcite settling pond and chemical waste evaporation ponds (ponds lined with plastic membrane)

This alternative consists of constructing above-grade calcite and liquid waste impoundments to the immediate northeast and southwest of the main plant building. The waste ponds will be constructed in square or rectangular basins excavated in relatively flat areas. To minimize seepage, the ponds will be lined with a 30-mil (0.08-cm) impermeable polyethylene liner. Leaks in the liner will be detected through the collection of seepage by a gravel bed and drain pipe system constructed beneath the pond. During operation, solids in the ponds will be stabilized against dusting by the maintenance of a liquid seal over the solids.

Long-term stabilization for each pond would be accomplished by applying a cover of clayey soil and topsoil which will be sufficiently thick to reduce gamma radiation levels to background and radon diffusion to twice background levels. The radium-226 concentration in the waste solids will be the most significant factor in the cover thickness. Therefore, the necessary cover thickness will vary from pond to pond according to radium content. The cover would be sufficiently impermeable to restrict the percolation of rainwater through the solids.

This alternative offers adequate isolation of radioactive and toxic wastes during operation and disposal. The use of a polyethylene pond liner, if installed and maintained properly, would eliminate the possibility of adverse impacts caused by seepage during operation. Long-term loss of pond liner integrity would not greatly affect the leaching of wastes, because the slightly permeable clayey soil cover would minimize groundwater percolation through the wastes.

Disadvantages of this alternative would be the loss of the waste impoundment areas from general land usage and the necessity of monitoring the impoundment for erosion and/or loss of vegetative cover.

Alternative 2: Onsite disposal using calcite settling pond and chemical waste evaporation ponds (ponds unlined)

This alternative is similar to Alternative 1 except there is no pond liner provided. Because the quantity of slimy solids relative to liquid waste volumes is small, no sealing of the pond bottom is expected. The ensuing seepage of chemical wastes and radionuclides for this alternative would be unacceptable.

Alternative 3: Onsite disposal with solidification of solid wastes

This alternative is similar to Alternative 1, except that, prior to application of the soil cover, the solids are stabilized in cement or asphalt. The major advantages of solidification are (1) leaching resistance is increased, (2) in asphalt-fixed solids, radon release is reduced, and (3) wind erosion is eliminated. However, as in Alternative 1, restricted land use and monitoring would be necessary.

Alternative 4: Temporary storage of solid wastes in calcite storage pond and chemical wastes evaporation pond with transport of solid wastes to an active uranium mill tailings impoundment

This alternative utilizes the plastic-lined ponds described in Alternative 1 for disposal of liquid wastes (by evaporation) and temporary storage of solids wastes. However, rather than stabilizing the solids for disposal onsite, all radioactive and/or toxic solid wastes will be removed to an active uranium mill tailings impoundment for disposal. The applicant would enter into a contractual agreement with the owner of the active uranium mill tailings impoundment for the disposal of these wastes. Calcite wastes containing higher than background concentrations of radium would be periodically removed from the calcite settling pond. Other solid chemical wastes will be removed when either the solid waste inventory approaches the holding capacity of the evaporation ponds or when reclamation procedures begin. Reclamation would consist of removing solid wastes, pond liners, and soils contaminated by radionuclides and/or process chemicals to the licensed tailings impoundment, followed by grading the temporary pond area to its natural contour, application of a topsoil cover, and revegetation with native plant species and suitable grasses approved by the Wyoming Department of Environmental Quality.

The advantage of this alternative is the safe disposal of both liquid and solid wastes so that there is no permanent land requirement for a disposal area. This benefit will become especially apparent in the later stages of project development, when the main recovery facility is moved or satellite facilities constructed. Such relocation would require construction of additional calcite settling ponds and solar evaporation ponds at the new sites. Should stabilization and

onsite disposal be permitted, the net result would be proliferation of small solid waste impoundments within the project area. Such dispersed disposal would incur increased monitoring requirements, larger total land requirements, and greater risk of radionuclide and toxic material release. Removal of such materials to an active uranium mill tailings pond would eliminate such problems. Transfer of the relatively minor amounts of solids to an active tailings pond will have an insignificant impact on the environmental effects of the mill tailings facility. Disadvantages center on the increased cost of solids handling, the cost of the disposal agreement, and the risk of dispersion of the waste during transportation.

12.3.3 Evaluation of alternatives

Alternatives 1, 3, and 4 utilize waste ponds constructed with impermeable polyethylene liners. With the maintenance of a liquid seal over deposited solids and the continued monitoring of the ponds for leakage (Sect. 8.2.1), these alternatives offer adequate isolation of liquid and solid wastes during the operational phase of the project. The unlined ponds proposed in Alternative 2 would allow uncontrolled seepage of chemicals and radionuclides and are therefore unacceptable.

Alternatives 1 and 3 offer adequate stabilization of waste solids and reduction of gamma exposure and radon release to acceptable levels. However, these onsite disposal alternatives would require permanent land use restrictions on the waste impoundment areas and would require continued monitoring against erosion and loss of protective plant cover. The indicated future mode of project operation (i.e., relocation of main uranium recovery plant and/or construction of satellite uranium recovery facilities) would require construction of waste impoundment areas at additional sites. The resulting proliferation of waste impoundment areas would be undesirable.

Alternative 4 is the applicant's proposed waste management plan. Under this plan, radioactive and toxic wastes would be removed from the site to an active uranium mill tailings pond for disposal. The quantity of waste would be small relative to the tailings produced by the conventional mill [less than 10 metric tons (11 tons) per day (3000-4000 tons/year) for the proposed in situ facility (Sect. 4.6.3) compared to more than 910 metric tons (1000 tons) per day for a conventional mill]. The staff feels that the disposal of such relatively small quantities of process wastes would not significantly affect the safety or storage capacity of a conventional mill tailings pond. Stabilization of the disposed wastes would be accomplished according to the NRC license and State permit conditions applying to the uranium mill receiving the wastes.

Waste impoundment areas on the Irigaray project site would be reclaimed by grading the impoundment to its original contour, followed by application of topsoil and revegetating the area. Because no hazardous wastes would be present, there would be no restrictions against deep-rooted native plant species. The staff recommends that a diverse selection of native species should be used to provide long-term stability of the reclaimed land and to ensure its future value as a wildlife habitat (Sect. 5.2.2). The result of such actions would be the return of all disturbed lands to their original usage. Therefore, there would be no restrictions on future human usage.

Alternative 4 would incur additional solids handling, transportation, and disposal costs and risks associated with the transport of the wastes. However, due to the limited number of shipments, the mild chemical nature of the wastes, and the low population densities along roads from the project to potential disposal sites, the risks are minimal.

12.4 ALTERNATIVE ENERGY SOURCES

12.4.1 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 basis, than all other fuels 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 12.1 shows the disparity between availability and usage of energy resources in the United States. Although these data are for 1974 (final figures for 1975 are not yet available), estimates for 1975 indicate little difference. Gas usage in 1975 decreased slightly (about 1%); oil, coal, and nuclear usage increased slightly.

Table 12.1. Reserves and current consumption of energy sources

	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

Source: "National Energy Outlook," Federal Energy Administration, February 1976.

In 1975, the United States consumed about 71 q of energy (1 q = 10^{15} Btu); of this total, 20 q consisted of electric energy. An estimated 8.6% of this electric energy was generated using nuclear fuels, but within ten years the percentage is expected to increase to 26%.

Coal was used for producing 59% of the electric energy generated by combustion of fossil fuel in 1975; the percentages for oil and gas were 20 and 21, respectively. Use of oil and gas to generate electric power has decreased about 10% over the last three years, a reflection of high oil prices and gas unavailability.

Current and projected requirements for electric energy (1975-1985) and relative changes in resources used for generation, as estimated in "Project Independence," are shown in Table 12.2. 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 United States does not have sufficient oil and gas reserves to ensure a long-run 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 will be severely depleted in the next few decades.

Expanding industrial capacity for increasing coal production to meet projected requirements must occur in the next decade (total requirement is 1040 million tons in 1985 vs 603 million tons in 1974). 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 United States 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 United States currently account for the major portion of the market price.

Table 12.2. Estimated relative changes in resources to be used for generation of projected energy requirements

Fuel resource used	Percent of thermal energy required in year:			
	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 required	15.6	20	25.5	34

^a Actual.

^b Estimated ("National Energy Outlook," Federal Energy Administration, February 1976.

^c Coal usage must increase 77% by 1985 to attain this level.

^d Uranium-fueled reactors furnished 9.9% of the total U.S. production in January 1976.

Source: "Project Independence," Federal Energy Administration, November 1974.

For a given thermal content, transport facilities for U_3O_8 are minimal compared with those for coal because of the much higher energy content of uranium fuel. Approximately 250 tons of U_3O_8 per year are required for a 1000-MW nuclear plant operating at a plant factor of 80%. Annual Western coal requirements for an equivalent 1000-MW coal plant would be more than 3 million tons, or the load 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 increasing long-range reliability in 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 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 energy requirements projected over the next few decades; major expansion of both industries will be required to fill projected needs.

The determination of availability of uranium in large enough quantities to fuel the projected nuclear generating capacity (for 1985) is currently a matter of study.⁷ Results of those studies are given below.

Estimates presented in the "National Energy Outlook"⁸ indicate that 140,000 to 150,000 MWe of nuclear generating capacity will be needed to supply 26% of the total electrical energy used in 1985. The first "Project Independence" report⁹ indicated that nuclear capacity could increase to more than 200,000 MWe by 1985. A more recent and lower estimate resulted from lower projections of electricity demand, financial problems experienced by utilities, uncertainty about government policy, and continued siting and licensing problems. The more recent projections of uranium requirements are given in Table 12.3.

Table 12.3. Uranium requirements

MWe operating by 1985	Lifetime U_3O_8 requirements (tons)	
	At P.F. of 0.8 ^a	At P.F. of 0.6
142,000	960,000	704,000

^aP.F. = plant factor, or capacity factor.

Source: "National Energy Outlook," Federal Energy Administration, February 1976.

Known reserves of uranium (as U_3O_8), as of January 1976, were an estimated 640,000 tons, as compared with 600,000 tons estimated in January 1975.⁷ These reserves could be mined and milled at a cost of \$30 per pound of U_3O_8 produced. The price of U_3O_8 in April of 1976 was \$40 per pound for delivery in 1976 and \$48 per pound for delivery in 1980.

ERDA has estimated total U.S. uranium resources as shown in Table 12.4.⁷ The total of all variously known categories of uranium resources is equivalent to 3,560,000 tons of U_3O_8 . Reserves are in known deposits; drilling and sampling have established the existence of these deposits beyond reasonable doubt. Probable resources have not been drilled and sampled as extensively as reserves. The speculative and possible resource categories have been estimated by inference from geologic evidence and limited sampling.

Table 12.4. United States uranium resources

Cost (dollars per pound of U_3O_8)	Reserves	Tons U_3O_8		
		Probable	Possible	Speculative
\$30	640,000	1,060,000	1,270,000	590,000

Source: "Mineral Resources and the Environment," Supplementary Report: "Reserves and Resources of Uranium in the U.S.," National Academy of Sciences, 1975.

Historically, resources of uncertain potential have become established reserves at an average rate of 7% per year since 1955.⁷ If this rate were to persist over the next decade, total reserves would exceed requirements (1,250,000 tons of reserves vs a maximum 960,000 tons required for lifetime nuclear generating capacity rated at 142,000 MWe) by about 300,000 tons. Assuming no transfer of possible resources into the probable category, probable resources would still contain 450,000 tons.

12.4.2 Solar, geothermal, and synthetic fuels

Estimates reported in the "National Energy Outlook"⁸ indicate that solar and geothermal sources will each supply about 1% of U.S. energy requirements by 1985 and about 2% by 1990. Supplies of synthetic gas and oil derived from coal will probably not exceed 1% of U.S. energy requirements as of year 1990. These projections are based on many considerations. The technology exists in all cases, but not in a proven, commercially viable manner. The potential for proving these technologies on a commercial scale is great, but timely development will require a favorable market as well as governmental incentives. A maximum of 6% of projected 1990 energy requirements is expected to be derived from solar, geothermal, and synthetic fuel resources combined.

12.4.3 By product uranium

The estimate of U_3O_8 recoverable through the year 2000 as a by product of wet-process phosphoric acid (phosphate fertilizer) and copper dump leaching is 115,000 tons and 25,000 tons respectively. This potential production is in addition to the 680,000 tons U_3O_8 available at a forward cost of \$30 or less per pound of U_3O_8 from conventional mining and milling sources.¹⁰

Quoting from ref. 7 (p. 106):

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 2,500 ST U_3O_8 per year could be recovered from Florida phosphate mined for fertilizer. The Bureau of Mines studied the sulfuric acid leaching of low grade dumps at 14 porphyry copper mines and concluded that about 750 ST U_3O_8 per year could be recovered. This would be recovered from rocks whose uranium content ranges from 1 to 12 ppm.

It was also thought that other porphyry copper deposits might also be possible sources of by-product uranium.

This possible byproduct uranium totals 3,250 ST U_3O_8 per year which is only slightly less than the initial annual production planned for the Rossing deposit in South West Africa.

Another source of byproduct uranium could be mine-mouth electric generating plants that burn uranium-bearing lignite as fuel. The uranium is concentrated in the ash. Some lignite contains as much as 0.30 percent U_3O_8 . Bieniewski estimates that about 1500 ST of U_3O_8 is contained in about 500,000 ST of high grade lignite. More recently reserves in lignite were estimated to be less than 5,000 ST of U_3O_8 and resources to be about 50,000 ST. Low-Btu lignites seem to be richest in uranium. Good-quality coals usually contain less than 0.001 percent U_3O_8 . If lignite is burned at too high a temperature, the uranium enters the ash in a form that is not easily leachable and for which an economic recovery system has not yet been developed.

12.4.4 Energy conservation

The NRC staff has examined available information concerning the potential reduction in energy usage that could be achieved by 1985 and concludes that incremental savings in *total* energy consumption could be achieved in all major consumption sectors: residential, commercial, industrial, and transportation. Actions which improve the thermal efficiency of automobiles, homes, and office buildings would have the greatest conserving effect. However, in the case of electrical energy, demand is expected to increase (during the next decade) at a rate about twice as great as that for total energy.⁸ It will be more difficult to conserve electrical energy since it will probably be a viable alternative for oil and gas use in residential

heating and for some industrial applications. Conservation will not materially change the need for increased dependence on coal and uranium as fuels for generating electric power during the next decade.

12.5 ALTERNATIVE OF NO LICENSING ACTION

Among the alternative actions available to the NRC is the denial of a source material license to the applicant. Classifications of source materials are discussed in 10 CFR Part 40.13(b); these classifications are based on Sect. 62 of the Atomic Energy Act of 1954, which specifically exempts "unbeneficiated ore" from control. If denied a license under these regulations, WMC could not solution mine the ore body, since the leaching process does "beneficiate" the ore.

Wyoming Mineral Corporation could surface mine or deep mine the ore body and have it processed at a mill possessing a source material license if economically feasible.

If the applicant were not granted a source material license, the uranium concentrate it intends to produce would not become available for use as fuel in nuclear reactors in a timely manner. Appendix E discusses the need and timeliness of the project and the basis for the NRC evaluation.

The U_3O_8 produced by the WMC solution mining project will be used as fuel in nuclear reactors which are either operating or under construction. These reactors will produce electric power for sale to U.S. consumers. Lack of fuel would require reactors that are short of fuel to reduce their output and could conceivably result in some reactor shutdown.

REFERENCES FOR SECTION 12

1. Karl R. Schendel, Wyoming Mineral Corporation, attachment to letter to L. C. Rouse, Nuclear Regulatory Commission, March 20, 1978, Docket No. 40-8502.
2. U.S. Environmental Protection Agency, *State-of-the-Art: Uranium Mining, Milling, and Refining Industry*, Report EPA-660/2-74-038, U.S. Government Printing Office, Washington, D.C., June 1974.
3. U.S. Nuclear Regulatory Commission, *Final Environmental Statement Related to Operation of Bear Creek Project*, Docket No. 40-8452, NUREG-0129, June 1977.
4. U.S. Nuclear Regulatory Commission, *Draft Environmental Statement Related to the Minerals Exploration Company's Sweetwater Uranium Project, Sweetwater County, Wyoming*, Docket No. 40-8584, NUREG-0403, December 1977.
5. U.S. Atomic Energy Commission, *Environmental Survey of the Uranium Fuel Cycle*, Report WASH-1248, U.S. Government Printing Office, Washington, D.C., April 1974.
6. William C. Larson, *The State of the Art of In Situ Leach Mining, FY 77*, prepared by Twin Cities Mining Research Center for the United States Department of the Interior, Bureau of Mines.
7. "Mineral Resources and the Environment," Supplementary Report: "Reserves and Resources of Uranium in the U.S.," National Academy of Sciences, 1975.
8. "National Energy Outlook," Federal Energy Administration, February 1975.
9. "Project Independence," Federal Energy Administration, November 1974.
10. U.S. Energy Research and Development Administration, Grand Junction Office, Statistical Data of the Uranium Industry, January 1, 1977, Report GJO-100(77), 1977.

13. NRC BENEFIT-COST SUMMARY FOR THE IRIGARAY PROJECT

13.1 GENERAL

The general need for uranium is subsumed in the operation of nuclear power reactors. In reactor licensing evaluations the benefits of the energy produced are weighed against related 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, it is appropriate to review the specific site-related benefits and costs of an individual fuel-cycle facility such as the Irigaray project.

13.2 QUANTIFIABLE ECONOMIC IMPACTS

Monetary benefits accrue to the community from the presence of the project, such as local expenditures of operating funds and the state and local taxes paid by the project. Against these monetary benefits are monetary costs to the communities involved, such as those for new or expanded schools and other community services. It is not possible to arrive at an exact numerical balance between these benefits and costs for any one community unit, or for the project, because of the ability of the community and possibly the project to alter the benefits and costs. For example, the community can use various taxing powers to redress any perceived imbalance in favor of the project. The project, on the other hand, may create larger revenues through increased product price to redress any imbalance it suffers through direct or indirect taxation.

13.3 THE BENEFIT-COST SUMMARY

The benefit-cost summary for a fuel cycle facility such as the Irigaray project involves comparing the societal benefit of an assured U_3O_8 supply (ultimately providing energy) against local environmental costs for which there is no directly related compensation. For the project, these uncompensated environmental costs are basically three: groundwater impact, radiological impact, and disturbance of the land. The radiological impacts of the project are small, and eventually radioactive wastes will be disposed of offsite (Sect. 4.6.4). The disturbance of the land is also a small environmental impact. All of the disturbed land will be reclaimed after the project is decommissioned and will become available for other uses. Complete restoration of an aquifer contaminated by a commercial-scale project has not yet been demonstrated although the staff considers that, in view of the applicant's pilot-scale demonstration, such restoration is feasible. The benefit of the production up to 1.1×10^6 kg (2.5×10^6 lb) of U_3O_8 is considered to offset the risk that the groundwater quality underlying the 20-ha (50-acre) mining zone will not be completely restorable. Moreover, development and demonstration of an acceptable restoration technique is an integral part of the project (Sect. 5.1.4).

13.4 STAFF ASSESSMENT

The staff concludes that the adverse environmental impacts and costs are such that the use of the mitigative measures suggested by the applicant and the regulatory agencies involved would reduce the short- and long-term adverse impacts associated with the project to acceptable levels.

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 societal impacts, the staff has concluded that the overall benefit-cost balance for the Irigaray project is favorable, and the indicated action is that of granting a source material license for this solution mining project with the conditions specified in the Summary and Conclusions.

Appendix A
COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

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Appendix A. COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT AND NRC RESPONSES

A.1 INTRODUCTION

Pursuant to 10 CFR Part 51, the Draft Environmental Statement (DES) was transmitted in April 1978, with a request to comment, to Federal, state, and local agencies listed in the summary of this Statement. In addition, the NRC requested comments on the DES from interested persons by means of a notice published in the *Federal Register* [43(88): 19488]] on May 5, 1978.

Letters in response to these requests were received from the following:

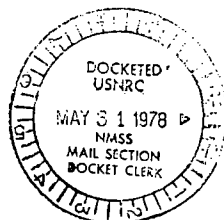
- Advisory Council on Historic Preservation
- Department of the Army
- Department of Energy
- Department of Health, Education, and Welfare
- Department of the Interior
- Department of Housing and Urban Development
- Environmental Protection Agency
- Federal Energy Regulatory Commission
- Soil Conservation Service
- Office of the Governor, Wyoming
- Game and Fish Department, Wyoming
- State Conservation Commission, Wyoming
- The Geological Survey of Wyoming
- Wyoming Department of Agriculture
- Wyoming State Highway Department
- Wyoming State Planning Commission
- Glenn J. Catchpole
- William A. Lochstet
- Wyoming Mineral Corporation
- Wyoming State Planning Coordinator
(Dept. of Environmental Quality, Air and Water Quality Divisions)

Each letter is reproduced in Sect. A.2 and is followed immediately by the NRC response. The staff's considerations of the issues raised in individual comments are presented in the responses and by changes in the text.

After publication of the DES, the applicant's revised *Application for In Situ Permit to Mine for the Irigaray Site* was approved by the Wyoming Department of Environmental Quality in August 1978. Although the information contained in the two documents is similar, the revised permit application contains more recent and more detailed information on some aspects of the proposed operation. Text revisions, in response to comments, included material from this document.

A.2 LETTERS RECEIVED AND RESPONSES TO COMMENTS

Advisory Council on
Historic Preservation
1522 K Street N.W.
Washington, D.C. 20005



May 18, 1978

Mr. Leland C. Rouse, Chief
Fuel Processing and Fabrication Branch
Division of Fuel Cycle & Material Safety
Nuclear Regulatory Commission
Washington, D. C. 20555



Dear Mr. Rouse:

This is in response to your request of April 28, 1978, for comments on the draft environmental statement (DES) for the Irigaray Project, Johnson County, Wyoming (Docket 40-8502).

The Council has reviewed the DES and notes that the Nuclear Regulatory Commission has determined that the proposed undertaking will not affect properties included in or eligible for inclusion in the National Register of Historic Places. However, we note that no archeological survey has been undertaken for the area to be affected by the numerous wells and access roads required by this proposal. In addition, ground reclamation at abandonment of the project will require extensive ground disturbance in the limited area affected by the project. It therefore appears that NRC's determination that the "staff cannot foresee any disturbance to any archaeological resources that might be on the site" is premature because no attempt appears to have been made to identify the presence or absence of archeological resources in accordance with Section 800.4(a) of the "Procedures for the Protection of Historic and Cultural Properties" (36 CFR Part 800).

Therefore, pursuant to Section 102(2)(C) of the National Environmental Policy Act of 1969 and the Council's Procedures your DES does not contain sufficient information concerning historic and cultural resources for review purposes. Please furnish the following data indicating:

Compliance with Section 106 of the National Historic Preservation Act of 1966 (16 USC 470f, as amended, 90 Stat. 1320).

The environmental statement must demonstrate that either of the following conditions exists:

1. No properties that may be eligible for inclusion in the National

The Council is an independent unit of the Executive Branch of the Federal Government charged by the Act of October 15, 1966 to advise the President and Congress in the field of Historic Preservation.

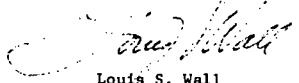
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Mr. Leland C. Rouse
Irigaray Project
May 18, 1978

Register of Historic Places are located within the area of environmental impact, and the undertaking will not affect any such property. In making this determination, the Council requires evidence of an effort to ensure the identification of properties eligible for inclusion in the National Register, including evidence of contact with the State Historic Preservation Officer, whose comments should be included in the final environmental statement. The State Historic Preservation Officer for Wyoming is Ms. Jan L. Wilson, Wyoming Recreation Commission, 604 East 25th Street, Box 309, Cheyenne, Wyoming 82001.

2. Properties that may be eligible for inclusion in the National Register of Historic Places are located within the area of environmental impact, and the undertaking will or will not affect any such property. In cases where there will be an effect, the final environmental impact statement should contain evidence of compliance with Section 106 of the National Historic Preservation Act through the Council's Procedures.

Should you have any questions, please call Brit Allan Storey of the Council's Denver staff at (303) 234-4946, an FTS number.

Sincerely yours,


Louis S. Wall
Assistant Director, Office of
Review and Compliance, Denver

A-4

NRC response to letter from Advisory Council on Historic Preservation

Wyoming Mineral Corporation initially contacted the Wyoming State Historic Preservation Officer (SHPO) in 1975 (Appendix F). The NRC has consulted the most recent listings in the National Register (revised Sect. 2.5.2) and recently contacted the Wyoming SHPO to confirm information on historic sites in the vicinity of the proposed operation (Appendix F, page F-6). In response to the NRC request the Wyoming SHPO provided a copy of a letter dated September 9, 1977 (page F-7).

An archaeological survey has been performed at the Irigaray site (Appendix F). The NRC will require, as a license condition, that an archaeological survey be conducted on any land outside the surveyed area prior to disturbance, and that the survey be submitted to NRC. Approval to proceed will be subject to NRC review and approval, in consultation with the SHPO. The license will also stipulate that the State Archeologist be notified immediately if any archeological materials are encountered during well field or other construction activities.



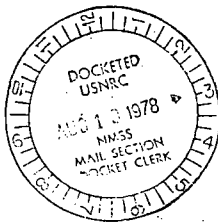
DEPARTMENT OF THE ARMY
OMAHA DISTRICT, CORPS OF ENGINEERS
6014 U.S. POST OFFICE AND COURTHOUSE
OMAHA, NEBRASKA 68102

MROPD-M

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1 August 1978

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



Gentlemen:

This letter contains our review comments on the draft EIS for Wyoming Mineral Corporation. Our comments are as follows:

a. General.

Section 404 Requirements. Streamflow data indicates that Willow Creek has an average annual flow of 5 cubic feet per second. Based on the information submitted, the proposed activity will involve the placement of fill into Willow Creek. Accordingly, the Wyoming Mineral Corporation is requested to submit application and a brief description of the activity in Willow Creek so a final permit determination can be made in compliance with Section 404 of the Federal Water Pollution Control Act as amended. The following information pursuant to Section 404(b) guidelines should be included in your final EIS.

- (1) Description of the proposed discharge of dredged or fill materials
- (2) Description of the effects of the proposed discharge of dredged or fill materials on the aquatic environment.
- (3) The effects of project factors on wetlands.
- (4) Description of the effects of the proposed discharge of dredged or fill materials on the destruction or degradation of aquatic resources.
- (5) The effects of project factors on the benthic community.

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and Material Safety

1 August 1978

(6) The effects that construction activities in the stream may have on the food chain including alterations or decreases in diversity of plant and animal species.

(7) The effect of the proposed discharge of dredged or fill material on the movement of fauna, especially in their movement into and out of feeding, spawning, breeding, and nursery areas.

(8) The effects that construction activities and all project factors would have on water characteristics that would subsequently affect nektonic and planktonic populations both upstream of and downstream from the project.

b. Specific.

(1) Flood Plain Management. A discussion of the flood hazard should be included. Gaging information of abandoned gages indicate the 100-year flood stages could be 10-15 feet higher than normal low flood stages on Powder River. A discussion should be made of potential flood damages to facilities and the environmental effects of a flood-induced spillage.

(2) Water.

(a) Reference para. 3 and 4, Section 6.3.1.1. Proposed method to prevent hazardous spills, surface water contamination, etc., from drilling activities in the Willow Creek streambed should be discussed in detail in the final environmental statement. Of concern is the criteria to be used in designing temporary dikes and/or channel diversion. In particular, hydrologic and hydraulic information should identify probable stage and discharge frequency relationships at the proposed construction site, as well as the dike and channel diversion locations. The discussion should also include an assessment of the extent of streambed disturbance and the effect of diking on flow and streambed and streambank erosion.

(b) Reference Section 6.3.1.2. The draft EIS states, "Surface water pollution, other than erosion, will result from precipitation runoff from the WMC project area. The runoff might contain significant concentrations of contaminants which would have accumulated on the land surface during normal facility operation. This would include accumulations such as small spills, particulate fall-out, grease and oil, etc." The possible significance of this problem should be addressed and if considered significant, mitigative measures such as runoff detention basins should be included in the proposed development plan.

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(c) Reference para. 3, Section 6.2.1.2. The draft EIS further states, "Due to distance to the Powder River, contaminated ground water from the initial 20-ha. (50-acre) mining area would cause relatively minor adverse impacts to surface waters." The approximate distance to the Powder River should be mentioned. Also, all possible minor adverse impacts should be discussed. The reader then can determine whether the impacts are minor in nature.

(3) Ecological Impacts.

(a) Impacts on Terrestrial Environment.

Reference para. 4, Section 6.61. What is the possibility that future mining activities could involve riparian areas? An aerial photograph should designate any habitat change proposed. If sage grouse booming grounds are located in or near the proposed project area, the locations should be mentioned. Also, density data on the sage grouse should be included. It should be noted that vegetation along streams should not be removed not only because it stabilizes streambanks but also because it provides food and cover for wildlife.

(b) Impacts of Aquatic Environment.

Reference para. 1, Section 6.63. In this paragraph, the statement is made that, "In situ mining operation near Willow Creek should have a negligible impact on aquatic biota that may be present during periods of flow." Why is this so? What kind or amount of flow are you referring to? Since the average annual flow of Willow Creek is 5 cubic feet per second and pools form in the streambed during the summer months, this aquatic habitat is extremely important to the existing food chain. It would appear that the in situ mining operation could completely eliminate several of these vital isolated pools and adversely affect the entire ecosystem. If some of these pools are going to be eliminated by the proposed project, mitigative action should be considered. Reference should be made to number, location, and size of pools affected and not affected by the construction activity in Willow Creek. Reference is made to your statement, "WMC is currently developing methods to minimize any adverse impacts." These methods should be completely discussed so the reader can determine if impacts have been reduced. Altering the stream channel could cause severe erosion action of the creek bank and should be closely examined. Expected adverse effects should be discussed if a channel change is proposed. The purpose for such a change should also be discussed.

1 August 1978

(4) Environmental Effects of Accidents.

(a) Reference Section 7. This section should include a discussion on potential damages and/or environmental effects due to flooding.

(b) Reference Conclusions Section, page 6-9. The draft EIS states, "Finally, if water from the contaminated aquifer reached any ecosystems (i.e., Powder River) it could adversely affect fish and other aquatic life." This discussion should be expanded in Reference Section 7.

(5) Education Opportunities.

Reference page 2-5. No conclusion is made concerning the additional students moving into the area. At the most, 90 students will be added to the public schools in Buffalo. This is an 8 percent increase which may be significant. Those children of the 40 employees already residing in Buffalo would have increased the school enrollment approximately 5.5 percent. The final EIS should discuss whether or not the existing school system is sufficient to handle the influx of new students without expansion.

(6) Cultural Resources.

Reference pages 2-7 and 6-2. The impact of the proposed project on cultural resources has not been adequately assessed. It does not appear that Section 106 of the National Historic Preservation Act of 1966 (P.L. 89-655), as modified by P.L. 94-422 and interpreted by 36 CFR Part 800, has been complied with. The final EIS should discuss such compliance. The assumption that no survey is needed because there will be no major excavation does not appear to consider the potential adverse impacts to archeological resources for the following reasons:

(a) The term "major" excavation would have to be defined and concurred with by the State Historic Preservation Officer.

(b) Any type of excavation can destroy an archeological site.

(c) The use of heavy equipment can:

1. compact a site
2. destroy a site located near the ground surface, particularly during rainy weather

MROPD-M
Director, Division and Fuel Cycle
and Material Safety

1 August 1978

(d) The effect of the chemical reagents upon any site is not addressed on:

1. radiocarbon dates
2. artifacts

(e) The effect of increased ground water movement on artifact positions has not been assessed.

(f) The visual impact on the Hoe Ranch has not been assessed.

(7) Cumulative Effects

Reference pages 1-1, 6-2. It is not known how many other mining projects are now existing, or proposed for construction in the Powder River Basin. These projects could cumulatively have a significant environmental impact on the region. The final EIS needs to discuss the impact of this project as it relates to other mining activities in the area and how it compounds or offsets the major impacts of those actions.


(8) Alternatives.

Reference Section 12. Since the description of the effects of the proposed discharge of dredged or fill materials involves a waterway under the jurisdiction of Section 404 of the Federal Water Pollution Control Act Amendments of 1972, you should describe any bridge construction procedure, channel change, fill procedure, riprapping, and all significant beneficial and detrimental impacts associated with this project for each alternative considered.

It does not appear that any of the proposed measures would impact adversely on any existing or planned Corps of Engineers projects or studies.

We appreciate the opportunity to review this draft document. Also please forward a copy of the final environmental statement when it becomes available.

Sincerely yours,


JOHN E. VELEHRADSKY, P.E.
Chief, Planning Division

1. Department of the Army, Corps of Engineers comment

Section 404 Requirements. Streamflow data indicates that Willow Creek has an average annual flow of 5 cubic feet per second. Based on the information submitted, the proposed activity will involve the placement of fill into Willow Creek. Accordingly, the Wyoming Mineral Corporation is requested to submit application and a brief description of the activity in Willow Creek so a final permit determination can be made in compliance with Section 404 of the Federal Water Pollution Control Act as amended. The following information pursuant to Section 404(b) guidelines should be included in your final EIS.

- (1) Description of the proposed discharge of dredged or fill materials.
- (2) Description of the effects of the proposed discharge of dredged or fill materials on the aquatic environment.
- (3) The effects of project factors on wetlands.
- (4) Description of the effects of the proposed discharge of dredged or fill materials on the destruction or degradation of aquatic resources.
- (5) The effects of project factors on the benthic community.
- (6) The effects that construction activities in the stream may have on the food chain including alterations or decreases in diversity of plant and animal species.
- (7) The effect of the proposed discharge of dredged or fill material on the movement of fauna, especially in their movement into and out of feeding, spawning, breeding, and nursery areas.
- (8) The effects that construction activities and all project factors would have on water characteristics that would subsequently affect nektonic and planktonic populations both upstream of and downstream from the project.

NRC response

Mining activities in the streambed of Willow Creek may require compliance with Section 404 of the Federal Water Pollution Control Act (as amended), and the applicant has been so informed. Section 6.3.1.1 has been revised to reflect the requirements of Section 404. The applicant will not be mining in the Willow Creek streambed prior to 1982 (Wyoming Mineral Corporation comment 23). Therefore, the applicant will have adequate time to finalize plans for mining in streambed areas, to conduct any studies, and to obtain any data necessary to obtain a Section 404 permit. A number of others providing comments on the EIS also have expressed concern over future mining in the Willow Creek streambed (e.g., Dept. of Interior, EPA, and the Wyoming Game and Fish Dept.). Measures proposed by the applicant to mitigate environmental impacts in response to Condition 7.j (p. v) and to meet the requirements of Section 404 will have to include the alternative of foregoing mining in the streambed. The staff will consult with the interested agencies in evaluating any plan submitted to the NRC.

2. Department of the Army, Corps of Engineers comment

Flood Plain Management. A discussion of the flood hazard should be included. Gaging information of abandoned gages indicate the 100-year flood stages could be 10-15 feet higher than normal low flow stages on Powder River. A discussion should be made of potential flood damages to facilities and the environmental affects of a flood-induced spillage.

NRC response

The proposed limited operation is approximately 6 km (4 miles) from the Powder River and does not warrant a discussion on flood hazard. The applicant will be required to address the flooding potential of Willow Creek in the plan for minimizing environmental impacts that must be submitted prior to conducting activities in the Willow Creek streambed (Condition 7.j., page v). Flooding potential of Willow Creek would also have to be considered in applying for a Section 404 permit.

3. Department of the Army, Corps of Engineers comment

Reference para. 3 and 4, Section 6.3.1.1. Proposed method to prevent hazardous spills, surface water contamination, etc., from drilling activities in the Willow Creek streambed should be discussed in detail in the final environmental statement. Of concern is the criteria to be used in designing temporary dikes and/or channel diversions. In particular, hydrologic and hydraulic information should identify probable stage and discharge frequency relationships at the proposed construction site, as well as the dike and channel diversion locations. The discussion should also include an assessment of the extent of streambed disturbance and the effect of diking on flow and streambed and streambank erosion.

NRC response

See response to Department of the Army, Corps of Engineers comment 1.

4. Department of the Army, Corps of Engineers comment

Reference Section 6.3.1.2. The draft EIS states, "Surface water pollution, other than erosion, will result from precipitation runoff from the WMC project area. The runoff might contain significant concentrations of contaminants which would have accumulated on the land surface during normal facility operation. This would include accumulations such as small spills, particulate fall-out, grease and oil, etc." The possible significance of this problem should be addressed and if considered significant, mitigative measures such as runoff detention basins should be included in the proposed development plan.

NRC response

Because of the small area involved with the limited operation, possible adverse effects due to mining activities on surface runoff are considered to be insignificant. Refer to Sect. 6.3.1.2.

5. Department of the Army, Corps of Engineers comment

Reference para. 3, Section 6.2.1.2. The draft EIS further states, "Due to distance to the Powder River, contaminated ground water from the initial 20-ha (50-acre) mining area would cause relatively minor adverse impacts to surface waters." The approximate distance to the Powder River should be mentioned. Also, all possible minor adverse impacts should be discussed. The reader then can determine whether the impacts are minor in nature.

NRC response

The initial mining area is approximately 5.6 to 6 km (3-1/2 to 4 miles) from the Powder River. The staff expects that any impacts from the limited operation on the Powder River would be negligible.

6. Department of the Army, Corps of Engineers comment

Reference para. 4, Section 6.61. What is the possibility that future mining activities could involve riparian areas? An aerial photograph should designate any habitat change proposed. If sage grouse booming grounds are located in or near the proposed project area, the locations should be mentioned. Also, density data on the sage grouse should be included. It should be noted that vegetation along streams should not be removed not only because it stabilizes streambanks but also because it provides food and cover for wildlife.

NRC response

See response to Department of the Army, Corps of Engineers comment 1, and condition 7j, page V.

7. Department of the Army, Corps of Engineers comment

Reference para. 1, Section 6.63. In this paragraph, the statement is made that, "In situ mining operation near Willow Creek should have a negligible impact on aquatic biota that may be present during periods of flow." Why is this so? What kind or amount of flow are you referring to? Since the average annual flow of Willow Creek is 5 cubic feet per second and pools form in the streambed during the summer months, this aquatic habitat is extremely important to the existing food chain. It would appear that the in situ mining operation could completely eliminate several of these vital isolated pools and adversely affect the entire ecosystem. If some of these pools are going to be eliminated by the proposed project, mitigative action should be considered. Reference should be made to number, location, and size of pools affected and not affected by the construction activity in Willow Creek. Reference is made to your statement, "WMC is currently developing methods to minimize any adverse impacts." These methods should be completely discussed so the reader can determine if impacts have been reduced. Altering the stream channel could cause severe erosion action of the creek bank and should be closely examined. Expected adverse effects should be discussed if a channel change is proposed. The purpose for such a change should also be discussed.

NRC response

The staff has made site visits on three separate occasions and has not observed any flow in Willow Creek. See response to Department of the Army, Corps of Engineers comment 1 pertaining to mining activities in the Willow Creek streambed.

8. Department of the Army, Corps of Engineers comment

Reference Section 7. This section should include a discussion on potential damages and/or environmental effects due to flooding.

NRC response

See response to Department of the Army, Corps of Engineers comment 2.

9. Department of the Army, Corps of Engineers comment

Reference Conclusions Section, page 6-9. The draft EIS states, "Finally, if water from the contaminated aquifer reached any ecosystems (i.e., Powder River) it could adversely affect fish and other aquatic life." This discussion should be expanded in Reference Section 7.

NRC response

See response to Department of the Army, Corps of Engineers comment 5.

10. Department of the Army, Corps of Engineers comment

Reference page 2-5. No conclusion is made concerning the additional students moving into the area. At the most, 90 students will be added to the public schools in Buffalo. This is an 8 percent increase which may be significant. Those children of the 40 employees already residing in Buffalo would have increased the school enrollment approximately 5.5 percent. The final EIS should discuss whether or not the existing school system is sufficient to handle the influx of new students without expansion.

NRC response

As noted in Sect. 6.8, the staff expects only 20 new employees and a total of 70 additional residents. Of the 70 new residents, the staff would expect 25 to be of school age. As stated in Sect. 2.4.2.1, the school system currently operates with a pupil/teacher ratio of 18.8 to 1. An additional two pupils per class would not represent a significant impact.

11. Department of the Army, Corps of Engineers comment

Reference pages 2-7 and 6-2. The impact of the proposed project on cultural resources has not been adequately assessed. It does not appear that Section 106 of the National Historic Preservation Act of 1966 (P.L. 89-655), as modified by P.L. 94-422 and interpreted by 36 CFR Part 800, has been complied with. The final EIS should discuss such compliance. The assumption that no survey is needed because there will be no major excavation does not appear to consider the potential adverse impacts to archaeological resources for the following reasons:

- (a) The term "major" excavation would have to be defined and concurred with by the State Historic Preservation Officer.
- (b) Any type of excavation can destroy an archaeological site.
- (c) The use of heavy equipment can:
 1. compact a site
 2. destroy a site located near the ground surface, particularly during rainy weather
- (d) The effect of the chemical reagents upon any site is not addressed on:
 1. radiocarbon dates
 2. artifacts
- (e) The effect of increased ground water movement on artifact positions has not been assessed.
- (f) The visual impact on the Hoe Ranch has not been assessed.

NRC response

See response to letter from the Advisory Council on Historic Preservation, page A-5.

12. Department of the Army, Corps of Engineers comment

Reference pages 1-1, 6-2. It is not known how many other mining projects are now existing, or proposed for construction in the Powder River Basin. These projects could cumulatively have a significant environmental impact on the region. The final EIS needs to discuss the impact of this project as it relates to other mining activities in the area and how it compounds or offsets the major impacts of those actions.

NRC response

Section 2.7.2, Mineral Resources, discusses mining projects in the Powder River Basin. There appears to be no conflict between current or anticipated mining activities and the proposed solution mining activity.

13. Department of the Army, Corps of Engineers comment

Reference Section 12. Since the description of the effects of the proposed discharge of dredged or fill materials involves a waterway under the jurisdiction of Section 404 of the Federal Water Pollution Control Act Amendments of 1972, you should describe any bridge construction procedure, channel change, fill procedure, riprapping, and all significant beneficial and detrimental impacts associated with this project for each alternative considered.

NRC response

See response to Department of the Army, Corps of Engineers comments 1 and 2.



Department of Energy
Washington, D.C. 20545

JUL 25 1978

Mr. Leland C. Rouse, Chief
Fuel Processing and Fabrication
Branch
Division of Fuel Cycle and
Material Safety
Nuclear Regulatory Commission
Washington, D.C. 20555

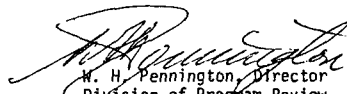
Dear Mr. Rouse:

This is in response to your letter of April 28, 1978, in which you invited the Department of Energy (DOE) to review and comment on the Nuclear Regulatory Commission's draft environmental impact statement related to the proposed Irigaray uranium solution mining project to be located in Johnson County, Wyoming (NUREG-0399).

We have reviewed the statement and have determined that the proposed action will not conflict with current or known future DOE programs. However, enclosed are comments which you may wish to consider in the preparation of the final statement.

Thank you for the opportunity to review and comment on the draft statement.

Sincerely,


W. H. Pennington, Director
Division of Program Review
and Coordination
Office of NEPA Affairs

Enclosure:
Staff Comments

STAFF COMMENTS
ON THE
NUCLEAR REGULATORY COMMISSION'S
DRAFT ENVIRONMENTAL IMPACT STATEMENT
RELATED TO THE PROPOSED IRIGARAY URANIUM SOLUTION MINING PROJECT
TO BE LOCATED IN JOHNSON COUNTY, WYOMING
NUREG-0399

Section 12.4.3 - First Paragraph

The estimate of U_3O_8 recoverable through the year 2000 as a by-product of wet-process phosphoric acid is 115,000 tons and as a by-product of copper dump leaching is 25,000 tons. This potential production is in addition to the 680,000 tons U_3O_8 available at a forward cost of \$30 or less per pound U_3O_8 from conventional mining and milling sources.

Source: "Statistical Data of the Uranium Industry, January 1, 1977"
GJO-100(77), United States Energy Research and Development
Administration, Grand Junction Office

Section 12.4.3 - Last Paragraph

The first three sentences might be replaced with the following:

Although it has been suggested occasionally that by-product uranium might be recovered from the ash from electric generating plants which burn lignite or coal as fuel, no data collected to date indicate that such uranium recovery is economically feasible at present U_3O_8 prices.

The U.S. Bureau of Mines, Metallurgy Research Center, Salt Lake City, has obtained and analyzed ash from eleven large coal-burning power plants in the United States. These samples contained 0.0015 to 0.003 percent U_3O_8 . The Grand Junction Office, EROA, obtained and had analyzed ash from nine power plants burning North Dakota lignites and two power plants burning lignite or brown coal from Texas. The uranium content of these ash samples was six to 20 parts per million. The lowest grade of uranium ore being processed is 0.025 percent U_3O_8 .

About one hundred out of several thousand coal and lignite samples analyzed by the USGS, Bureau of Mines and Atomic Energy Commission contained more than 0.01 percent U_3O_8 , but none of these high-uranium, coal-like materials has been burned in power plants. Most high-uranium lignites contain so much water that they cannot be burned unless combined with other fuel.

1/
Unpublished data 1975

A-13

Department of Energy comment

Section 12.4.3 — First Paragraph. The estimate of U_3O_8 recoverable through the year 2000 as a by-product of wet-process phosphoric acid is 115,000 tons and as a by-product of copper dump leaching is 25,000 tons. This potential production is in addition to the 680,000 tons U_3O_8 available at a forward cost of \$30 or less per pound U_3O_8 from conventional mining and milling sources.

Source: "Statistical Data of the Uranium Industry, January 1, 1977" GJO-100(77), United States Energy Research and Development Administration, Grand Junction Office

NRC response

The text has been revised to include this information.

Department of Energy comment

Section 12.4.3 — Last Paragraph. The first three sentences might be replaced with the following:

Although it has been suggested occasionally that by-product uranium might be recovered from the ash from electric generating plants which burn lignite or coal as fuel, no data collected to date indicate that such uranium recovery is economically feasible at present U_3O_8 prices.

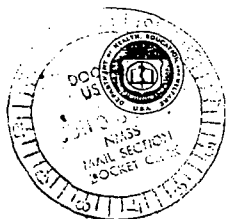
The U.S. Bureau of Mines, Metallurgy Research Center, Salt Lake City, has obtained and analyzed ash from eleven large coal-burning power plants in the United States. These samples contained 0.0015 to 0.003 percent U_3O_8 .^{*} The Grand Junction Office, ERDA, obtained and had analyzed ash from nine power plants burning North Dakota lignites and two power plants burning lignite or brown coal from Texas. The uranium content of these ash samples was six to 20 parts per million. The lowest grade of uranium ore being processed is 0.025 percent U_3O_8 .

About one hundred out of several thousand coal and lignite samples analyzed by the USGS, Bureau of Mines and Atomic Energy Commission contained more than 0.01 percent U_3O_8 , but none of these high-uranium, coal-like materials has been burned in power plants. Most high-uranium lignites contain so much water that they cannot be burned unless combined with other fuel.

^{*} Unpublished data 1975.

NRC response

The DOE comment provides further support to the conclusion that uranium recovery from lignite ash is not feasible currently from an economic standpoint.



DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
FOOD AND DRUG ADMINISTRATION
ROCKVILLE, MARYLAND 20857

JUN 5 1978

Mr. Leland C. Rouse, Chief
Fuel Processing and Fabrication
Branch
Division of Fuel Cycle
and Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rouse:

The Department of Health, Education and Welfare has reviewed the health aspects of the Draft Environmental Statement related to operation of Wyoming Mineral Corporation, Trigaray Solution Mining Project, Docket No. 40-8052 and has the following comments to offer.

Chapter 5. The problems associated with restoration of the groundwater containing the ore-bearing sandstone after extraction of the uranium has been recognized and identified in various sections of the Statement. The restoration of the water quality cannot be evaluated until data are available from the production scale mining unit. Thus, there is a probability that the water cannot be restored to its pre-mining quality and modification will be required in the restoration program prior to mining any area beyond the first production unit. In particular, some aspects of the ammonium problem could remain unresolved following restoration of the first production unit and will require further study. Also, the NRC conclusion on page 6-9 raises question about the degradation of the groundwater in the mining area that need to be resolved before full-scale solution mining can be considered acceptable.

Chapter 6, Section 6.7. The radiological impacts of routine operations results in radiation dose commitments to individuals and populations that are within acceptable limits. It is noted that Table 6.7 includes the future EPA Standard (40 CFR 190) in the comparison of the annual dose commitment with the radiation protection standards.

Some discussion should be included in the Statement on occupational exposure of the mill workers and the control measures that will be used to minimize the dose.

Chapter 7, Section 7.1. The discussion of surface accidents has not included tornadoes. Since the mill site is in an area categorized as Region 3 in relative tornado intensity the radiological impact of a tornado should be added to this section. Even though it is not possible to accurately predict the amount of material dispersed by a tornado a conservative estimate could be made by assuming 2 days production of yellowcake is free and not packaged in containers, the maximum production of yellowcake is onsite when the tornado strikes, and 15% of the contained material is released.

Page 2 - Mr. Leland Rouse

Chapter 8. The minimum radiological monitoring program may be adequate in view of the low release rates for radionuclides from the well field and recovery plant. However, for at least the first year of operations the monitoring program should be expanded to the level recommended by the NRC for acid or alkaline leach uranium mills.

The well field monitoring program from a public health standpoint is critical because of the potential degradation of the groundwater. The location of the wells and frequency of sampling appear to be adequate until further site specific data have been developed and evaluated.

In summary it is believed that the Trigaray Solution Mining of Project can be operated to meet current radiation protection guidance and provide adequate protection of the public health and safety. However, until the restoration program of the first production unit has been successfully completed a conclusion on this aspect of the operation cannot be made.

Sincerely yours,

Charles L. Weaver
Charles L. Weaver
Consultant
Bureau of Radiological Health

A-15

1. U.S. Department of Health, Education, and Welfare comment

Chapter 5. The problems associated with restoration of the groundwater containing the ore-bearing sandstone after extraction of the uranium has been recognized and identified in various sections of the Statement. The restoration of the water quality cannot be evaluated until data are available from the production scale mining unit. Thus, there is a probability that the water cannot be restored to its pre-mining quality and modification will be required in the restoration program prior to mining any area beyond the first production unit. In particular, some aspects of the ammonium problem could remain unresolved following restoration of the first production unit and will require further study. Also, the NRC conclusion on page 6-9 raises question about the degradation of the groundwater in the mining area that need to be resolved before full-scale solution mining can be considered acceptable.

NRC response

No response necessary.

2. U.S. Department of Health, Education, and Welfare comment

Chapter 6, Section 6.7. The radiological impacts of routine operations results in radiation dose commitments to individuals and populations that are within acceptable limits. It is noted that Table 6.7 includes the future EPA Standard (40 CFR 190) in the comparison of the annual dose commitment with the radiation protection standards.

Some discussion should be included in the Statement on occupational exposure of the mill workers and the control measures that will be used to minimize the dose.

NRC response

Section 6.7.5, entitled "Occupational exposure," has been added to the text.

3. U.S. Department of Health, Education, and Welfare comment

Chapter 7, Section 7.1. The discussion of surface accidents has not included tornadoes. Since the mill site is in an area categorized as Region 3 in relative tornado intensity, the radiological impact of a tornado should be added to this section. Even though it is not possible to accurately predict the amount of material dispersed by a tornado, a conservative estimate could be made by assuming two days production of yellowcake is free and not packaged in containers, the maximum-production of yellowcake is onsite when the tornado strikes, and 15% of the contained material is released.

NRC response

Section 7.1.4 pertaining to tornadoes has been added to the text.

4. U.S. Department of Health, Education, and Welfare comment

Chapter 8. The minimum radiological monitoring program may be adequate in view of the low release rates for radionuclides from the well field and recovery plant. However, for at least the first year of operations the monitoring program should be expanded to the level recommended by the NRC for acid or alkaline leach uranium mills.

The well field monitoring program from a public health standpoint is critical because of the potential degradation of the groundwater. The location of the wells and frequency of sampling appear to be adequate until further site specific data have been developed and evaluated.

NRC response

Because of the nature of the projected sources, types, and quantities of radiological effluent from solution mining activities, the staff does not believe that it is reasonable or necessary to expand the radiological monitoring program to the level presently prescribed by NRC for conventional uranium mills.

See response to WMC comment 31, on page A-82 for further discussion of radiological monitoring program.



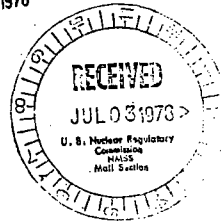
United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER-78/390

JUN 29 1978

Mr. Leland C. Rouse, Chief
Fuel Processing and Fabrication
Branch
Division of Fuel Cycle and Material
Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555



Dear Mr. Rouse:

This is in response to your letter of April 28 requesting comments on the draft environmental statement for the Wyoming Mineral Corporation's Irigaray Solution Mining Project, Johnson County, Wyoming.

GENERAL COMMENTS

This environmental statement should be clearly limited in scope to the small experimental pilot program near Willow Creek (50-acre site). In our opinion it would be inappropriate to attempt to address the total impacts of any long-term commercial operations in this EIS. Fundamental engineering and environmental data that would be developed during the initial experimental phase would be necessary to address the impacts of any expanded full-scale commercial program.

There are no maps, legal descriptions, or other data concerning the surface and mineral ownership in the project area. Thus it is difficult to determine exactly what comprises the proposed Federal action.

The lack of a discrete section of mitigating measures lends uncertainty to the impact analysis. The general conditions at the beginning of the document, as well as the monitoring indicated in chapter 8, do not fully explain those measures

which will be accomplished to mitigate impact. As an example, the statement should include a discussion of reclamation plans on the site. This discussion should detail how and when reclamation will occur, and the degree to which reclamation would restore use of the project site (grazing, wildlife habitat, etc.).

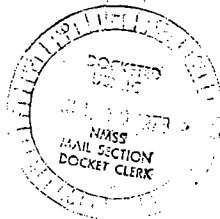
A much more detailed discussion of the radiological monitoring program for water, air, and the soil/biota system should be prepared. Until these programs are developed and described in detail, this impact statement is incomplete.

The draft statement does not evidence adequate identification of cultural resources in the planning of the proposed project. The National Register of Historic Places has been consulted concerning the existence of presently known historic sites on or eligible for the National Register. In addition, we recommend that the Nuclear Regulatory Commission contact the SHPO and/or the State Archeologist to determine if there are other cultural resources in the area, and the type and level of a cultural resource survey that may be needed in the study corridor. These opinions should be included in the final statement.

If the SHPO and/or the State Archeologist indicate that a survey is advisable, we recommend that such be undertaken prior to the selection of a preferred alternative, and that a full discussion of the findings of such survey be included in the final statement.

The final statement should include a determination of the level of significance (local, State, or national) for all cultural resources now known to exist, or which may be discovered, in the study corridor. Such determinations should be undertaken in consultation with the SHPO. If it is determined that any such resources meet or may meet the National Register criteria, then the procedures of 36 CFR 800.4(a)(2) and 36 CFR 63 should be followed and reported in the final statement.

Whenever large volumes of ground water are removed from the aquifer, the possibility of subsidence exists. This slumping or settling phenomenon can alter aquifers, cause surface disturbances, and encourage erosion by modifying local topography. The probability of occurrence and preventive measures to be taken should be mentioned in the statement.



A-17

SPECIFIC COMMENTS

Page 1-1, sec. 1.2: Discussion of the mineral ownership should be included for the initial 50-acre well field and also for future expanded activities.

Page 2-10: The EIS indicates that no baseline flow or water-quality data are available on Willow Creek. Willow Creek is adjacent to the proposed pilot experiment and the alluvium in the creek bottom may be connected with the underlying uranium-bearing aquifer. The company must, therefore, collect sufficient data on Willow Creek and the alluvial system so that potential impacts can be determined.

Page 2-22, sec. 2.7.2: This discussion is a good, accurate synopsis of mineral resources in the project area except that the recently discovered Table Mountain oilfield in secs. 35 and 36, T. 45 N., R. 77 W., should be mentioned. This two-well field, discovered in 1977, could be affected if it trends north-northwest into the project area. The nearby Heldt Draw oilfield does have a north-northwest trend.

Page 2-30, sec. 2.9.1.2: The bald eagle (Haliaeetus leucocephalus) is known to occur in the Powder River drainage. This raptor is on the Federal list of endangered species of fauna and should be so stated in the section.

Page 3-1 through 3-15: This chapter is a generalized discussion of solution mining and doesn't pertain to this specific project. The material should be referenced in an appendix or eliminated.

Page 4-1 through 4-16: This chapter needs to be expanded to include solubility and rates of solution of uranium minerals in the elutive leach solution, effects of the leaching oxidizing solution as to interaction with reducing compounds present, etc.

Page 4-1, sec. 4.3.1: The oxidizing agent to be used, presumably hydrogen peroxide, should be indicated.

Page 4-7: The fracturing pressure for the host sandstone is given as about 140 pounds per square inch (psi) and the importance of maintaining injection pressures below fracturing pressure levels is discussed (sec. 4.3.3). The discussion of site geology (sec. 2.7.1.4) indicates that the host sandstone

is from 75 to 500 feet below the land surface. The statement should indicate more precisely the range of depths to the host sandstone in areas of the planned well fields and the related ranges of fracturing pressures or the procedure to be followed in selecting critical fracture pressures in the various areas. The analysis of possible impacts should include planned mitigation of effects of accidental hydraulic fracturing of the host sandstone, including methods of restoration of effective hydraulic integrity of the sandstone. The accident analysis should include consideration of accidental vertical fracturing that might allow escape of solutions to the surface or permit solutions to bypass observation wells. A prediction of the movement of radionuclide contaminants in the ground water should be included.

Page 5-5: A technical report on ground-water restoration should be included as an appendix to the EIS. We assume that ground-water restoration must be proven feasible in order for approval for any project of this type to be considered.

Page 6-3, sec. 6.3.1.1: The amount of soil loss from construction of the Irigaray Project is compared to cumulative average sedimentation in the Powder River. The comparison is weakened, however, by the absence of an indication of the significance of the cumulative levels of sedimentation. Surface-water quality may be impacted by other existing or proposed sources of sediment.

It is also indicated that solution mining will be conducted in the streambed of Willow Creek. Methods to be used to mitigate the indicated adverse impacts should be discussed.

Page 6-3, sec. 6.5.1.1: It is stated that measures to protect mining equipment during periods of high water, as well as downstream water quality, are currently being developed for in-stream mining of Willow Creek. Enough emphasis cannot be placed on the need to prevent radioactive or chemical pollutants from entering the Powder River system via Willow Creek, or by any other means. It is stated that protective measures will be adopted and reviewed by NRC prior to commencement of mining in the streambed in 1979. It is highly desirable that these measures be designed prior to mining and covered in a supplemental EIS so that all concerned agencies can review them. A major spill in the watershed may not only impact the Powder River but could possibly have undesirable effects on the Yellowstone River ecosystem as well.

Page 6-4, sec. 6.3.2.2: The discussion of impacts on ground-water quality predicted increases in chemical concentrations for various contaminants but did not put the significance of these impacts in perspective. The analysis would be strengthened if contamination were related to effects on ground-water users in the area.

Page 6-9, sec. 6.4: This section raises an interesting point regarding alternative mining methods and resource conservation versus economic considerations. Although solution mining would allow partial recovery of certain ore deposits too low in grade or size to be mined economically by conventional methods, uranium recovery may not be as efficient as from open pit or underground mining. Conventional open-pit mining of the Irigaray deposit has not been ruled out as an alternative (sec. 12.1.1); one could safely assume the company would select the most profitable method of recovery when size and grade of the ore body are known more completely. Conceivably, the company could maximize profits through lower-cost solution mining, with a consequent loss of resources, even though the ore is marginally rich enough to be mined by higher-cost open-pit methods. The point is pertinent to all such deposits of size and grade that would allow a choice between conventional and solution mining. Philosophically, we might ask if we can afford to waste a part of these marginal resources and who should make the choice.

Page 6-9, Conclusions: The degree of degradation of ground water in the mining zone from the proposed project is stated to be significantly dependent on an unknown factor involving nitrites and nitrates. Fish, other aquatic life, and livestock could be adversely affected. Therefore, it would be desirable prior to mining to develop additional knowledge and protective measures to prevent contamination.

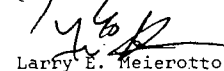
Page 8-4, sec. 8.2.1: As indicated, the waste ponds are to be monitored monthly. This program should be discussed in detail.

Page 9-1, sec. 9.4: We do not regard extraction of uranium, as proposed, as an unavoidable adverse impact on mineral resources; such resources are useless to society until they are developed. Extraction of the uranium, however, does involve a commitment of the resource, as noted in section 11.1, although only a small fraction of the uranium is actually lost in the nuclear power generation cycle.

Page 9-1, sec. 9.6.1: It is stated that the evaporation ponds will harm, to some extent, all forms of wildlife that may come in contact with them. This should be dealt with in more detail under "Biological Impacts." Also, preventative measures such as fencing and flagging should be taken to discourage the entry of wildlife, including shorebirds and waterfowl. The consumption of contaminated wildlife by predators, to include man, could introduce undesired elements into the natural food chain.

Thank you for the opportunity to comment.

Sincerely,


Larry E. Meierotto

Deputy Assistant SECRETARY

1. U.S. Department of the Interior comment

This environmental statement should be clearly limited in scope to the small experimental pilot program near Willow Creek (50-acre site). In our opinion it would be inappropriate to attempt to address the total impacts of any long-term commercial operations in this EIS. Fundamental engineering and environmental data that would be developed during the initial experimental phase would be necessary to address the impacts of any expanded full-scale commercial program.

NRC response

The staff agrees. See Sect. 1.1.

2. U.S. Department of the Interior comment

There are no maps, legal descriptions, or other data concerning the surface and mineral ownership in the project area. Thus it is difficult to determine exactly what comprises the proposed Federal Action.

NRC response

The proposed Federal action is the issuance of a source material license by the Nuclear Regulatory Commission (see Sects. 1.3 and 1.5). Surface and mineral ownership are addressed in response to Department of the Interior comment 7.

3. U.S. Department of the Interior comment

The lack of a discrete section of mitigating measures lends uncertainty to the impact analysis. The general conditions at the beginning of the document, as well as the monitoring indicated in Chapter 8, do not fully explain those measures which will be accomplished to mitigate impact. As an example, the statement should include a discussion of reclamation plans on the site. This discussion should detail how and when reclamation will occur, and the degree to which reclamation would restore use of the project site (grazing, wildlife habitat, etc.).

NRC response

Mitigating measures for the Irigaray project include aquifer restoration and reclamation. These are addressed in detail in Sect. 5; Sect. 8.2.3.6, Corrective Actions, discusses mitigating measure for leach solution excursions during operations.

4. U.S. Department of the Interior comment

A much more detailed discussion of the radiological monitoring program for water, air, and the soil/biota system should be prepared. Until these programs are developed and described in detail, this impact statement is incomplete.

NRC response

Resulting radiation exposures, as shown in Sect. 6.7, demonstrate that radiological releases are expected to be low. The radiological monitoring program takes into account the scope of the proposed project and the projected releases.

Additional information on the monitoring program has been provided in revised Sect. 8.2.2; see also NRC response to WMC comment 31, page A-82.

5. U.S. Department of the Interior comment

The draft statement does not evidence adequate identification of cultural resources in the planning of the proposed project. The National Register of Historic Places has been consulted concerning the existence of presently known historic sites on or eligible for the National Register. In addition, we recommend that the Nuclear Regulatory Commission contact the SHPO and/or the State Archeologist to determine if there are other cultural resources in the area, and the type and level of a cultural resource survey that may be needed in the study corridor. These opinions should be included in the final statement.

If the SHPO and/or the State Archeologist indicate that a survey is advisable, we recommend that such be undertaken prior to the selection of a preferred alternative, and that a full discussion of the findings of such survey be included in the final statement.

The final statement should include a determination of the level of significance (local, State, or national) for all cultural resources now known to exist, or which may be discovered, in the study corridor. Such determinations should be undertaken in consultation with the SHPO. If it is determined that any such resources meet or may meet the National Register criteria, then the procedures of 36 CFR 800.4(a)(2) and 36 CFR 63 should be followed and reported in the final statement.

NRC response

See response to letter from the Advisory Council on Historic Preservation, p. A-5.

6. U.S. Department of the Interior comment

Whenever large volumes of ground water are removed from the aquifer, the possibility of subsidence exists. This slumping or settling phenomenon can alter aquifers, cause surface disturbances, and encourage erosion by modifying local topography. The probability of occurrence and preventive measures to be taken should be mentioned in the statement.

NRC response

The applicant's solution mining process is basically a closed circuit operation with near-balanced flow. The 1% bleed will not result in the removal of large volumes of groundwater from the aquifer. Consequently, the net drawdown is not expected to result in significant subsidence of overlying clays. As noted in Sect. 12.1.3.2, a minimum of subsidence is expected with this mining method.

SPECIFIC COMMENTS

7. U.S. Department of the Interior comment

Page 1-1, sec. 1.2. Discussion of the mineral ownership should be included for the initial 50-acre well field and also for future expanded activities.

NRC response

Figures 1.3 and 1.4 showing surface and mineral ownership have been added to the text.

8. U.S. Department of the Interior comment

Page 2-10. The EIS indicates that no baseline flow or water-quality data are available on Willow Creek. Willow Creek is adjacent to the proposed pilot experiment and the alluvium in the creek bottom may be connected with the underlying uranium-bearing aquifer. The company must, therefore, collect sufficient data on Willow Creek and the alluvial system so that potential impacts can be determined.

NRC Response

Figures 2.16 and 2.17 show no evidence of a connection between the alluvium in the creek bottom and the uranium-bearing aquifer. In addition, baseline surveys as recommended in Section 8.1.5.3 will also generate data to assess any impacts.

9. U.S. Department of the Interior comment

Page 2-22, sec. 2.7.2. This discussion is a good, accurate synopsis of mineral resources in the project area except that the recently discovered Table Mountain oilfield in secs. 37 and 36, T. 45N. R. 77 W., should be mentioned. This two-well field, discovered in 1977, could be affected if it trends north-northwest into the project area. The nearby Heldt Draw oilfield does have a north-northwest trend.

NRC response

This information has been added to the text.

10. U.S. Department of the Interior comment

Page 2-30, sec. 2.9.1.2. The bald eagle (*Haliaeetus leucocephalus*) is known to occur in the Powder River drainage. This raptor is on the Federal list of endangered species of fauna and should be so stated in the section.

NRC response

Section 2.9.1.2 has been revised to include the bald eagle.

11. U.S. Department of the Interior comment

Page 3-1 through 3-15. This chapter is a generalized discussion of solution mining and doesn't pertain to this specific project. The material should be referenced in an appendix or eliminated.

NRC response

The staff added this section to provide the general public with background information as this was the first Statement for a production-scale uranium solution mining operation

12. U.S. Department of the Interior comment

Page 4-1 through 4-16. This chapter needs to be expanded to include solubility and rates of solution of uranium minerals in the elutive leach solution, effects of the leaching oxidizing solution as to interaction with reducing compounds present, etc.

NRC response

The rates of mineral solution are diffusion controlled. Further information on this subject may be found in P. Galichon et al., "Chemical Factors in In-Situ Uranium Leach Mining," *In Situ* 1(2): 125-146 (1977).

13. U.S. Department of the Interior comment

Page 4-1, sec. 4.3.1. The oxidizing agent to be used, presumably hydrogen peroxide, should be indicated.

NRC response

The specific oxidant to be used has been included in this section.

14. U.S. Department of the Interior comment

Page 4-7. The fracturing pressure for the host sandstone is given as about 140 pounds per square inch (psi) and the importance of maintaining injection pressures below fracturing pressure levels is discussed (sec. 4.3.3). The discussion of site geology (sec. 2.7.1.4) indicates that the host sandstone is from 75 to 500 feet below the land surface. The statement should indicate more precisely the range of depths to the host sandstone in areas of the planned well fields and the related ranges of fracturing pressures in the various areas. The analysis of possible impacts should include planned mitigation of effects of accidental hydraulic fracturing of the host sandstone, including methods of restoration of effective hydraulic integrity of the sandstone. The accident analysis should include consideration of accidental vertical fracturing that might allow escape of solutions to the surface or permit solutions to bypass observation wells. A prediction of the movement of radionuclide contaminants in the ground water should be included.

NRC response

As stated on p. 4-7 of the DES successful leaching could be markedly impeded if fracturing occurs. The applicant's experience with the unconsolidated Upper Irigaray sandstone indicates that this unit is essentially self-sealing when pressure has been relieved. Should accidental fracturing occur, that portion of the well field would be shut down, and the fracture would be allowed to close. Solutions migrating through the host sandstone as a result of accidental fracturing would behave as an excursion. Their presence would be detected in either the trend or monitor wells.

15. U.S. Department of the Interior comment

Page 5-5. A technical report on ground-water restoration should be included as an appendix to the EIS. We assume that ground-water restoration must be proven feasible in order for approval for any project of this type to be considered.

NRC response

The applicant's demonstration test (see Sect. 5.1.2) has provided data indicating the feasibility of groundwater restoration. However, this data was derived from small-scale field tests. As stated in Sects. 5.1.5 and 13.3, the development and demonstration of an acceptable groundwater restoration technique on a production-scale mining unit is a prime objective of the project.

16. U.S. Department of the Interior comment

Page 6-3, sec. 6.3.1.1. The amount of soil loss from construction of the Irigaray Project is compared to cumulative average sedimentation in the Powder River. The comparison is weakened, however, by the absence of an indication of the significance of the cumulative levels of sedimentation. Surface water quality may be impacted by other existing or proposed sources of sediment.

It is also indicated that solution mining will be conducted in the streambed of Willow Creek. Methods to be used to mitigate the indicated adverse impacts should be discussed.

NRC response

The staff believes the conclusion that increased sediment release would "constitute a negligible addition" is adequate. See Department of the Army, Corps of Engineers comments and NRC responses (page A-9) for mining impacts on Willow Creek.

17. U.S. Department of the Interior comment

Page 6-3, sec. 6.5.1.1. It is stated that measures to protect mining equipment during periods of high water, as well as downstream water quality, are currently being developed for in-stream mining of Willow Creek. Enough emphasis cannot be placed on the need to prevent radioactive or chemical pollutants from entering the Powder River system via Willow Creek, or by any other means. It is stated that protective measures will be adopted and reviewed by NRC prior to commencement of mining in the streambed in 1979. It is highly desirable that these measures be designed prior to mining and covered in a supplemental EIS so that all concerned agencies can review them. A major spill in the watershed may not only impact the Powder River but could possibly have undesirable effects on the Yellowstone River ecosystem as well.

NRC response

See response to Dept. of the Army Corps of Engineers Comment 1 (page A-9). As noted in condition 7j, page v, further assessment of the potential impact of mining in the creek bed area is intended. This will be coordinated with other agencies as appropriate. It should be recognized that the lixiviants (both barren and pregnant) are chemically very dilute and would not realistically impact the Powder River watershed.

18. U.S. Department of the Interior comment

Page 6-4, sec. 6.3.2.2. The discussion of impacts on groundwater quality predicted increases in chemical concentrations for various contaminants but did not put the significance of these impacts in perspective. The analysis would be strengthened if contamination were related to effects on ground-water users in the area.

NRC response

The staff believes that this is accomplished in Sect. 6.3.2.2 under the subheading Water Use.

19. U.S. Department of the Interior comment

Page 6-9, sec. 6.4. This section raises an interesting point regarding alternative mining methods and resource conservation versus economic considerations. Although solution mining would allow partial recovery of certain ore deposits too low in grade or size to be mined economically by conventional methods, uranium recovery may not be as efficient as from open pit or underground mining. Conventional open-pit mining of the Irigaray deposit has not been ruled out as an alternative (Sect. 12.1.1); one could safely assume the company would select the most profitable method of recovery when size and grade of the ore body are known more completely. Conceivably, the company could maximize profits through lower-cost solution mining, with a consequent loss of resources, even though the ore is marginally rich enough to be mined by higher-cost open-pit

methods. The point is pertinent to all such deposits of size and grade that would allow a choice between conventional and solution mining. Philosophically, we might ask if we can afford to waste a part of these marginal resources and who should make the choice.

NRC response

The Department of the Interior raises an important philosophical point regarding solution mining that is applicable to the recovery of any mineral resource. No extraction method recovers 100% of the resource sought. The preferred method for mining marginal uranium deposits would depend primarily on economics (current and projected price of the product), technical feasibility and environmental impacts. Uranium solution mining is a developing technology. Product recovery rates have created increased interest by mining operators in applying this method where the disposition, geometry and grade of the ore bodies lend themselves to this technique. Furthermore, the environmental advantages of solution mining may offset the value of the relatively small percentage of uranium not extracted by this mining method.

20. U.S. Department of the Interior comment

Page 6-9, Conclusions. The degree of degradation of ground water in the mining zone from the proposed project is stated to be significantly dependent on an unknown factor involving nitrites and nitrates. Fish, other aquatic life, and livestock could be adversely affected. Therefore, it would be desirable prior to mining to develop additional knowledge and protective measures to prevent contamination.

NRC response

The staff believes that this task will be accomplished by additional studies (DES, p. 6-8), postrestoration monitoring (DES, p. 8-7), and information obtained during the limited operation.

21. U.S. Department of the Interior comment

Page 8-4, sec. 8.2.1. As indicated, the waste ponds are to be monitored monthly. This program should be discussed in detail.

NRC response

Section 8.2.1 has been revised.

22. U.S. Department of the Interior comment

Page 9-1, sec. 9.4. We do not regard extraction of uranium, as proposed, as an unavoidable adverse impact on mineral resources; such resources are useless to society until they are developed. Extraction of the uranium, however, does involve a commitment of the resource, as noted in section 11.1, although only a small fraction of the uranium is actually lost in the nuclear power generation cycle.

NRC response

The text has been edited.

24. U.S. Department of the Interior comment

Page 9-1, sec. 9.6.1. It is stated that the evaporation ponds will harm, to some extent, all forms of wildlife that may come in contact with them. This should be dealt with in more detail under "Biological Impacts." Also, preventative measures such as fencing and flagging should be taken to discourage the entry of wildlife, including shorebirds and waterfowl. The consumption of contaminated wildlife by predators, to include man, could introduce undesired elements into the natural food chain.

NRC response

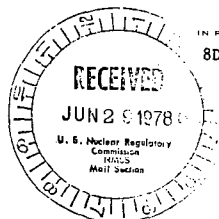
Section 6.6.1 has been revised to include impacts on wildlife.



DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
REGIONAL OFFICE
EXECUTIVE TOWER - 1405 CURTIS STREET
DENVER, COLORADO 80202

REGION VIII

June 21, 1978



IN REPLY REFER TO:

8DE

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

Dear Mr. Rouse:

This is in response to your letter dated April 28, 1978, requesting comments on the draft Environmental Impact Statement (EIS) related to the operation of Wyoming Mineral Corporation.

As you know, responsibilities of the U.S. Department of Housing and Urban Development (HUD) for review of other agency EIS's include consideration of a proposal's compatibility with comprehensive plans for the area, and the impact the proposal is likely to have on an urbanized area.

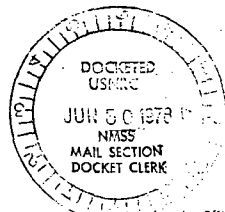
The relationship of the proposal to the comprehensive plan for the area is not clear. Your estimates of population increase resulting from this proposal do not suggest a problem for urban services in the city of Buffalo, Wyoming, or Johnson County, Wyoming. However, the attitudes of local governments toward this proposal and the compatibility with local and regional plans should be clearly articulated in the EIS.

We appreciate this opportunity to comment on your EIS. If we can be of further assistance, please contact Mr. Timothy Hepp, Environmental Specialist, at FTS 327-3102 or (303) 837-3102.

Sincerely,

Robert J. Matyschek

Robert J. Matyschek
Assistant Regional Administrator
Office of Community Planning
and Development



Including Offices
Casper, Wyoming - Denver, Colorado - Fargo, North Dakota - Helena, Montana - Salt Lake City, Utah - Sioux Falls, South Dakota

A-25

1. Department of Housing and Urban Development comment

The relationship of the proposal to the comprehensive plan for the area is not clear. Your estimates of population increase resulting from this proposal do not suggest a problem for urban services in the city of Buffalo, Wyoming, or Johnson County, Wyoming. However, the attitudes of local governments toward this proposal and the compatibility with local and regional plans should be clearly articulated in the EIS.

NRC response

The staff contacted the Johnson County Planning agency as noted in revised Sect. 6.2.



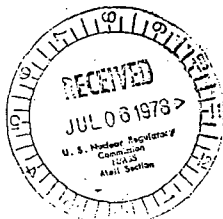
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VIII
1860 LINCOLN STREET
DENVER, COLORADO 80203

July 3, 1978

Ref: BAH-WM

Mr. Leland C. Rouse, Chief
Fuel Processing & Fabrication Branch
Division of Fuel Cycle and Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555



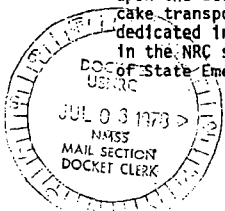
Dear Mr. Rouse:

We have completed reviewing your Agency's recently issued draft environmental statement (DES) on the Irigary Uranium Solution Mining Project (NUREG-0399) planned by the Westinghouse Corporation.

In general, the EPA reviewing staff found the DES to be a thorough and well prepared document. We strongly support the NRC's phased-development approach during the first five years which limits the size of the operation to 50 acres until restoration is demonstrated on a production-scale mining unit. The NRC's licensing approach to the Irigary Project seems a reasonable action that will set a positive precedence for future in-situ solution mining projects.

Regarding the restoration question, we are concerned with the residual ammonia in groundwater or absorbed to clay particles in the aquifer after mining. The applicant's ability to remove this contaminant to an acceptable level is still open to some doubt as is the fate of the ammonia which can be converted to nitrate (NO₃) under given conditions. Since there are strict EPA limitations on nitrate in drinking water due to its public health implications, we urge the NRC to exert the utmost vigilance in evaluating the applicant's restoration program and its results. Before any additional solution mining is authorized in adjoining sections, the NRC staff should get a consensus agreement from involved Wyoming State Agencies and EPA that any further degradation of groundwater is within acceptable limits.

In this DES, as in other recently issued statements, the NRC staff has stated that the source material license will be contingent upon the acceptance of the applicant's emergency action plan for yellow-cake transportation accidents. Since the EPA Region VIII office has a dedicated interest in this area, as evidenced by the staff's involvement in the NRC supported publication "Guide and Example Plan for Development of State Emergency Response Plans and Systems for Transportation-Related



2

Radiation Incidents", we request that the Region VIII office be given the opportunity to review the applicant's plans and the NRC staff's acceptability criteria.

According to the procedures EPA has adopted to rate environmental statements, NUREG-0399 will be listed in the Federal Register as L0-2. This means that based on the information presented, we have no environmental objection to the limited five year project, but request some additional information be presented.

We will be glad to discuss the attached comments if you need further clarification or desire additional guidance on how these can be dealt with in the final environmental statement.

Sincerely yours,

Charles C. Merson
Alan Merson
Regional Administrator

Enclosure

A-27

EPA REGION VIII

SPECIFIC COMMENTS ON

DRAFT ENVIRONMENTAL STATEMENT (DES)

(NUREG-0399)

SWEETWATER URANIUM PROJECT

2

1. Page 2-8, Section 2.6.1: Based on the detailed drawings provided in Figures 1.2 and 2.7, it should be stated in the FES that the Powder River flows through the Irigary solution mining area rather than adjacent to the Irigary Site as stated in the DES, because the additional area may be developed at a later date.
2. Page 2-10, Section 2.6.2: The data on groundwater at the site does not appear to be detailed enough to make a complete analysis as to what may happen in the area when mining is initiated. It is not clear whether the groundwater in the area is confined to the Irigary sandstones or if there is water contained in the material which overlies the coal unit. There is also no data on the extent of groundwater in the alluvium and what its relationship is to water in the Wasatch formation. There should be data on the extent and depth to water in both the alluvium and the Wasatch formation. If there is water overlying the upper Irigary sandstone there should be some data to indicate the degree of interconnections or lack of connection between the various units. It would be helpful if the FES included data on the depths at which water was first encountered in each of the major geologic units in the various core holes and injection wells on the property. Data on the static water levels in these holes should also be furnished.
3. Page 2-13, Section 2.6.3: The data on the storage coefficient and the hydraulic conductivity in the area of the mine does not seem sufficient to evaluate whether zones with much larger conductivities may exist. A pump test of 19 hours duration is not generally sufficient in a material of this type to adequately evaluate the storage coefficient and conductivity. In interbedded sandstones it is usually necessary to pump a well at a continuous rate (+5% of average discharge) for at least one week in order to obtain reasonable estimates. It is often the case that as the well is pumped the storage coefficient will approach that of a water table aquifer. The initial low values are caused by interbedded sands and clays of the formation which cause a delayed drainage effect that causes a water table aquifer to act like an artesian unit in the early stages of pumping. The applicant should be required to run a more detailed pumping test on the first commercial unit to be mined.

The hydraulic characteristics of individual lenses (or channels) may vary considerably. Can possible ranges be given for these characteristics (e.g. groundwater flow rates)?

4. Page 2-18, Section 2.6.3: What are the uses of the Powder River and Willow Creek both in the project area and downstream from it?
5. Page 2-18, Section 2.7.1: The data on the geology at the plant site appears sketchy and should be amplified. There should be some data on the extent of alluvial materials in the area. It is hard to envision that the claystone overlying the ore body is as continuous as is shown on Figure 2.16 and 2.17, given the type of depositional history of the Wasatch Formation. Also, the lack of data on the nature of the materials overlying the coal unit makes it difficult to make a judgement on the groundwater hydrology of the entire unit. It would be helpful if the FES included a table which lists the detailed logs for each of the drill holes, shown in the cross sections. In addition, there should be some discussion on the integrity of the claystone and the coal seam as far as the degree of fracturing that may be present in the site area.
6. Page 2-22, Section 2.7.1.4: The Site Geology Section states that the fluvial depositional environment of the Wasatch Formation has resulted in numerous facies changes and highly lenticular stratigraphy. The FES should address the continuity of the claystone which overlies and underlies the Upper Irigary Sandstone.
7. Page 2-31, Section 2.9.2: In the last paragraph on page 2-31 note is made of a pre-operational monitoring deficiency:

"Very little is known about Willow Creek and any aquatic biota that may inhabit it... Although Willow Creek is intermittent, it may provide breeding habitat for fish during parts of the year..."

In contrast to this position of the NRC staff, which does not require a biological study, we believe an aquatic biology study should be conducted to establish the baseline conditions against which possible future events can be compared.

8. Page 3-6, Section 3.2.4.4: The drying temperature should be given as well as the percentage of U_3O_8 and ammonium diuranate.
9. Page 3-7, Section 3.2.6: The proposed approach to groundwater quality restoration seems to be the best possible with existing technology. However, considering the probable high costs of the proposed restoration process (groundwater sweeping, reverse osmosis, etc.). We are suspicious that there may be an attempt to "back-off" to a less costly and less effective process where the restoration process must be initiated. The argument would be that the minimal potential use of groundwater in this area and the low actual consumptive uses are compatible with a lower post-restoration water

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quality than that which existed in the pre-mining period. What procedure or method will be utilized to bind the Company to the implementation of the best possible restoration process?

10. Page 4-1, Section 4.3.1: If all the identified ore zones are mined by the solution process, what is the total number of wells (production and monitoring) that will be drilled?
11. Page 4-7, Section 4.4.1: This section implies that the processing plant may be moved to several locations during the life of the project. It would seem that each new site would then become an area requiring eventual decontamination. It could also require a number of waste impoundments. The alternative of longer runs of piping to a single plant site should be discussed.
12. Page 4-8, Section 4.4.2.1: If a plant breakdown occurs such that flow to and from the wells cannot be maintained, what is the method for preventing pipeline freezing and rupture (i.e., the United Nuclear - Homestake Partners pipeline rupture).
13. Page 4-10, Section 4.4.2.4: See above comment on U_3O_8 and ammonium diuranate.
14. Page 4-11, Section 4.6.2.1: The wastes may also contain other uranium chain nuclides.
15. Page 4-12, Section 4.6.2.1: The calcite pond should also have an underlying seepage collection system similar to the waste ponds.
16. Page 4-15, Section 4.6.3, Last paragraph: Is it clear that the radium would be in the form of radium sulfate and not radium chloride?
17. Page 4-15, Section 4.6.4: Unless special efforts are made to dewater these wastes, liquid releases during handling and transport may be more important than dust releases.
18. Page 4-16, Section 4.6.5: We would expect some radon release from the ion exchange columns. Has this been estimated or measured?
19. Page 5-2, Section 5.1.2: The applicants restoration test procedure is unclear as to the order that was followed in the various steps and as to whether the order of each step might effect the final level of restoration. More importantly, nothing was mentioned as to how the data collected on a restoration of part of the five spot pattern might represent the restoration of the entire plot. There is no indication as to whether the data collected at the injection and pumping wells is representative of the average value throughout the area effected by a given five spot. It would seem likely that the water in the immediate vicinity of an injection well, pumping well, or along the diagonal between the two wells would be of

better quality than elsewhere in the pattern. In future restoration tests the applicant should implace some monitoring wells within the pattern to allow sampling of the preresoration and post-restoration quality. Any restoration test should include an entire five spot not just a small corner.

There is little discussion as to the quality of water on the outside of the five spot pattern both after leaching and after restoration. This area will contain some of the mobilized minerals and it is difficult to imagine that restoration will be as complete as it might be in the center of the five spot especially if the treated water is reinjected into the same well as the leach solution was injected. The level of restoration immediately outside the five spot will be important on the very edge of the ore body. There should be some postleach test holes implaced outside the five spot pattern but within the proven zone of influence of the injection wells. These can be used to provide data on the effectiveness of the program in reducing contaminants just outside the five spot.

20. Page 5-2, Section 5.1.2, Groundwater Sweep Test: At what pumping rate was the groundwater sweep test conducted.
 21. Page 5-3, Table 5.1: The values shown in Columns A and B of Table 5.1 evidently were obtained from a single sampling of wells and reflect average concentrations rather than the chemistry for any specific well. The Columns need to be explained in terms of which wells were sampled to obtain the average values shown and what the time frame was between the preleaching sample and the postleaching sample. The range of each constituent for preleaching and post-leaching groundwater quality should be listed.
- It is not clear what Column E represents. The average constituent levels for all wells in the test pattern should be listed along with the range of each constituent.
- Do the blank spaces mean that the levels were below detection limits or that measurements were not made?
22. Page 5-4, Table 5.2: Table 5.1 gives very limited data with respect to carbonate, and where given, the data vary considerably from those given in Table 5.2 (e.g., 4.7 ppm vs. 267 ppm following groundwater sweeping). The FES should clear up this discrepancy.
 23. Pages 5-3 and 5-4, Tables 5.1 and 5.2: Minor discrepancies exist between Column E of Table 5.1 and Column E of Table 5.2 (e.g., ammonia, carbonate, and conductivity). These discrepancies should be resolved in the FES. In addition, what data is available with respect to postrestoration groundwater quality for gross alpha and gross beta? How many pore volumes were utilized in the residual total dissolved solids reduction test?

24. Page 6-1, Section 6.1: The combustion of propane may also result in release of radon which may at times confuse measurements made for radon released from other site operations.

25. Page 6-3, Section 6.3.1.1:

"...WMC plans to conduct solution mining in the streambed of Willow Creek and this activity has the greatest potential for adverse impact. WMC is currently developing engineering designs and methods to (1) protect pipes and equipment in the streambed from floods and (2) prevent adverse impacts to downstream water quality."

Considering the admitted high potential for adverse impact, the more advisable approach might be the prohibition of mining activity in the streambed. If mining will be permitted, the FES should be expanded to show that the anticipated benefits of mining in the environmentally sensitive area are substantially higher than possible environmental consequences (and the costs of special operating procedures).

26. Page 6-4, Section 6.3.2.2: The DES states that the leaching test conducted at the Irigary 517 test site was conducted for 107 days and that longer periods of leaching over a much larger area could possibly result in higher concentrations of toxic substance in groundwater. The FES should compare the specifications (e.g., period of leaching) of the leaching test with actual planned operations and attempt to draw conclusions with respect to restoration success of actual operations (i.e., how well does restoration data provided in the leaching tests simulate restoration that might be expected under actual commercial operation at the Irigary Site).
27. Page 6-5, Table 6.1: Was the analysis specific for U_3O_8 , uranium or uranyl dicarbonate?
28. Page 6-8, Section 6.3.2.2: The DES states that water in the post-restoration test hole PRC-1 has contained small quantities of ammonia. Data for this test hole should be presented in the FES.
29. Page 6-11, Section 6.7: How do the human radiation doses change as the Irigary plant location changes (as indicated on page 4-7, section 4.4.1)? For instance, as the plant is located closer to the Irigary and Hoe Ranches, we assume the radiation doses would go up.
30. Page 7-2, Section 7.1.1.2: It may be difficult to detect small leaks with radiological instruments in the presence of the radiation levels from the pipeline. Since small leaks may not be readily detectable by flow measurements frequent pipeline inspections should be conducted.

31. Page 7-5, Section 7.3.1: Are the exposure calculations based on the assumption that the yellowcake was composed solely of U_3O_8 or did they take into consideration the more soluble portion of the yellowcake? Do the calculations also take into account the ^{230}Th and ^{226}Ra content of the yellowcake?

As we indicated in previous DESs, we do not feel that the Colorado yellowcake transportation accident should be used as a typical case. The consequences of the accident would have been far more damaging had it not been for a series of fortunate, but non-controllable circumstances. Further, the major hazard is a chemical toxicity to the kidneys and not a radiation lung dose.

Industry should be encouraged to develop and use smaller, less hazardous yellowcake packaging containers suitable for transportation. The applicant's emergency response plan should be included in the FES.

32. Page 8-1, Table 8.1: As we stated in our review of WMC's ER, top soil and two vegetation samples are inadequate for a baseline radiological characterization.
33. Page 8-2, Table 8.2: It should be pointed out that the concentration data refers to radium 226 in the dissolved state, and not the total concentration of dissolved plus suspended.
34. Page 8-2, Section 8.1: We agree with the NRC staff that additional data is needed.
35. Page 8-2, Section 8.1.5.1: Three stations on the Powder River are satisfactory. However, instead of the proposed quarterly sampling frequency, it is recommended that the collection frequency be monthly for a two year period (the last year of the preoperational period and the first year of full production mining). Quarterly or semi-annual composite samples should be analyzed for both the suspended and dissolved concentrations of uranium and radium 226.
- Bottom sediment samples should be collected annually at each surface water station in early fall or late summer following a several week period of low flow. (Note: Although not discussed in the text, the collection of such samples are indicated in Table 8.4, Minimum Radiological Monitoring Program)
36. Page 8-3, Table 8.3: We recommend that the list of parameters be expanded to include lead-210 and polonium-210, but at a reduced analysis frequency.
37. Page 8-3, Section 8.1.5.2: With regard to sampling frequency for groundwater baseline data, what is the basis for a minimum of three water samples obtained at intervals of no less than two weeks? Would not sampling quarterly for a year provide more representative baseline data?

38. Page 8-4, Table 8.4: Vegetation samples should be added to the minimum radiological monitoring program with annual collection at each air quality monitoring site.
39. Page 8-5, Sections 8.2.3.1 and 8.2.3.3: The sections on operational monitoring does not discuss the design of the proposed monitoring wells. If these wells have a large perforated interval the resulting mixing effect may mask the fact that an excursion is occurring until such time as a great deal of contaminant has moved into a none-mine area. If the Irigary sandstone in the area of the mine has a definite layered effect even though the various layers are not totally continuous, any contaminant would tend to move mainly in a lateral direction with less dispersion than in a non layered situation. In such a case, the more layered lenses that are furnishing water to a sample, the more diluted the water being removed from the contaminated zone will become, making it difficult to detect the initial stages of the excursion. There should be some discussion as to the possible masking of excursion in this manner and some guidance provided as to a course of action that would minimize this possibility. If the sandstone does have definite layering that can be traced for a relatively large distance, the monitoring well should not tap more than 2-3 times the thickness of the injection zone (this would allow overlap above and below the zone that is equivalent to the mined interval. Accordingly, the shallow and deep monitoring wells should be perforated to sample no more than a 5 - 10 foot zone immediately above and below the claystone units which are believed to overlie and underlie the ore zone.
40. Page 8-7, Section 8.2.4: "However, if significant releases of sediments or other constituents occur, WMC should undertake an ecological survey of Willow Creek or Powder River in order to assess the extent of any damage to biota." As noted in an earlier comment, the biological baselines of these two streams should be established prior to the start of production-scale uranium recovery operations. Unless this is done, there will be no baseline for comparison of ecological monitoring data after a significant release of sediments or other constituents.
41. Page 12-6, Section 12.3.3: Ultimate disposal of radioactive and toxic wastes should be performed at an active uranium mill tailings disposal site that is of the most environmentally sound design, such as below ground disposal. The NRC should exercise authority as to the acceptability of an active tailings disposal site for the Irigary wastes.
42. Page 8-4, Table 8.3: Is the uranium content actually U_3O_8 ? What are its units (i.e., mg/l or ppm)?

1. U.S. Environmental Protection Agency comment

Page 2-8, Section 2.6.1. Based on the detailed drawings provided in Figures 1.2 and 2.7, it should be stated in the FES that the Powder River flows through the Irigaray solution mining area rather than adjacent to the Irigaray Site as stated in the DES, because the additional area may be developed at a later date.

NRC response

The text has been revised to state that the Powder River flows through the western part of the Irigaray property (see Sect. 2.6.1).

2. U.S. Environmental Protection Agency comment

Page 2-10, Section 2.6.2. The data on groundwater at the site does not appear to be detailed enough to make a complete analysis as to what may happen in the area when mining is initiated. It is not clear whether the groundwater in the area is confined to the Irigaray sandstones or if there is water contained in the material which overlies the coal unit. There is also no data on the extent of groundwater in the alluvium and what its relationship is to water in the Wasatch formation. There should be data on the extent and depth to water in both the alluvium and the Wasatch formation. If there is water overlying the upper Irigaray sandstone there should be some data to indicate the degree of interconnections or lack of connection between the various units. It would be helpful if the FES included data on the depths at which water was first encountered in each of the major geologic units in the various core holes and injection wells on the property. Data on the static water levels in these holes should also be furnished.

NRC response

The alluvium in the Willow Creek streambed ranges from 9 to 18 m (30 to 60 ft) in thickness and is not connected with the Upper Irigaray sandstone (Figs. 2-16 and 2-17). Both the alluvium and the units overlying the Upper Irigaray sandstone contain some groundwater, although the extent is not known. The static water level in the Upper Irigaray sandstone (artesian) is within 18 m (60 ft) of the surface.

3. U.S. Environmental Protection Agency comment

Page 2-13, Section 2.6.3. The data on the storage coefficient and the hydraulic conductivity in the area of the mine does not seem sufficient to evaluate whether zones with much larger conductivities may exist. A pump test of 19 hours duration is not generally sufficient in a material of this type to adequately evaluate the storage coefficient and conductivity. In interbedded sandstones it is usually necessary to pump a well at a continuous rate ($\pm 5\%$ of average discharge) for at least one week in order to obtain reasonable estimates. It is often the case that as the well is pumped the storage coefficient will approach that of a water table aquifer. The initial low values are caused by interbedded sands and clays of the formation which cause a delayed drainage effect that causes a water table aquifer to act like an artesian unit in the early stages of pumping. The applicant should be required to run a more detailed pumping test on the first commercial unit to be mined.

The hydraulic characteristic of individual lenses (or channels) may vary considerably. Can possible rates be given for these characteristics (e.g., groundwater flow rates)?

NRC response

The applicant will conduct a detailed pump test on each mining well field prior to mining that unit and will submit the results to the Wyoming Department of Environmental Quality for review.

An indication of the variability is provided on p. 2-13 by the staff's calculated groundwater velocity of 18 m/year (60 ft/year).

4. U.S. Environmental Protection Agency comment

Page 2-18, Section 2.6.3. What are the uses of the Powder River and Willow Creek both in the project area and downstream from it?

NRC response

The text has been revised to include additional information on water use both in the project area and downstream from it.

5. U.S. Environmental Protection Agency comment

Page 2-18, Section 2.7.1. The data on the geology at the plant site appears sketchy and should be amplified. There should be some data on the extent of alluvial materials in the area. It is hard to envision that the claystone overlying the ore body is as continuous as is shown on Figure 2.16 and 2.17, given the type of depositional history of the Wasatch Formation. Also, the lack of data on the nature of the materials overlying the coal unit makes it difficult to make a judgement on the groundwater hydrology of the entire unit. It would be helpful if the FES included a table which lists the detailed logs for each of the drill holes, shown in the cross sections. In addition, there should be some discussion on the integrity of the claystone and the coal seam as far as the degree of fracturing that may be present in the site area.

NRC response

The staff believes that the general discussion on geology in Sect. 2.7.1 is adequate for the limited operation.

6. U.S. Environmental Protection Agency comment

Page 2-22, Section 2.7.1.4. The Site Geology Section states that the fluvial depositional environment of the Wasatch Formation has resulted in numerous facies changes and highly lenticular stratigraphy. The FES should address the continuity of the claystone which overlies and underlies the Upper Irigaray Sandstone.

NRC response

Figures 2.16 and 2.17 show the continuity of the claystone overlying the Upper Irigaray sandstone. The extent of the claystone unit underlying the Upper Irigaray sandstone is discussed on p. 2-22 of the DES.

7. U.S. Environmental Protection Agency comment

Page 2-31, Section 2.9.2. In the last paragraph on page 2-31, note is made of a pre-operational monitoring deficiency:

"Very little is known about Willow Creek and any aquatic biota that may inhabit it...Although Willow Creek is intermittent, it may provide breeding habitat for fish during parts of the year...."

In contrast to this position of the NRC staff, which does not require a biological study, we believe an aquatic biology study should be conducted to establish the baseline conditions against which possible future events can be compared.

NRC response

Section 8.1.5.3 recommending that the applicant survey the aquatic habitat has been added.

8. U.S. Environmental Protection Agency comment

Page 3-6, Section 3.2.4.4. The drying temperature should be given as well as the percentage of U_3O_8 and ammonium diuranate.

NRC response

Section 3, a general discussion of solution mining, was included to provide the general public with background information on this new technology. See response to EPA comment 13 for the requested information on the WMC operation.

9. U.S. Environmental Protection Agency comment

Page 3-7, Section 3.2.6. The proposed approach to groundwater quality restoration seems to be the best possible with existing technology. However, considering the probable high costs of the proposed restoration process (groundwater sweeping, reverse osmosis, etc.). We are suspicious that there may be an attempt to "back-off" to a less costly and less effective process where the restoration process must be initiated. The argument would be that the minimal potential use of

groundwater in this area and the low actual consumptive uses are compatible with a lower post-restoration water quality than that which existed in the pre-mining period. What procedure or method will be utilized to bind the Company to the implementation of the best possible restoration process?

NRC response

Sect. 3.2.6 is a general discussion of groundwater quality restoration. The EPA comment recognizes an important consideration. In context with the general discussion, the staff would expect that postrestoration water quality established by the appropriate regulatory agency will determine the restoration process(es) that will be used.

10. U.S. Environmental Protection Agency comment

Page 4-1, Section 4.3.1. If all the identified ore zones are mined by the solution process, what is the total number of wells (production and monitoring) that will be drilled?

NRC response

The total number of wells to be drilled will depend on well spacing and patterns used, hydraulic nature of the ore zone and the production well field unit area. For the initially proposed operation, using a seven-spot well pattern with a 12 m (40 ft) spacing, approximately 40 injection and recovery wells would be drilled per acre of production unit well field. WMC has estimated that about 500 wells, including monitor wells, may be drilled per year.

11. U.S. Environmental Protection Agency comment

Page 4-7, Section 4.4.1. This section implies that the processing plant may be moved to several locations during the life of the project. It would seem that each new site would then become an area requiring eventual decontamination. It could also require a number of waste impoundments. The alternative of longer runs of piping to a single plant site should be discussed.

NRC response

The relocation or construction of another uranium recovery plant for the proposed project will require an amendment licensing action and related environmental assessment that will require evaluation of this factor.

12. U.S. Environmental Protection Agency comment

Page 4-8, Section 4.4.2.1. If a plant breakdown occurs such that flow to and from the wells cannot be maintained, what is the method for preventing pipeline freezing and rupture (i.e., the United Nuclear-Homestake Partners pipeline rupture).

NRC response

The applicant states that pipelines will be constructed of an expandable plastic designed to resist fluid loss under freezing conditions. Heat tracing will be used on pipelines if necessary.

13. U.S. Environmental Protection Agency comment

Page 4-10, Section 4.4.2.4. See above comment on U_3O_8 and ammonium diuranate.

NRC response

The dryer temperature ranges from 600 to 650°C (1110 to 1200°F). Ammonium diuranate is an intermediate product of variable composition. The resulting product is approximately 95% U_3O_8 .

14. U.S. Environmental Protection Agency comment

Page 4-11, Section 4.6.2.1. The wastes may also contain other uranium chain nuclides.

NRC response

The text has been revised accordingly.

15. U.S. Environmental Protection Agency comment

Page 4-12, Section 4.6.2.1. The calcite pond should also have an underlying seepage collection system similar to the waste ponds.

NRC response

The calcite pond will have the same leak detection system as the other waste ponds.

16. U.S. Environmental Protection Agency comment

Page 4-15, Section 4.6.3, Last paragraph. Is it clear that the radium would be in the form of radium sulfate and not radium chloride?

NRC response

Precipitation from such a mixed salt solution during liquid evaporation will be controlled by the least soluble salt of each cation.

17. U.S. Environmental Protection Agency comment

Page 4-15, Section 4.6.4. Unless special efforts are made to dewater these wastes, liquid releases during handling and transport may be more important than dust releases.

NRC response

The text has been revised to indicate that liquid releases will be kept to a minimum.

18. U.S. Environmental Protection Agency comment

Page 4-16, Section 4.6.5. We would expect some radon release from the ion exchange columns. Has this been estimated or measured?

NRC response

Some radon has been detected above the columns during R&D activities, with concentrations in the range of 1-20 pCi/liter. The applicant will be required to develop and conduct a measurement program to cover both the well field control buildings and the recovery plant to enable a quantitative estimate of the radon source term (Curies/year).

19. U.S. Environmental Protection Agency comment

Page 5-2, Section 5.1.2. The applicants restoration test procedure is unclear as to the order that was followed in the various steps and as to whether the order of each step might effect the final level of restoration. More importantly, nothing was mentioned as to how the data collected on a restoration of part of the five spot pattern might represent the restoration of the entire plot. There is no indication as to whether the data collected at the injection and pumping wells is representative of the average value throughout the area effected by a given five spot. It would seem likely that the water in the immediate vicinity of an injection well, pumping well, or along the diagonal between the two wells would be of better quality than elsewhere in the pattern. In future restoration tests, the applicant should emplace some monitoring wells within the pattern to allow sampling of the preresoration and postrestoration quality. Any restoration test should include an entire five spot not just a small corner.

There is little discussion as to the quality of water on the outside of the five spot pattern both after leaching and after restoration. This area will contain some of the mobilized minerals and it is difficult to imagine that restoration will be as complete as it might be in the center of the five spot especially if the treated water is reinjected into the same well as the leach solution was injected. The level of restoration immediately outside the five spot will be important on the very edge of the ore body. There should be some postleach test holes implaced outside the five spot pattern but within the proven zone of influence of the injection wells. These can be used to provide data on the effectiveness of the program in reducing contaminants just outside the five spot.

NRC response

The restoration tests are discussed in the text in the order they were conducted. The limitations recognized by EPA are similar to those noted by the NRC staff that resulted in the recommendations and license conditions contained in Sect. 5.1.5. Additional postleach test holes are discussed in Sect. 8.2.3.7.

20. U.S. Environmental Protection Agency comment

Page 5-2, Section 5.1.2, Groundwater Sweep Test. At what pumping rate was the groundwater sweep test conducted?

NRC response

The pumping rate for the groundwater sweep test was 15 gal/min.

21. U.S. Environmental Protection Agency comment

Page 5-3, Table 5.1. The values shown in Columns A and B of Table 5.1 evidently were obtained from a single sampling of wells and reflect average concentrations rather than the chemistry for any specific well. The Columns need to be explained in terms of which wells were sampled to obtain the average values shown and what the time frame was between the preleaching sample and the postleaching sample. The range of each constituent for preleaching and postleaching groundwater quality should be listed.

It is not clear what Column E represents. The average constituent levels for all wells in the test pattern should be listed along with the range of each constituent.

Do the blank spaces mean that the levels were below detection limits or that measurements were not made?

NRC response

The values in Column A are the averages from single samples taken from five wells selected at random in the field. Column B is a single set of values taken from well 517-3. Column E contains the average values from the production wells used in the test and can be compared with Column A. Blank spaces indicate that measurements were not made.

22. U.S. Environmental Protection Agency comment

Page 5-4, Table 5.2. Table 5.1 gives very limited data with respect to carbonate, and where given, the data vary considerably from those given in Table 5.2 (e.g., 4.7 ppm vs. 267 ppm following groundwater sweeping). The FES should clear up this discrepancy.

NRC response

See response to the following comment.

23. U.S. Environmental Protection Agency comment

Pages 5-3 and 5-4, Tables 5.1 and 5.2. Minor discrepancies exist between Column E of Table 5.1 and Column E of Table 5.2 (e.g., ammonia, carbonate, and conductivity). These discrepancies should be resolved in the FES. In addition, what data is available with respect to postrestoration groundwater quality for gross alpha and gross beta? How many pore volumes were utilized in the residual total dissolved solids reduction test?

NRC response

Data in Tables 5.1 and 5.2 represent the results of sample analyses carried out at different times for different purposes by different laboratories. The CaCO_3 shown in Table 5.1 is total alkalinity expressed as CaCO_3 and consists primarily of HCO_3^- . The carbonate shown in Table 5.2 is total carbonate and also consists primarily of HCO_3^- ions. The ratio of CO_3^{2-} ions to total CaCO_3 is approximately 0.6 at these pH values, so the total carbonate ion value in Table 5.1 would be $445 \times 0.6 \approx 267$. Similarly, the values for ammonia appear in Table 5.1 simply as NH_4^+ . Converting the value of N to NH_4^+ in Table 5.1 would be $18/14 \times 27 = 34.7$, which would round to 35.

The carbonate value in Column E of Table 5.1 (given as bicarbonate) should read 60.0. This would agree closely with the carbonate value in Table 5.2.

Values for gross α and gross β in postrestoration groundwater were determined to be 722 ± 45 and 42^{+78}_{-42} respectively.

About 13 pore volumes were pumped in the referenced test.

24. U.S. Environmental Protection Agency comment

Page 6-1, Section 6.1. The combustion of propane may also result in release of radon which may at times confuse measurements made for radon released from other site operations.

NRC response

This is considered to be unlikely. However, should spurious radon measurements be observed, the applicant would be advised to check the radon content of the propane.

25. U.S. Environmental Protection Agency comment

Page 6-3, Section 6.3.1.1.

"...WMC plans to conduct solution mining in the streambed of Willow Creek and this activity has the greatest potential for adverse impact. WMC is currently developing engineering designs and methods to (1) protect pipes and equipment in the streambed from floods and (2) prevent adverse impacts to downstream water quality."

Considering the admitted high potential for adverse impact, the more advisable approach might be the prohibition of mining activity in the streambed. If mining will be permitted, the FES should be expanded to show that the anticipated benefits of mining in the environmentally sensitive area are substantially higher than possible environmental consequences (and the costs of special operating procedures).

NRC response

See response to Department of the Army, Corps of Engineers comment 1, page A-9.

26. U.S. Environmental Protection Agency comment

Page 6-4, Section 6.3.2.2. The DES states that the leaching test conducted at the Irigaray 517 test site was conducted for 107 days and that longer periods of leaching over a much larger area could possibly result in higher concentrations of toxic substance in groundwater. The FES should compare the specifications (e.g., period of leaching) of the leaching test with actual planned operations and attempt to draw conclusions with respect to restoration success of actual operations (i.e., how well does restoration data provided in the leaching tests simulate restoration that might be expected under actual commercial operation at the Irigaray Site).

NRC response

Although higher concentrations may occur during mining operations, a full-term leach operation may actually result in lower final concentrations. The initial 20-ha (50-acre) operation will not be expanded until the first production well field has been restored. The staff believes that this and other concurrent studies will provide the necessary data to evaluate restoration prior to any continued expansion of the mining area.

27. U.S. Environmental Protection Agency comment

Page 6-5, Table 6.1. Was the analysis specific for U_3O_8 , uranium or uranyl dicarbonate?

NRC response

The analysis was for U_3O_8 .

28. U.S. Environmental Protection Agency comment

Page 6-8, Section 6.3.2.2. The DES states that water in the postrestoration test hole PRC-1 has contained small quantities of ammonia. Data for this test hole should be presented in the FES.

NRC response

The single sample obtained from this core hole contained approximately 2 ppm of ammonia.

29. U.S. Environmental Protection Agency comment

Page 6-11, Section 6.7. How do the human radiation doses change as the Irigaray plant location changes (as indicated on page 4-7, section 4.4.1)? For instance, as the plant is located closer to the Irigaray and Hoe Ranches, we assume the radiation doses would go up.

NRC response

As discussed in Sect. 6.7.1, the radiation doses contained in Sect. 6.7 are estimates. After the plant has been in operation, measured data will be available for calculating doses should the recovery plant be relocated.

30. U.S. Environmental Protection Agency comment

Page 7-2, Section 7.1.1.2. It may be difficult to detect small leaks with radiological instruments in the presence of the radiation levels from the pipeline. Since small leaks may not be readily detectable by flow measurements, frequent pipeline inspections should be conducted.

NRC response

Visual inspection of surface pipelines will be conducted by the applicant.

31. U.S. Environmental Protection Agency comment

Page 7-5, Section 7.3.1. Are the exposure calculations based on the assumption that the yellowcake was composed solely of U_3O_8 or did they take into consideration the more soluble portion of the yellowcake? Do the calculations also take into account the ^{230}Th and ^{226}Ra content of the yellowcake?

As we indicated in previous DESs, we do not feel that the Colorado yellowcake transportation accident should be used as a typical case. The consequences of the accident would have been far more damaging had it not been for a series of fortunate, but noncontrollable circumstances. Further, the major hazard is a chemical toxicity to the kidneys and not a radiation lung dose.

Industry should be encouraged to develop and use smaller, less hazardous yellowcake packaging containers suitable for transportation. The applicant's emergency response plan should be included in the FES.

NRC response

The dose conversion factors used for dose calculations assume that all of the uranium in the yellow cake is insoluble U_3O_8 . The content of Th-230 and Ra-226 plus daughters in the yellow cake was considered in the dose calculations. The need for revised requirements for yellowcake packaging and transport is being evaluated by an interagency study group (DOT and NRC) and a report will be issued on its conclusions. The applicant's emergency plan will be reviewed by the staff using guidelines developed by an AIF Working Group; a copy of the guidelines will be sent to EPA.

32. U.S. Environmental Protection Agency comment

Page 8-1, Table 8.1. As we stated in our review of WMC's ER, top soil and two vegetation samples are inadequate for a baseline radiological characterization.

NRC response

Additional baseline data has been provided in Table 8.1.

33. U.S. Environmental Protection Agency comment

Page 8-2, Table 8.2. It should be pointed out that the concentration data refers to radium 226 in the dissolved state, and not the total concentration of dissolved plus suspended.

NRC response

The table caption has been annotated.

34. U.S. Environmental Protection Agency comment

Page 8-2, Section 8.1. We agree with the NRC staff that additional data is needed.

NRC response

No response necessary.

35. U.S. Environmental Protection Agency comment

Page 8-2, Section 8.1.5.1. Three stations on the Powder River are satisfactory. However, instead of the proposed quarterly sampling frequency, it is recommended that the collection frequency be monthly for a two year period (the last year of the preoperational period and the first year of full production mining). Quarterly or semiannual composite samples should be analyzed for both the suspended and dissolved concentrations of uranium and radium 226.

Bottom sediment samples should be collected annually at each surface water station in early fall or late summer following a several week period of low flow. (Note: Although not discussed in the text, the collection of such samples are indicated in Table 8.4, Minimum Radiological Monitoring Program.)

NRC response

Although a monthly sampling for two years would provide a more complete assessment of baseline conditions, such a program would be expensive in terms of sample collection and laboratory costs. Until MWC applies to NRC and the State of Wyoming for expansion of the mining area toward the Powder River, the staff considers the baseline sampling program described in Section 8.1.5.1 to be adequate. The program is consistent with that of the permit and license to mine approved by Wyoming in August 1978.

36. U.S. Environmental Protection Agency comment

Page 8-3, Table 8.3. We recommend that the list of parameters be expanded to include lead-210 and polonium-210, but at a reduced analysis frequency.

NRC response

Lead-210 is currently analyzed in surface water samples by the applicant.

37. U.S. Environmental Protection Agency comment

Page 8-3, Section 8.1.5.2. With regard to sampling frequency for groundwater baseline data, what is the basis for a minimum of three water samples obtained at intervals of no less than two weeks? Would not sampling quarterly for a year provide more representative baseline data?

NRC response

The NRC staff agrees that, at an undisturbed site, a one-year sampling period would be more representative. The short-term sampling frequency is for additional production units at the Irigaray site and was developed with the concurrence of the Wyoming Department of Environmental Quality.

38. U.S. Environmental Protection Agency comment

Page 8-4, Table 8.4. Vegetation samples should be added to the minimum radiological monitoring program with annual collection at each air quality monitoring site.

NRC response

Vegetation sampling will be conducted by the applicant as shown in revised Table 8.4.

39. U.S. Environmental Protection Agency comment

Page 8-5, Sections 8.2.3.1 and 8.2.3.3. The sections on operational monitoring does not discuss the design of the proposed monitoring wells. If these wells have a large perforated interval the resulting mixing effect may mask the fact that an excursion is occurring until such time as a great deal of contaminant has moved into a non -mine area. If the Irigaray sandstone in the

area of the mine has a definite layered effect, even though the various layers are not totally continuous, any contaminant would tend to move mainly in a lateral direction with less dispersion than in a non layered situation. In such a case, the more layered lenses that are furnishing water to a sample, the more diluted the water being removed from the contaminated zone will become, making it difficult to detect the initial stages of the excursion. There should be some discussion as to the possible masking of excursion in this manner and some guidance provided as to a course of action that would minimize this possibility. If the sandstone does have definite layering that can be traced for a relatively large distance, the monitoring well should not tap more than 2-3 times the thickness of the injection zone (this would allow overlap above and below the zone that is equivalent to the mined interval. Accordingly, the shallow and deep monitoring wells should be perforated to sample no more than a 5-10 foot zone immediately above and below the claystone units which are believed to overlie and underlie the zone.

NRC response

The problems raised by EPA in this comment are expected to be negated by the use of three techniques. First, monitor wells are perforated through the entire thickness of the Upper Irigaray sandstone. A single monitor well may provide surveillance over a number of cells, and the convolutions of the mineralized roll front are such that different cells may be perforated at different intervals. The necessity of being assured of sampling all strata into which lixiviant is being injected is paramount. Secondly, recognizing the dilution effects that occur in the horizontal plane, as well as in a vertical plane, the upper control limits have been chosen to provide acceptable sensitivity. The third technique is the use of trend wells between the well field and the monitor wells to provide early indications of a problem before it reaches the limits defined by the monitor wells.

40. U.S. Environmental Protection Agency comment

Page 8-7, Section 8.2.4. "However, if significant releases of sediments or other constituents occur, WMC should undertake an ecological survey of Willow Creek or Powder River in order to assess the extent of any damage to biota." As noted in an earlier comment, the biological base-lines of these two streams should be established prior to the start of production-scale uranium recovery operations. Unless this is done, there will be no baseline for comparison of ecological monitoring data after a significant release of sediments or other constituents.

NRC response

Section 8.1.5.3 has been added to the text for an ecological baseline survey.

41. U.S. Environmental Protection Agency comment

Page 12-6, Section 12.3.3. Ultimate disposal of radioactive and toxic wastes should be performed at an active uranium mill tailings disposal site that is of the most environmentally sound design, such as below ground disposal. The NRC should exercise authority as to the acceptability of an active tailings disposal site for the Irigaray wastes.

NRC response

Tailings reclamation plans have been approved by the staff for all active mills in Wyoming. The staff considers that any of these could suitably handle the relatively small volume of wastes generated by WMC (compared to the volume of conventional mill tails).

42. U.S. Environmental Protection Agency comment

Page B-4, Table B.3. Is the uranium content actually U_3O_8 ? What are its units (i.e., mg/l or ppm)?

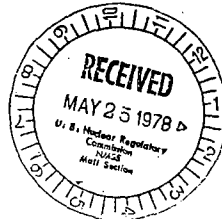
NRC response

Uranium content is expressed as U_3O_8 in units of milligrams per liter.

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426

May 22, 1978

Mr. Leland C. Rouse
Chief
Fuel Processing and Fabrication
Branch
Division of Fuel Cycle and Material
Safety
Nuclear Regulatory Commission
Washington, D. C. 20555



Dear Mr. Rouse:

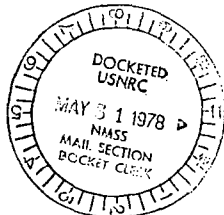
I am replying to your request of April 28, 1978 to the Federal Energy Regulatory Commission for comments on the Draft Environmental Impact Statement for the Irigaray Solution Mining Project. This Draft EIS has been reviewed by appropriate FERC staff components upon whose evaluation this response is based.

The staff concentrates its review of other agencies' environmental impact statements basically on those areas of the electric power, natural gas, and oil pipeline industries for which the Commission has jurisdiction by law, or where staff has special expertise in evaluating environmental impacts involved with the proposed action. It does not appear that there would be any significant impacts in these areas of concern nor serious conflicts with this agency's responsibilities should this action be undertaken.

Thank you for the opportunity to review this statement.

Sincerely,

Jack M. Heinemann
Jack M. Heinemann
Advisor on Environmental
Quality

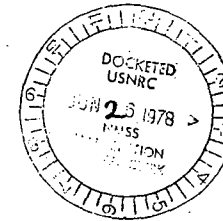


UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

P.O. Box 2440, Casper, WY 82602

July 19, 1978

Leland C. Rouse, Chief
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555



Dear Mr. Rouse:

We appreciate the opportunity to review the draft environmental statement related to operation of the Wyoming Mineral Corporation Irigaray Solution Mining Project, Johnson County, Wyoming. We have only one comment.

Page 2-29, paragraph 2, under Vegetation - Western Wheatgrass, prairie June grass, and needle-and-thread grass are implied to be annuals, they are perennials. Buckwheat, yucca and prickly pear are implied to be forbs, they are shrubs and half shrubs. Vegetative cover is stated to be 5% to 25%. The unit of measurement should be stated, such as "crown canopy cover of 5% to 25%."

Frank S. Dickson
Frank S. Dickson
State Conservationist

cc:

K. L. Williams, Director, West Technical Service Center
Glen Loomis, Director, Environmental Services Division, Washington, D. C.

A-41



NRC response to Federal Energy Regulatory Commission letter

No response necessary.

1. Soil Conservation Service comment

Page 2-29, paragraph 2, under Vegetation. Western Wheatgrass, prairie June grass, and needle-and-thread grass are implied to be annuals, they are perennials. Buckwheat, yucca and prickly pear are implied to be forbs, they are shrubs and half shrubs. Vegetative cover is stated to be 5% to 25%. The unit of measurement should be stated, such as "crown canopy cover of 5% to 25%."

NRC response

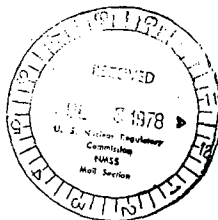
The text has been revised.



WYOMING
EXECUTIVE DEPARTMENT
CHEYENNE

ED HERSCHLER
GOVERNOR

June 12, 1978



Mr. Leland C. Rouse, Chief
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Irrigaray Solution Mining
Project - Draft Environmental
Statement

Dear Mr. Rouse:

The state of Wyoming has completed it's review of the
above mentioned environmental statement. (See attached
comments). We have no further comments at this time.

Thank you for the opportunity to review the Draft statement.
Please contact this office regarding any further developments
with the Irrigaray project.

Yours sincerely,

EH:tro

NRC response to Office of the Governor, Wyoming, letter

No response necessary.



THE STATE OF WYOMING

RECEIVED

ED HERSCHLER
GOVERNOR

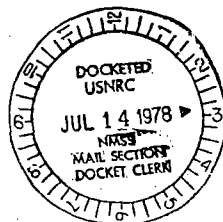
Game and Fish Department

Re: 050578
ES 37

EARL M. THOMAS
DIRECTOR

CHEYENNE, WYOMING 82002

U.S. MAIL REG.
JUL 5 1978
MAIL SECTION



Leland C. Rouse, Chief
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rouse:

Having reviewed the draft environmental statement (DES) for the proposed Irigaray Uranium Solution Mining Project located in Sections 19, 29, 30, and 32, T46N, R77W and Sections 4, 5, 9, 16, 21, and 28, T45N, R77W, Johnson County, Wyoming, we offer the following comments in the interest of the wildlife resource.

Generally, we find that the document is much too general. It does not fully describe the environment, the environmental effects of the project, and the proposed reclamation. We are concerned that the possibility of release of chemical or radioactive pollutants from this project will enter the Powder River and affect the downstream aquatic habitat. These impacts should be more fully described in the document. The following specific comments are arranged in order of pagination of the DES:

Pp. 2-30, Wildlife:

This section does not adequately describe the wildlife of this area. Data in the Thunder Basin EIS are good, but the site is more than 40 miles away, and the Irigaray site includes much riparian habitat. As a result, the two areas are not comparable. Data collected by the company and found in Appendix C should have been included in this section. We know from our review of the application for a mining and reclamation permit that there are problems with some of these wildlife data. One problem is the age of the data which were obtained in 1974, in the first spring after the severe winter of 1972-73. Numbers of animals have markedly increased since then. For example, there were 200 antelope, 100 mule deer, 100 turkeys, 30 sage grouse, and many nongame birds and mammals on this site in 1977. These numbers are much higher than numbers presented in this EIS. The description

Wyoming Game and Fish Department

July 5, 1978

of wildlife given on page 30 could have been obtained from literature sources without ever having visited the site, and does not represent actual data collected and displayed in Appendix C.

The statement, "the wild turkey likely occurs here" should state, as we noted in our review of the mine plan for this project, that wild turkeys do occur on this site.

A discussion of nongame species comparable to that on game species should have been included in this section.

Rare and Endangered Species:

The bald eagle is now endangered, and is known to frequent this area of the Powder River, particularly in winter.

We don't feel that there is enough site-specific wildlife data presented here to allow either NRC or this Department to judge the impacts of this project. For example: What are the habitat affinities of species on-site? How much of this habitat is present on site and how much habitat will be disturbed? Are there any raptors nesting on-site? What species? How many animals will be lost due to this development? Will public access be stopped in the area? What fences will be constructed and how long will they remain? These are wildlife questions that require answers to be presented in this document.

Pp. 2-31: The next to last paragraph mentions three nationally listed endangered aquatic species in Wyoming. Of these, only the Kendall Warm Springs dace is recognized by our Department as occurring in the State. The humpback chub and Colorado River squawfish are considered extinct in Wyoming. None of these species occur in the Powder River Basin.

Pp. 2-33, Figure 2.20 is a nice flow chart for a typical food web in livestock ponds; however, it doesn't depict an impact assessment on the aquatic habitats of concern.

Pp. 4-12: What measures will be used to keep waterfowl and other animals from landing in waste ponds? We have stated before that these should be flagged and fenced.

Wyoming Game and Fish Department

July 5, 1978

Pp. 5-8: We do not agree that crested wheatgrass or any other exotics should be used for reclamation on this site or on other mined areas in the State. If reseeding of sagebrush and other shrubs is not successful, seedlings should be used. These can be purchased from companies in the west. There is not enough detail provided on the reclamation plan. For example, what species will be used in the "diverse mixture of grasses, forbs and shrubs" to be planted on-site? We have noted this inadequacy in previous comments on this project.

Pp. 6-2: We do not agree that the closing of ten square miles of the area to hunting is an insignificant impact, particularly to those people who hunt this area and in view of the fact that much of the "abundant" excellent hunting nearby is closed to public access or subject to fee hunting.

Pp. 6-3: Paragraphs one and two mention impacts to aquatic systems resulting from discharges of sediments, oil, and grease. Discharges in excess of those permitted by Wyoming's water quality regulations are not acceptable and must not be permitted. Paragraph three mentions that solution mining in the streambed of Willow Creek has the greatest potential for adverse impacts, but precautions are yet to be developed. They should be finalized prior to acceptance of the final environmental statement.

Pp. 6-10 and 6-11 provide inadequate assessment of impacts on aquatic environments. Impacts or lack of impacts on fish (including rare species) in the Powder River, should be addressed. Possible effects on both water quantity and quality in the Powder River should be spelled out. Necessary precautions should be taken to prevent adverse discharges into the drainage, thereby affording some protection to the downstream fishery in the Powder River. Channel catfish should be included among the species of fish present in the lower Powder River.

Pp. 6-10, Impacts: The sagebrush-grassland vegetation type supposedly widely distributed in the Powder River Basin is rapidly disappearing in the face of sagebrush spraying projects and mining activities such as this. The fact that wildlife are abundant elsewhere does not alter the fact that there will be severe impacts to those animals on-site. Disturbance of 400 acres of habitat will severely impact those animals on-site.

Wyoming Game and Fish Department

July 5, 1978

We would like to see an assessment of the possible impact to the species inadvertently using the evaporation ponds. Holding ponds must be properly designed and constructed to avoid spillage of toxic/radioactive materials even after heavy rainstorms. All discharges must comply with State water quality regulations.

Pp. 8-2 and 8-3 describe a surface water baseline monitoring program. All items mentioned in Table 8.3, plus additional parameters specified in Wyoming's water quality regulations that may be influenced by the project, should be included in the baseline study and monitored at appropriate intervals.

Pp. 9-1: The statement, "...some possible loss of hunting opportunities" should provide quantification. Elsewhere in the document it is noted that there will be a definite loss of opportunity to ten square miles of land.

Pp. 11-1: Wildlife resources are renewable but, are they renewable if reclamation does not include wildlife food or cover species? We do not believe so.

This document is much too general. It fails to fully describe the environment, the environmental effects of the project and the proposed "reclamation". We realize that experimental projects such as this are necessary for technological development but we would prefer that such experiments occur in less valuable wildlife areas and in areas where there is less potential for environmental contamination.

Our Department should have been mentioned in the list of Agencies contacted earlier concerning this project. We hope the above comments on the DES will be useful in making the final statement on this project more complete and accurate. If we can be of further assistance, please do not hesitate to contact us.

Sincerely,



W. Donald Dexter,
Assistant Director, Operations
Wyoming Game and Fish

WDD:HBM:kjt

cc: SPC
Game Division
Fish Division
Planning

1. Wyoming Game and Fish Department comment

Generally, we find that the document is much too general. It does not fully describe the environment, the environmental effects of the project, and the proposed reclamation. We are concerned that the possibility of release of chemical or radioactive pollutants from this project will enter the Powder River and affect the downstream aquatic habitat. These impacts should be more fully described in the document.

NRC response

The NRC staff has produced a document that is adequate to meet the requirements of NEPA for the proposed project. The limited operation is approximately 5.6 to 6 km (3-1/2 to 4 miles) from the Powder River and should have no impact on the river. The staff will consult with Wyoming State agencies when the applicant submits plans for any mining on Willow Creek, now scheduled for 1982 (see response to Corps of Engineers comments 1 and 2).

SPECIFIC COMMENTS

2. Wyoming Game and Fish Department comment

Pp. 2-30, Wildlife. This section does not adequately describe the wildlife of this area. Data in the Thunder Basin EIS are good, but the site is more than 40 miles away, and the Irigaray site includes much riparian habitat. As a result, the two areas are not comparable. Data collected by the company and found in Appendix C should have been included in this section. We know from our review of the application for a mining and reclamation permit that there are problems with some of these wildlife data. One problem is the age of the data which were obtained in 1974, in the first spring after the severe winter of 1972-73. Numbers of animals have markedly increased since then. For example, there were 200 antelope, 100 mule deer, 100 turkeys, 30 sage grouse, and many nongame birds and mammals on this site in 1977. These numbers are much higher than numbers presented in this EIS. The description of wildlife given on page 30 could have been obtained from literature sources without ever having visited the site, and does not represent actual data collected and displayed in Appendix C.

The statement, "the wild turkey likely occurs here" should state, as we noted in our review of the mine plan for this project, that wild turkeys do occur on this site.

A discussion of nongame species comparable to that on game species should have been included in this section.

NRC response

The staff considers the section on wildlife to be an adequate discussion of existing conditions. Species discussed in the text are from Appendix C, and the significance of riparian habitat is noted in Sects. 2.9.1.1 and 6.6.1. Appendix C was included to provide additional information. The staff also recognizes the year-to-year variation in game and nongame species.

A discussion of nongame species is included in the first paragraph of Sect. 2.9.1.2.

3. Wyoming Game and Fish Department comment

Rare and Endangered Species. The bald eagle is now endangered, and is known to frequent this area of the Powder River, particularly in winter.

We don't feel that there is enough site-specific wildlife data presented here to allow either NRC or this Department to judge the impacts of this project. For example: What are the habitat affinities of species on-site? How much of this habitat is present on site and how much habitat will be disturbed? Are there any raptors nesting on-site? What species? How many animals will be lost due to this development? Will public access be stopped in the area? What fences will be constructed and how long will they remain? These are wildlife questions that require answers to be presented in this document.

NRC response

Section 2.9.1.2 has been revised to include the bald eagle.

The NRC staff believes that the discussion of habitat is adequate for assessment purposes.

4. Wyoming Game and Fish Department comment

Pp. 2-31. The next to last paragraph mentions three nationally listed endangered aquatic species in Wyoming. Of these, only the Kendall Warm Springs dace is recognized by our Department as occurring in the State. The humpback chub and Colorado River squawfish are considered extinct in Wyoming. None of these species occur in the Powder River Basin.

NRC response

The NRC staff acknowledges this information.

5. Wyoming Game and Fish Department comment

Pp. 2-33. Figure 2.20 is a nice flow chart for a typical food web in livestock ponds; however, it doesn't depict an impact assessment on the aquatic habitats of concern.

NRC response

As mentioned in the last paragraph of Sect. 2.9.2, isolated pools that may exist in Willow Creek for extended periods may develop this type of biotic community.

6. Wyoming Game and Fish Department comment

Pp. 4-12. What measures will be used to keep waterfowl and other animals from landing in waste ponds? We have stated before that these should be flagged and fenced.

NRC response

Section 6.6.1 has been revised to include impacts on wildlife.

7. Wyoming Game and Fish Department comment

Pp. 5-8. We do not agree that crested wheatgrass or any other exotics should be used for reclamation on this site or on other mined areas in the State. If reseeding of sagebrush and other shrubs is not successful, seedlings should be used. These can be purchased from companies in the west. There is not enough detail provided on the reclamation plan. For example, what species will be used in the "diverse mixture of grasses, forbs and shrubs" to be planted on-site? We have noted this inadequacy in previous comments on this project.

NRC response

Section 5.3 on reclamation has been revised to include the reclamation plan as approved by the Wyoming Department of Environmental Quality.

8. Wyoming Game and Fish Department comment

Pp. 6-2. We do not agree that the closing of ten square miles of the area to hunting is an insignificant impact, particularly to those people who hunt this area and in view of the fact that much of the "abundant" excellent hunting nearby is closed to public access or subject to fee hunting.

NRC response

Public safety may warrant exclusion of hunters from the site. The Department may wish to discuss the hunting restrictions with WMC.

9. Wyoming Game and Fish Department comment

Pp. 6-3. Paragraphs one and two mention impacts to aquatic systems resulting from discharges of sediments, oil, and grease. Discharges in excess of those permitted by Wyoming's water quality regulations are not acceptable and must not be permitted. Paragraph three mentions that solution mining in the streambed of Willow Creek has the greatest potential for adverse impacts, but precautions are yet to be developed. They should be finalized prior to acceptance of the final environmental statement.

NRC response

The applicant must meet the requirements of the State of Wyoming, Department of Environmental Quality.

See response to Department of the Army, Corps of Engineers comment 1, which pertains to mining activities in the Willow Creek streambed.

10. Wyoming Game and Fish Department comment

Pp. 6-10 and 6-11 provide inadequate assessment of impacts on the aquatic environments. Impacts or lack of impacts on fish (including rare species) in the Powder River, should be addressed. Possible effects on both water quantity and quality in the Powder River should be spelled out. Necessary precautions should be taken to prevent adverse discharges into the drainage, thereby affording some protection to the downstream fishery in the Powder River. Channel catfish should be included among the species of fish present in the lower Powder River.

NRC response

The NRC staff expects that the limited mining operation will have no effect on the Powder River. The applicant's surface-water monitoring program includes stations on the Powder River that will detect changes in water quality. Channel catfish are mentioned in Sect. 2.9.2.

11. Wyoming Game and Fish Department comment

Pp. 6-10, Impacts. The sagebrush-grassland vegetation type supposedly widely distributed in the Powder River Basin is rapidly disappearing in the face of sagebrush spraying projects and mining activities such as this. The fact that wildlife are abundant elsewhere does not alter the fact that there will be severe impacts to those animals on-site. Disturbance of 400 acres of habitat will severely impact those animals on-site.

We would like to see an assessment of the possible impact to the species inadvertently using the evaporation ponds. Holding ponds must be properly designed and constructed to avoid spillage of toxic/radioactive materials even after heavy rainstorms. All discharges must comply with State water quality regulations.

NRC response

The reclamation plan includes the reestablishment of sagebrush.

The staff has recognized that onsite wildlife will be affected. Fencing and flagging should minimize wildlife use of the evaporation pond.

Pond design must meet the approval of the State Engineer's Office and the Wyoming Department of Environmental Quality, Water Quality Division.

12. Wyoming Game and Fish Department comment

Pp. 8-2 and 8-3 describe a surface water baseline monitoring program. All items mentioned in Table 8.3, plus additional parameters specified in Wyoming's water quality regulations that may be influenced by the project, should be included in the baseline study and monitored at appropriate intervals.

NRC response

The staff agrees that the applicant should include monitoring parameters required by the State of Wyoming.

13. Wyoming Game and Fish Department comment

Pp. 9-1. The statement, "... some possible loss of hunting opportunities" should provide quantification. Elsewhere in the document it is noted that there will be a definite loss of opportunity to ten square miles of land.

NRC response

A loss of hunting opportunities will occur, but the staff has not attempted to quantify the extent.

14. Wyoming Game and Fish Department comment

Pp. 11-1. Wildlife resources are renewable but, are they renewable if reclamation does not include wildlife food or cover species? We do not believe so.

NRC response

Reclamation to viable levels of food and shelter is expected.



THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

State Conservation Commission

2219 CAREY AVENUE

PHONE 777-7321

CHEYENNE, WYOMING 82002

WAYNE A. EDGERTON
CONSERVATION COMMISSION STATE EXECUTIVE
DWIGHT KIMSEY
208 WATER QUALITY MANAGEMENT

MEMORANDUM

DATE: May 26, 1978

TO: Don Daiss

FROM: Tim Kautza

COMMISSION MEMBERS:

LARRY BOURRET, CHAIRMAN (STATE AG. DEPT.)
CHARLES JAMESON, VICE-CHAIRMAN (AREA V DIRECTOR)
PETER MEIKE, JR. (AREA I DIRECTOR)
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EUGENE HARDY (LIVESTOCK BOARD)
JOHN NILAND (D.E.P.A.D.)

I have reviewed the "Soils" and "Reclamation" sections of the draft Environmental Statement Related to Operation of Wyoming Mineral Corporation Irigaray Solution Mining Project and offer the following comments for your consideration.

The U.S. Soil Conservation Service soil survey for southern Johnson County was the source utilized for soils information regarding this project. General plans have been made to reclaim the land to be disturbed by the project. It is recommended that the Wyoming Mineral Corporation contact the Powder River Conservation District at Box H, Kaycee 82639 to obtain technical assistance regarding erosion control practices and reclamation techniques. A copy of Standards and Specifications for Mine Reclamation might be of assistance and can be acquired from the Wyoming Conservation Commission, 2219 Carey Ave., Cheyenne, WY 82002.

1. State Conservation Commission comment

The U.S. Soil Conservation Service soil survey for southern Johnson County was the source utilized for soils information regarding this project. General plans have been made to reclaim the land to be disturbed by the project. It is recommended that the Wyoming Mineral Corporation contact the Powder River Conservation District at Box H, Kaycee 82639 to obtain technical assistance regarding erosion control practices and reclamation techniques. A copy of Standards and Specifications for Mine Reclamation might be of assistance and can be acquired from the Wyoming Conservation Commission, 2219 Carey Ave., Cheyenne, WY 82002.

NRC response

The Wyoming Mineral Corporation and the Powder River Conservation District cooperated to develop a reclamation plan (WY-A1-743) for the site.

DANIEL N. MILLER, JR.
DIRECTOR AND
STATE GEOLOGIST

STAFF GEOLOGISTS
ROY M. BRECKENRIDGE
GARY B. GLASS
W. DAN HAUSEL
DAVID R. LAGESON
ALAN J. VERPLOEG



THE GEOLOGICAL SURVEY OF WYOMING

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M E M O R A N D U M

TO: State Planning Coordinator
Wyoming State Clearinghouse

FROM: Gary B. Glass, Deputy Director
W. Dan Hausel, Staff Geologist - Minerals

SUBJECT: Irigaray Solution Mining Project, Wyoming
Mineral Corporation, DEIS

DATE: May 24, 1978

COMMENTS BY DAN HAUSEL

Page iv, para. 5. The Governor's Clearinghouse is not listed as a reviewing agency.

Page 2-22, para. 4. Mineral deposits not mentioned in this paragraph are bentonite, gypsum, and zeolites. Both bentonite and gypsum units crop out along the east flank of the Bighorn Mountains. In the past, gypsum was mined in that area, and bentonite is still mined by the Kaycee Bentonite Corporation and the Benton Clay Company.

Zeolites occur in some of the ash units in the Wasatch Formation within the Pumpkin Buttes area. The close proximity of zeolites to the uranium mineralization suggests that a zeolite discussion is warranted.

Page 6-9. Mineral Resources. There is no mention of zeolite deposits.

Page 11-1, para. 11.1. Land and Mineral Resources. This statement infers that solution mining operations result in floral and faunal changes. I don't believe that was the intended meaning.

Additional comment: Gary B. Glass

Para. 11.3. Vegetation and Wildlife. I don't understand the difference between "flora and fauna" discussed under para. 11.1 and "Vegetation and Wildlife" discussed here. Flora and fauna are out of place in para 11.1, aren't they?

COMMENTS BY GARY B. GLASS

Page 6-9, para. 6.4. The report admits that solution mining is less efficient than other mining methods, but they never really present any comparative

MEMORANDUM, Dated May 24, 1978
TO: State Planning Coordinator
FROM: Gary B. Glass, and W. Dan Hausel

Page 2

recovery rates. Are there not rates available?

Page 6-9. Conclusions. The report admits that the restoration plan has potential risks. This is particularly apparent in the northern part of the property nearest the Powder River. The report also points out that groundwater rises in the vicinity of the river - I assume contributing to some of the flow in the river.

Risks to aquifers and surface waters must be weighed against the recovery potential and economic benefit of this type of operation.

Page 7-3, para. 7.2.3. Regarding well field excursions, it should be noted that "monitoring" does not mitigate an excursion, it only identifies it. The way this paragraph is worded, one might get the impression that monitoring mitigates the potential danger of aquifer contamination.

There is reference to post-mine monitoring.

Who is expected to do that monitoring, and for how long?

A-53

1. The Geological Survey of Wyoming comment

Page iv, para. 5. The Governor's Clearinghouse is not listed as a reviewing agency.

NRC response

This listing has been expanded to include the Office of the Governor, State of Wyoming.

2. The Geological Survey of Wyoming comment

Page 2-22, para. 4. Mineral deposits not mentioned in this paragraph are bentonite, gypsum, and zeolites. Both bentonite and gypsum units crop out along the east flank of the Bighorn Mountains. In the past, gypsum was mined in that area, and bentonite is still mined by the Kaycee Bentonite Corporation and the Beton Clay Company.

Zeolites occur in some of the ash units in the Wasatch Formation within the Pumpkin Buttes area. The close proximity of zeolites to the uranium mineralization suggests that a zeolite discussion is warranted.

NRC response

The text of Section 2.7.2 has been revised to reflect this information.

3. The Geological Survey of Wyoming comment

Page 6-9, Mineral Resources. There is no mention of zeolite deposits.

NRC response

The text has been revised.

4. The Geological Survey of Wyoming comment

Page 11-1, Para. 11.1, Land and Mineral Resources. This statement infers that solution mining operations result in floral and faunal changes. I don't believe that was the intended meaning.

Additional Comment, Gary B. Glass: Para. 11.3, Vegetation and Wildlife. I don't understand the difference between "flora and fauna" discussed under para. 11.1 and "Vegetation and Wildlife" discussed here. Flora and fauna are out of place in para. 11.1, aren't they?

NRC response

The statement has been deleted from Sect. 11.1.

5. The Geological Survey of Wyoming comment

Page 6-9, para. 6.4. The report admits that solution mining is less efficient than other mining methods, but they never really present any comparative recovery rates. Are there not rates available?

NRC response

See response to Department of the Interior comment 19.

6. The Geological Survey of Wyoming comment

Page 6-9, Conclusions. The report admits that the restoration plan has potential risks. This is particularly apparent in the northern part of the property nearest the Powder River. The report also points out that groundwater rises in the vicinity of the river — I assume contributing to some of the flow in the river.

Risks to aquifers and surface waters must be weighed against the recovery potential and economic benefit of this type of operation.

NRC response

The limited operation will be initially conducted approximately 5.6 to 6 km (3.5 to 4 miles) from the Powder River and proceed southward away from the river. Although future activities will proceed toward the river, the staff believes that data (geohydrologic, restoration, etc.) obtained in the intervening period will resolve the question of risks from such future activities.

Benefit-costs of the operation are discussed in Sect. 13.1.

7. The Geological Survey of Wyoming comment

Page 7-3, para. 7.2.3. Regarding well field excursions, it should be noted that "monitoring" does not mitigate an excursion, it only identifies it. The way this paragraph is worded, one might get the impression that monitoring mitigates the potential danger of aquifer contamination.

NRC response

The paragraph has been edited for clarification.

8. The Geological Survey of Wyoming comment

Who is expected to do that monitoring, and for how long?

NRC response

Postmining monitoring, as discussed in Sect. 8.2.3.8, would be conducted by WMC in accordance with license conditions.



THE STATE OF WYOMING

Wyoming Department of Agriculture

TELEPHONE: (307) 777-7321

CHEYENNE, WYOMING 82002

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ED HERSCHLER, GOVERNOR
DR. NEAL HILSTON, DEAN
COLLEGE OF AGRICULTURE
UNIVERSITY OF WYOMING, LARAMIE

MEMORANDUM

DATE: June 15, 1978

TO: State Planning Coordinator
Wyoming State Clearinghouse

FROM: Don Daiss, Assistant Commissioner
and Liaison Officer for E.I.S. Review

SUBJECT: Irigaray Solution Mining Project, Wyoming Mineral
Corporation, DEIS
State Identifier Number: 77-139D

We have reviewed the E.I.S. and concur.

Although one thousand acres of grazing land will be involved in the total project, it is apparent that the displacement of livestock grazing will be minimal. The proposed reclamation is a necessity and as stated in the proposal is very satisfactory to agriculture.

Attached are the comments from Tim Kautzä, Program Consultant, Wyoming Conservation Commission.

Thank you for the opportunity to comment.

DDjh

Interagency - Hand Carried



THE STATE OF WYOMING

Wyoming State Highway Department

P. O. BOX 1708

CHEYENNE, WYOMING 82001

Ed Herschler, Governor
Lena Manghini, Superintendent and Chief Engineer

MEMORANDUM

June 5, 1978

TO: Mr. Steve Freudenthal, State Planning Coordinator
Wyoming State Clearinghouse
2320 Capitol Avenue
Cheyenne, Wyoming 82001

FROM: William P. King, P.E., Environmental Services Engineer *WPK*

SUBJECT: Comments on Draft EIS for Irigaray Project, Wyoming Mineral
Corporation. State Identifier Number 77-139 D.

Page 6.2 - It is estimated that approximately 50 miles of roads will be constructed or improved over the life of this project. However, there is no mention of whose jurisdiction these roads are under, whether special design features will be required for hazard protection, and who will pay for the improvements.

A-56

1. Wyoming Department of Agriculture comment

Although one thousand acres of grazing land will be involved in the total project, it is apparent that the displacement of livestock grazing will be minimal. The proposed reclamation is a necessity and as stated in the proposal is very satisfactory to agriculture.

NRC response

No response necessary.

1. Wyoming State Highway Department comment

Page 6.2. It is estimated that approximately 50 miles of roads will be constructed or improved over the life of this project. However, there is no mention of whose jurisdiction these roads are under, whether special design features will be required for hazard protection, and who will pay for the improvements.

NRC response

Road mileage given in this section on environmental impacts was noted to recognize these roads as having an impact on air quality (source of dust) and land use. The estimated 80 km (50 miles) of roads will be gravel and dirt roads constructed on the site by WMC to provide access to project operations.

Glenn J. Catchpole
4067 East 14th Street
Casper, WY 82601

June 27, 1978

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

Attention: Dr. Ray Cooperstein

Subject: Comments Pertaining to the NRC Draft Environmental
Statement (DES) on the Wyoming Mineral Corporation
Irigaray Solution Mining Project, April 1978,
Docket No. 40-8502

Dear Ray:

At your invitation I have reviewed the subject DES and find it is
well written, particularly with regard to the objectivity shown by the
NRC staff in preparing the statement.

The following are a couple of minor comments pertaining to the DES
that I would like to have the NRC staff consider during the writing of
the final environmental statement.

I. Re: Page 1-4, Table 1.1

It is my understanding that the construction of an impoundment
also requires DEQ-WOD approval. Also, I don't believe WISC
involvement is required for this size of a project.

2. Re: Page 8-5, Section 8.2.3.1 Monitor Wells

It is felt that the proposal by the applicant to place monitor
wells at 400 feet from the limits of mineralization is reasona-
ble as the 200 foot restriction could possibly place a monitor
well in a position that would intercept normal operating fluid
flows, thereby triggering a false alarm.

3. Re: Page 8-6, Section 8.2.3.6 Corrective Actions

The drilling of detection wells to locate the extent of migra-
tion is not recommended except in certain situations such as
where the well field is located near a water supply source.
The monitor well itself should provide sufficient documentation
that the corrective action has been successful.

Office of Fuel Cycle and Material Safety
Attn: Ray Cooperstein

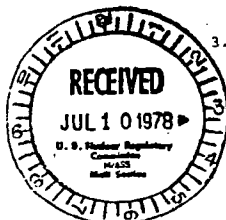
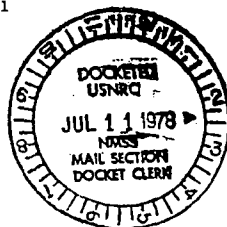
Page 2
June 27, 1978

4. Re: Page 8-7, Section 8.2.3.7 Postrestoration Monitoring

The drilling of at least two wells outside the mine field
(if trend wells not used) to assist with postrestoration
monitoring is not recommended unless an unusually steep hydraulic
gradient coupled with a relatively large hydraulic conductivity
value produces high ground water velocities. In most situations
in Wyoming, of which I am familiar, the use of wells within the
mining zone will provide sufficient documentation of aquifer
restoration.

Sincerely,

Glenn J. Catchpole
Glenn J. Catchpole, P.E.
Hydrologist



A-58

1. Glenn J. Catchpole comment

Page 1-4, Table 1-1. It is my understanding that the construction of an impoundment also requires DEQ-WQD approval. Also, I don't believe WISC involvement is required for this size of a project.

NRC response

Table 1.1 has been revised to include DEQ-WQD.

2. Glenn J. Catchpole comment

Page 8-5, Section 8.2.3.1, Monitor Wells. It is felt that the proposal by the applicant to place monitor wells at 400 feet from the limits of mineralization is reasonable as the 200 foot restriction could possibly place a monitor well in a position that would intercept normal operating fluid flows, thereby triggering a false alarm.

NRC response

See revised Sect. 8.2.3.1.

3. Glenn J. Catchpole comment

Page 8-6, Section 8.2.3.6, Corrective Actions. The drilling of detection wells to locate the extent of migration is not recommended except in certain situations such as where the well field is located near a water supply source. The monitor well itself should provide sufficient documentation that the corrective action has been successful.

NRC response

See revised Sect. 8.2.3.6.

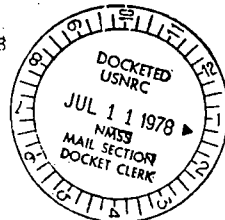
4. Glenn J. Catchpole comment

Page 8-7, Section 8.2.3.7, Postrestoration Monitoring. The drilling of at least two wells outside the mine field (if trend wells not used) to assist with postrestoration monitoring is not recommended unless an unusually steep hydraulic gradient coupled with a relatively large hydraulic conductivity value produces high ground water velocities. In most situations in Wyoming, of which I am familiar, the use of wells within the mining zone will provide sufficient documentation of aquifer restoration.

NRC response

This monitoring is part of the studies required of the applicant to resolve questions on ammonia. Postrestoration monitoring is to be conducted on the first mining well field that is restored.

104 Davey Lab.
Penn. State Univ.
University Park
Pa., 16802
4 July 1978



Director, Div. of Fuel Cycle
and Material Safety
U.S. NRC
Washington, D.C., 20555

Gentlemen:

Enclosed are my comments on NUREG - 0399, draft EIS on Irigaray solution mining project. Please note that the opinions expressed are not necessarily those of The Pennsylvania State University.

It is stated in table 4.5 and also in table 6.4 that the well field is expected to release 76 curies of radon per year. This does not agree with the value in table D.4. It would be helpful to have some discussion of how this number was arrived at, and what could be done to lower it. Perhaps gaseous emissions could be temporarily stored.

The recommendation of Staff to limit operations to 20 ha (50 acres) until the mined out area is restored (Sec. 5.1.5) seems very wise. It is hoped that NRC will conduct appropriate on-site inspections and tests to verify restoration. The requirement of a performance bond for aquifer restoration (Sec. 1.3) seems appropriate. The value might be difficult to assess, given the lack of proven aquifer restoration methods.

The discussion of the wells in section 4.3.2 indicates that the casing will be cemented down to some level. It would be helpful if this level were specified to be below the bottom of the claystone that caps off the upper Irigaray sandstone.

The comparison of the use of coal and uranium fuels is dismissed in the first paragraph of section 12.4.1. It would seem that NEPA would require that these be compared in detail.

Sorry to be late.

Sincerely,
William A. Lochstet
W.A. Lochstet

Radiological Impact of the
Irigaray Solution Mining Project
by

Dr. William A. Lochstet

The Pennsylvania State University*

The Nuclear Regulatory Commission (NRC) has attempted to evaluate the public health consequences of the operation of the proposed Irigaray Solution Mining Project (Ref. 1). However, the impact is calculated by calculating dose commitments for 50 years due to one year's intake for people within an 80 kilometer (50 mile) radius of the plant. I shall evaluate the dose commitment from the mill operations without an arbitrary cutoff in time or distance.

In 1976, Pohl pointed out that the thorium - 230 in the mill tailings decays to radium - 226, which in turn decays to radon - 222, with a time scale determined by the 8×10^4 year half life of thorium - 230 (Ref. 2). Recently, Kenford has pointed out that the uranium - 238 in the mill tailings, and the enrichment tailings decays thru several steps thru thorium - 230 to radon - 222 and should also be considered (Ref. 3). This position has been supported by 21 September 1977 memorandum of Dr. Walter H. Jordan of the ASLBP (Ref. 4). These matters have also been reviewed by Dr. R.L. Gotchy of the NRC staff. These arguments will be considered in the case of the Irigaray solution mining project.

* The opinions and calculations contained herein are my own, and not necessarily those of The Pennsylvania State University.

Since solution mining does not produce a pile of mill tailings, there is no mill tailings pile to have an environmental impact. The largest impact is the material which is removed from the deposit, the uranium. It is expected that the project will produce 500,000 lb of U_3O_8 per year, and be licensed to operate for an initial 5 years (Ref. 1, Sec. 5.1.5). This implies the production of 2.5×10^6 lb or 1.14×10^6 kg of U_3O_8 which will contain 9.6×10^5 kg of uranium (99.3% U-238). Present operations of the gaseous diffusion enrichment plants result in an output of about 1/5 of the feedstock as fuel, and 4/5 as enrichment tails. The enrichment tails will contain about 7.7×10^5 kg of uranium, which will eventually decay radioactively with the production of 1.1×10^{14} curies of radon - 222.

The amount of radon actually released into the air depends on the barriers which impede this release. It is assumed that there is no reprocessing of spent fuel and that the uranium in the spent fuel is managed very well, so that no radon is released to the atmosphere from this source. At present, some recent mill tailings piles have 2 feet of dirt covering. In this case the EPA has estimated that 1/20 (Ref. 5) of the radon escapes into the air. At present the enrichment tails are located in the eastern part of the country, and no method of disposal has been suggested. It is assumed ~~xxx~~ that this material will be buried near their present locations. Since the soil in the east is usually wet, and this affects radon mobility, it will be assumed that 1/100 of the radon escapes into the air. This estimate could easily be in error by a factor of 10.

To evaluate the health consequences of such a release, one must know the population at risk. This is clearly not exactly possible. Therefore some baseline must be provided. This basis for a first estimate shall be the present population in its current distribution. The NRC has recently done this, assuming a U.S. population of 300 million (Ref. 6, Page 3), with the result that the release of 1.0 curie of radon - 222 from a typical tailings pile in a western state will result in a total dose of 0.56 Person - rem to the bronchial epithelium. Since a radon release from an eastern state ~~x~~ will result in much of this radon decaying over the ocean rather than populated land areas, as would be the case for release from a western state. With all these factors, the total dose to the bronchial epithelium would be 3.1×10^{11} person - rem.

The NRC estimate of cancer risk is 22.2 deaths per million person - rem for the bronchial epithelium (Ref. 6, Page 7) and is derived from WASH - 1400 and GESMO. Even though this estimate is too low, it will be used here. The result is 6.9×10^6 deaths. Over six million deaths.

There are other possible radiological impacts. Solid wastes will ~~xx~~ be generated by the project, and disposed of in an active mill tailings impoundment (Ref. 1, Sec. 4.6.3 and 4.6.4). The radium content expected is ~~x~~ given, but no indication of thorium or uranium content is shown. No details are given for the management of the mill tailings impoundments to be used. This information would be useful if the long term implications are to be estimated. That is, how much radon would get into the air from this material.

The mineral deposit will be modified by the mining process. Uranium oxide and calcite will be removed along with some other materials. It is unclear if enough material will be removed to result in accelerated compression of the mined area, or cave-ins. The sandstone would change if a large fraction of the binder material between sand granules was removed. Furthermore, it is necessary to examine to see if the overlying claystone might be breached.

It is difficult to estimate long term impacts without firm expectations for the restoration of the mined areas. If uranium ~~xx~~ remaining in the formation is more mobile than before mining, then it would be swept away by the ~~f~~ groundwater. ~~QR~~ Figure 2.9 (Ref. 1) would suggest that such flow would be toward the ~~x~~ Powder River. Ammonia remaining after the mining is completed might proceed similarly. It ~~xxxi~~ should be noted that as such ammonia is released to the Powder River, it will be available to oxygen and possibly nitrifying bacteria which could convert the ammonia into nitrites or nitrates (Ref. 1, Sec. 6.3.2.2).

Erosion will ultimately cut thru to the upper irigaray formation. Willow Creek cuts across the mining area near the plant location in section nine. The stream bed is about 100 ~~x~~ feet above the ~~xxx~~ sandstone at well 9-248 (Ref. 1, Fig. 2.16). At some finite time in the future, erosion will have cut thru this, and begin ~~xx~~ relocation of the material of the upper irigaray formation. If the deposit had not been mined, this would begin the release of uranium ~~xx~~ ~~xxx~~, thorium and radium to the surface ~~xxxx~~ where the resulting radon can escape into the air. The total erosion of the entire deposit will take a

long time. If the deposit is mined, things will be different. There ~~x~~ will be less uranium, but more ammonia. The mobility of the uranium present will be different. The sandstone will be different due to removal of material such as calcite from it. All these factors make a net assessment difficult. It might be argued that there is currently a balance between uranium, and its daughters being exposed due to erosion and their being similarly buried. Although this has some statistical appeal, it is probably too naive. Ammonia released at this time will have oxygen available for conversion to nitrites and nitrates.

It is shown above that under certain "reasonable" assumptions, the operation of this project would result in the deaths of 6.9 million people. Dr. Walter Jordan notes (Ref. 4, P.7):

It is very difficult to argue that deaths to future generations are unimportant. But it can be shown that the number is insignificant compared to those due to the radon contribution in natural background.

This is not an environmental assessment of background, but of the specific impact of this project. The radon from the enrichment tailings is released on a time scale determined by the 4.5 billion year half life of Uranium - 238. Footnote 12 of NRDC v. USNRC, 547 F.2nd 633 (D.C. Cir. 1976), states in part:

We note at the outset that this standard is misleading because the toxic life of the wastes under discussion far exceeds the life of the plant being licensed. The environmental effects to be considered are those flowing from reprocessing and passive storage for the full detoxification period.

Thus, the long time scale used in these evaluations must be used.

It may be argued that someone in the future should bury these wastes. This would produce an invalid cost - benefit analysis, and is in violation of the National Environmental Policy Act of 1969, as amended (NEPA). In *Calvert Cliffs Coordinating Committee v. USAEC*, 449 F. 2nd 1109 (D.C. Cir., 1971) the court stated:

We conclude, then, that Section 102 of NEPA mandates a particular sort of careful and informed decision - making process and creates judicially enforceable duties But if the decision was reached procedurally without individualized consideration and balancing of environmental factors--conducted fully and in good faith-- it is the responsibility of the courts to reverse, (emphasis added)

Thus, everything must be considered fully and honestly. It is hoped that NRC will fulfill its statutory requirements to consider to address these issues in the final environmental analysis.

It would appear that solution mining has less near term environmental impact than traditional mining procedures which leave tailings piled up in heaps above grade.

References

- 1 "Draft Environmental Statement related to operation of Wyoming Mineral Corporation Irigaray Solution Mining Project" NUREG - 0399, Draft, U.S. N.R.C., (April 1978)
- 2 R.O. Pohl, "Health Effects of Radon - 222 from Uranium Mining", *Search*, 7(5), 345-350 (August 1976)
- 3 Testimony of Dr. Chauncey R. Kepford, "Health Effects Comparison for Coal and Nuclear Power" in the matter of Three Mile Island Unit 2 (Docket No. 50 - 320) operating license hearings, and portions of transcript related, in which the NRC staff supports Kepford's numbers.
- 4 Memorandum of Dr. Walter H. Jordan, Atomic Safety and Licensing Board Panel (ASLBP) to James R. Yore, Chairman, ASLBP (September 21, 1977).
- 5 "Environmental Analysis of The Uranium Fuel Cycle, Part I - Fuel Supply" EPA-520/9-73-CO3-B, U.S. Environmental Protection Agency, (October 1973)
- 6 Affidavit of R.L. Gotchy, "Appendix", "Radiological Impact of Radon - 222 Releases", USNRC, in the matter of Three Mile Island Unit 2, (Docket No. 50 - 320), (January 20, 1978).

NRC response to the William A. Lochstet letter

The staff has elected to reply to the above letter in its entirety because comments and assertions are interposed in such a manner as to be inseparable.

A. The release of 76 Ci of radon per year in Tables 4.5 and 6.4 is that value calculated by the staff assuming the following:

- (1) Radon is in secular equilibrium in the ore body.
- (2) All of the radon associated with the dissolved uranium reaches the surface in the leachates, and
- (3) All of the radon is vented to the atmosphere.

This calculated value is considerably higher than what is actually expected because

- (1) the time from leachate injection to recovery of the uranium-bearing solution is tens of days,
- (2) no credit for radon decay is taken, and
- (3) it is unlikely that 100% release of the radon from the surface surge tanks will occur.

The typographical error in Table D.4 has been corrected.

B. The NRC will be supplied with documentation by the applicant verifying that groundwater quality restoration has been affected. Inspections and operational performance reviews are a responsibility of the NRC. To ensure that groundwater quality restoration and land reclamation for their respective premining uses is done, a performance bond is held by the State of Wyoming Department of Environmental Quality.

C. The wells will be cemented below the bottom of the Irigaray sandstone in the underlying clay-stone stratum.

D. The staff considers the discussion of coal and uranium as fuels in Sect. 12.4.1 as adequate for both will be required in the foreseeable future.

NRC response to the attachment to the Lochstet letter

Pages 1, 2, and 3. Recent hearings before the Atomic Safety and Licensing Board to consider the controversial question of the proper assessment of the impact of radon releases from the nuclear fuel cycle and health effects than can reasonably be assumed associated therewith, concluded that such releases and impacts are insignificant in striking the cost-benefit balance for a nuclear power station.

Enrichment tails are stored in sealed containers and are considered a valuable resource either as feed material for breeder reactors or as sources of more fissionable U-235 at a higher cost per pound for separation. The Ra-226 and Th-230 content of these tails is much less than 1% of the original amount associated with the uranium. In the staff's estimation, these tails, if stored for 1000 years, will contain less than 1% of the equilibrium value of Ra-226, the source of radon. For the foreseeable future no sizeable radon releases from tails are expected.

Solid wastes, which will be disposed of in an active tailings impoundment or a licensed burial site, will release an estimated 1.4 Ci/year of Rn-222. After burial, the release is expected to be negligible.

Page 4. The sandstone is expected to remain structurally stable. Monitoring, as discussed in Sect. 8.2.3.1, will detect any structural change in time for mitigating measures to be taken.

Mobilized uranium will be recovered during production or restoration. Ammonia remaining in the formation after restoration will primarily be adsorbed on clay. If this ammonia were released to the surface environment, it would not present a greater hazard than ammonia or ammonium nitrate normally applied as a fertilizer in agricultural activities.

Page 5. The staff notes that 6.9 million deaths over 4.5 billion years is 0.0015 statistical deaths per year.

Page 6. The staff addressed the intent of NEPA as specified in the foreword of this document.

The staff agrees that solution mining appears to have a lesser environmental impact than conventional uranium mining methods.

Wyoming Mineral
Corporation

Exploration and Mining
Division

GEA-78-809

3900 S. Wadsworth Blvd.
Lakewood, Colo. 80235
Phone 303 988-8530

A Subsidiary of
Westinghouse Electric Corporation

June 21, 1978

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

Attention: Mr. L. C. Rouse, Chief
Fuel Processing and Fabrication Branch

Subject: Comments by Wyoming Mineral Corporation on NUREG-0399,
Docket 40-8502

Gentlemen:

Late in April of 1978, the NRC published NUREG-0399, entitled "Draft Environmental Statement Related to Operation of Wyoming Mineral Corporation Irigaray Solution Mining Project", and invited comments thereon from the public. The Wyoming Mineral Corporation (WMC) wishes to use the opportunity presented by that invitation to express our position on the draft environmental impact statement.

We concur that certain license conditions derived from the environmental evaluation may be appropriate. To the extent that we find certain of the license conditions proposed in the DEIS to be feasible, we have provided tentative conditions in Attachment 9 of a revised license application submitted on Docket 40-8502 concurrent with this letter. The intent of this procedure would be to accumulate all of our license concerns, both radiological and environmental, in a coherent document. However, as stated in Attachment 9, we desire that the final license conditions be consistent with the final requirements considered necessary by the State of Wyoming. Therefore, the conditions proposed in Attachment 9 may require revision following finalization of the mine permit by the State.

As a part of that transmittal we have also included a discussion of each of the conditions proposed in the "Summary and Conclusions" portion of the DEIS. The purpose of the discussions is to support our proposed licensing position. However, to the extent that such discussions supplement or take issue with the contents of NUREG-0399, they may be considered to constitute comments on the DEIS.

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Furthermore, we are enclosing as an attachment to this letter, specific comments and additional data that we feel should be incorporated into the FEIS.

If you have any questions in this matter, please write me at the above address, or telephone me on (303) 988-8530, Extension 226.

Very truly yours,

Karl R. Schendel
K. R. Schendel
Manager, Licensing Projects
Government & Environmental Affairs

Enclosure

KRS/man

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ATTACHMENT TO WMC LETTER, Dated June 21, 1978

COMMENTS ON DEIS, NUREG-0399

1. Paragraph 2.5.2 (page 2-7) and Paragraph 6.2.4 (page 6-2). (New information). An archaeological survey of the proposed mining areas was conducted on April 5, 1978, by Mr. Thomas K. Larson, the Wyoming Assistant State Archaeologist. Mr. Larson found no archaeological materials and recommended archaeological clearance. (A copy of Mr. Larson's letter is enclosed.)
2. Subparagraph 2.6.2.3 (pages 2-13 and 2-16). (Data correction). WMC has determined that the groundwater flow rate is only 14 feet per year rather than the 60 feet per year as stated on page 2-13. In this respect, we wish to point out that the hydraulic gradient for the Irigaray site should be given as an average of 0.005 ft/ft instead of the 0.033 ft/ft value used in the DEIS. We have established that the artesian head that the aquifer is under is to within approximately 60 feet of the surface.
3. Subparagraph 2.6.2.3 (page 2-16). (Clarification). WMC suggests that the NRC discuss the rationale for the statement that the data "suggests a leaky (locally unconfined) artesian system."
4. Subparagraph 3.2.4.2 (page 3-4). (Clarification). Ion exchange resins currently are eluted continuously rather than periodically.
5. Subparagraph 3.2.4.4 (page 3-6). The uranium slurry entering the drying and packaging unit currently is not washed prior to dewatering. Also, the spent scrubber solution may be transferred to the evaporation ponds rather than being recycled.
6. Section 4.2 (page 4-1). (Clarification). WMC wishes to emphasize that the seven-spot cell configuration and corresponding spacings presently envisioned for use in production mining operations may be subject to change if geohydrological conditions warrant it.
7. Paragraph 4.3.1 (page 4-1). Figure 4.1 (page 4-2) and Subparagraph 4.3.4.2 (page 4-7). (New information). WMC's latest proposed mining schedule is shown on the drawing entitled "General Mine Plan", dated 3/17/78. This drawing is enclosed.
8. Paragraph 4.3.3 (page 4-4). (Clarification). The significant parameter from a production standpoint within a production cell is a balanced flow rate from various wells. This rate is a function of injection pressure injection flow and recovery flow. Statements referring to actual or implied injection pressure and flow rate limits should always be qualified to assure that they are considered within this context of balanced flow.

9. Figure 4.5 (page 4-6). (Clarification). WMC has enclosed a drawing entitled "Revised Fig. 4.5. Diagram of Well Completion Methods" that more accurately describes the well completion method used at Irigaray.
10. Paragraph 4.4.1 (page 4-7). (New information). Well field control buildings as currently planned will run at least 60' x 60'.
11. Figure 4.6 (page 4-9), Paragraph 4.4.3 (page 4-10), and Section 4.5 (page 4-10). (Clarification). Please note that the governing parameter for the processing plant is the uranium output. Uranium output is dependent on the uranium concentration in the feed solution and the flow rate of that solution. For the recovery plant, the flow rate is adjusted by changing the number of production cells being pumped and fed into the recovery process. We wish to emphasize that the cell flow rates are not necessarily related to the plant flow rates. Also, the plant flow rate during production activities may deviate substantially, depending on the concentration of the dissolved uranium that occurs in the pregnant lixiviant. As well fields are drilled, and permeability and grade determinations are completed, flow adjustments will have to be made to maintain projected uranium output.
12. Table 4.3 (page 4-12). (New information). The latest values for the "Estimated Volumes of Liquid Effluents" should be those given below and in Attachment 8 to the revised license application.

Source	Acre Feet Per Year
1. Residual lixiviant left in the mined formation prior to commencement of aquifer restoration	90
2. Over production of the well field (Basis: Operating experience to date as projected for a 500,000 lb/yr. facility. Over production includes both programmed overproduction (~0.6%) and contingent excursion over production (~0.4%).)	14.6
3. Well cleaning to maintain injection flows (Basis: 10 acres land on 7 spot configuration, 40 ft. spacings (200 wells) with 1500 gallons/well once every two months required to accomplish cleaning).	5.5
4. Resin wash water for contaminant control.	Included in Item 2

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Source	Acre Feet Per Year
5. Eluant bleed for contaminant control.	Included in Item 2
6. Plant and well field sanitary water use (Basis: estimated consumption rate of ~ 2,000 gpd)	2.1*
7. Monitor well sampling for any monitor wells on excursion status, ~200 gallons/well is necessary to obtain a representative sample.	.2
<hr/>	
Total Required Pond Capacity during Operations (Items 2, 3, and 7)	20.3 acre feet per year

* Goes to Sanitary Waste Field

13. Table 4.4 (page 4-12). (Clarification). The presently planned pond capacities at Irigaray should be those shown below and in Attachment 8 to the revised license application.

Type	Number	Size	Freeboard Capacity	Total Capacity
Calcite Waste	1	100x250x6	2.7 acre-feet	4.4 acre-feet
Low TDS Waste	1	250x250x6	6.3 acre-feet	9.9 acre-feet
High TDS Waste	1	250x250x6	6.3 acre-feet	9.9 acre-feet
High TDS Waste	2	160x390x6	6.4 acre-feet, ea.	10.0 acre-feet, ea.

14. Figure 4.7 (page 4-13). (New information). Please note that the pond configurations given above and as shown on the enclosed drawing entitled "General Mine Plan" (see Comment 8) update the pond configurations shown in Figure 4.7.
15. Figure 4.8 (page 4-14). (New information). The pond construction at Irigaray as currently planned is more appropriately described in the attached drawings designated "Dimensions of Rectangular Evaporation Ponds" and "Typical Cross Section and Inspection Tube Detail of Large Evaporation Ponds, etc."
16. Paragraph 4.6.3 (page 4-15). (Clarification). Please note that the category of solid wastes also includes such contaminated items as used filters, contaminated hardware, etc. These items will be disposed of offsite to a licensed disposal facility or to an active tailings pile.

17. Paragraph 4.6.4 (page 4-15). * (Clarification). Please see our comments on proposed license condition 7.f. that appears in Attachment 9 to the application for a license, Docket 40-8502. Those comments state:

"WMC is particularly puzzled and concerned by the NRC proposal that the accumulation of calcite be limited to a two year period. The basis for this requirement is not provided anywhere in the DEIS. Imposition of this requirement could well cause us to abandon any concept of ponding calcite and instead force us to a routine drumming type operation. Such a procedure would obviously involve routine personnel exposures on a continuing basis. It also would mean that the calcite would be dispersed at the off-site tailing pile at regular intervals and would effectively prevent any subsequent processing to recover radium, uranium or other desirable constituents, should such processing be deemed advantageous at some future time.

We also find it uncomfortable to be unilaterally required by license condition to maintain a contractual arrangement with another mining organization for the disposal of radioactive wastes. WMC suggests that the NRC provide by license condition to all appropriate milling licensees that they be required to enter into suitable contractual arrangements with us. Such provisions would assure that we could then in fact make such arrangements on a reasonable basis. Lacking such mandatory provisions, we could well find ourselves totally at the mercy of our competitors. Of course, WMC could possibly convert to a conventional mining operation to assure us of access to a tailings pile."

18. Table 4.5 (page 4-16). (Correction and clarification). The emission rate for NH_4Cl from the calcite storage pond should read "9.5-10.5". This appears to be a transcription error. Also, WMC suggests that the calculations used to determine the radon-222 releases be provided or referenced.
19. Paragraph 5.1.3 (page 5-5). (Clarification). WMC wishes to emphasize that the restoration program described in this paragraph is the optimum program as presently planned. The actual program for any given area may be modified to suit the individual requirements of that area so as to achieve the established water quality criteria.

As one explicit clarification, WMC suggests that in Figure 5.2, the block labelled "Ponding" be changed to read "Surge Pond." The Fifth and sixth sentences of the paragraph above the figure also should be edited to indicate clearly that restoration water will be extracted, treated and reinjected on a continuing basis.

20. Paragraph 5.1.5 (page 5-7). (New information). WMC is aware of reverse osmosis plants with capacities of up to a million gallons per day that are in operation. Such capacities are not "developmental" installations.

WMC has proposed that the definition of the area to be included in initial restoration be separately defined in writing. This proposal is based on the difficulties associated with achieving full production at a new site. In the interests of meeting the demands of the State of Wyoming, WMC is also preparing a proposal to permit us to demonstrate restoration in an "equivalent and representative unit from demonstration or test areas." It is intended that the 517 site be considered as an "equivalent area".

21. Paragraph 5.2.2 (page 5-8). (Clarification). The use of yellow sweet clover, alfalfa, and crested wheatgrass to help stabilize reclaimed areas rapidly, as suggested by the staff, would almost certainly preclude the development of a diverse plant community of native species to provide long-term stability and value as wildlife habitat. These species are dominant, intense competitors and would prevent the establishment of the native species listed in our reclamation plan.

We concur that the direct seeding of shrubs, particularly big sagebrush, would probably not be successful. Our reclamation plan will involve the direct planting of shrub seedlings which will result in a diverse stand of shrubs at the desired density. The transplantation of mature shrubs from surrounding areas as recommended by the staff is undesirable because of its extremely high cost (relative to direct plantings of shrubs or seedlings) and the subsequent impacts to areas from which shrubs are removed.

The details of our reclamation program are subject to approval by the State of Wyoming as a condition of issuing the mining permit.

22. Section 5.3 (page 5-8). (Amplification). WMC requests that the following exception be included. "If the surface owner requests the use of a structure as a ranch building after mining, the structure would be permitted to remain, subject to appropriate regulatory approvals."
23. Subparagraph 6.3.1.1 (page 6-3). (New information). WMC's latest mining schedule does not anticipate mining activities in the vicinity of Willow Creek until probably 1982.
24. Subparagraph 6.3.1.2 (page 6-3) and Subparagraph 6.3.2.2 (page 6-4). (Amplification). WMC submits that any assumption that WMC activities at Irigaray could be reflected in the Powder River is not credible.

The effects of initial operations carried out on a limited scale present no hazard. Then, by the time operations approach the Powder River in the north, sufficient data on restoration, groundwater chemistry, and available lixivants will have been accumulated to assure the absence of any credible threat to the water quality of the river.

We also submit that while it may not be "possible to predict which constituents would be removed from the contaminated water (during) movement through the aquifer", it is broadly known to the industry that clays will remove ammonia. At this time, WMC's restoration demonstrations have proven the capability to deal adequately with all other constituents of concern. Based on these considerations, no impact from our operations at any appreciable distance from the boundaries of mining operations can be credited.

25. Subparagraph 6.3.2.2 (page 6-7). (Clarification). To avoid confusion from a phrase out of context, WMC prefers that our proposal be phrased using the words on page 4-28 of the support document entitled "Irigaray Restoration Data Package - March 1978," that accompanied my letter designated in the DEIS as Reference 10. Those words on page 4-28 state, "It is concluded that 20-50 ppm ammonia as the residual level after restoration should be acceptable. . . ." When WMC proposed "a minimum value in the 20-50 ppm (average) range" the discussion dealt with establishing a criterion, that is, the value for purposes of comparison did not have to be less than 20-50 ppm (average). Once the criterion was established, the values measured in a restored aquifer would have to be < 20-50 ppm (average), that is, the 20-50 ppm would be a maximum allowable.

As a minor comment, in the third line from the bottom of the page, the valence sign of NO₂ should be negative.

26. Subparagraph 6.3.2.2 (page 6-9). (Clarification). There is confusion regarding the contents of the section labelled Conclusions, particularly the first paragraph.

At the top of page 6-8, the staff determines that the total theoretical extent of oxidation, even under conditions described as "neither of which the staff considers likely", to produce only 3.2 ppm nitrogen in nitrates. Yet the Conclusions paragraph conditions the use of aquifer water with the phrase "unless partial nitrification resulted in concentrations of nitrate-nitrogen greater than 10 mg/liter," (i.e. greater than 10 ppm). In view of the earlier calculated results, we do not see the rationale for the later conditional statement. Similarly as discussed in Comment 24, effects on surface waters "(i.e. Powder River)" simply are not credible.

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27. Paragraph 6.6.3 (page 6-11). (New information). The WMC mining schedule now postpones activities that might effect Willow Creek until 1982.
38. Subparagraph 8.1.5 (page 8-2). (Clarification). WMC can see no basis for the proposed "expanded baseline survey" at this time. Please refer to our discussion under Comment 24 regarding the credibility of subsurface activities in the licensed 50-acre well field having any effect on the Powder River. The present radiological sampling of surface waters is sufficient.

We will undertake to sample the Powder River for baseline at some future time, years into the future, prior to the commencement of mining operations in close proximity to surface water flow or in close proximity to natural drainage that may discharge to surface water flow. Such sampling would then be meaningful and would be subject to approval by the State of Wyoming.

29. Subparagraph 8.1.5.2 (page 8-3). (Amplification). WMC will perform initial sampling of monitoring and designated production wells at a frequency of three samples over a period of two weeks.

Details of the WMC sampling techniques, stabilization criteria, analytical quality control procedures, etc., are maintained at the Irigaray site.

If data on repetitive measurements provides the necessary assurance of stability, stabilization may, at some future time, be established using a predetermined pumping time or pumped volume. The statistics and safety factor used for such a calculation will be documented and retained on site.

30. Table 8.3 (page 8-3). (Clarification). WMC does not accept the extensive list of parameters contained in this table for application to surface waters. Present radiological sampling for uranium, thorium-230, radium-226 and gross alpha are sufficient to establish any airborne effects on surface waters. When, or if, operations are commenced in close proximity to the Powder River, such that groundwater changes might effect it, the appropriate baseline parameters to be measured will be mutually established with the State of Wyoming.
31. Table 8.4 (page 8-4). (Clarification). WMC proposes that the indicated sampling of the yellowcake dryer stack (if drying is performed) be revised to read "Samples representative of a 24-hour release rate shall be collected from the exhaust stack of the calciner scrubber during normal operations of this equipment on a monthly basis." This requirement is consistent with the WMC application and current NRC practice.

In view of the requirements elsewhere that WMC maintain a liquid seal over the pond precipitates and that we monitor pond radiation levels, we see no justification for routinely sampling sediments. WMC will make the measurements necessary to properly protect personnel from radioactive material exposures prior to deliberately processing exposed sediments.

The proposal that monthly air samples be measured for the presence of radon-222 does not appear justified. The quantitative values of radon measured at the air monitoring sites, if any, would be only very slightly above background. The equipment required to detect these levels would be expensive, and if not portable, would have to be provided for each site. In view of the difficulty and expense involved in making measurements of no real value, WMC urges that this parameter be deleted.

32. Subparagraph 8.2.3.1 (page 8-5). (New information). WMC wishes to establish clearly that the State of Wyoming "Supportive Information Handout" is purely a recommendation. We feel that our program at Irigaray precedes the publication of that document. We also wish to point out that a subsequent Guideline, dated March 20, 1978, revises the criteria for the placement of monitor wells, stating "Monitoring wells in the production zone should be located no more than sixty (60) meters from the boundaries of a given mine area.... Monitoring wells in the production zone may be placed at distances greater than sixty (60) meters from the mine area if reliable hydrologic data indicate that greater distances are necessary, or if trend wells are utilized between the mine area perimeter and the monitoring well. When trend wells are used monitoring wells should not be placed at a distance greater than one hundred twenty (120) meters. Monitoring wells in non-production zones should be centrally located within the mine area."

WMC proposes to locate monitoring wells in accordance with this latest guide.

33. Subparagraph 8.2.3.3 (page 8-5). (Clarification). WMC takes exception to the proposed arbitrary requirement to provide deep and shallow monitor wells on a "per acre" basis. Deep and shallow monitor wells will be located and provided as determined to be necessary based on data from electric logs.
34. Subparagraph 8.2.3.4 (page 8-5). (Clarification). WMC proposes routinely to sample monitor wells only for water depth, conductivity, chloride, alkalinity and sulfate in accordance with the revised mine permit application submitted to the State of Wyoming.

The purpose of sampling the monitor wells is to detect an excursion. General industry experience with in-situ mining operations using an ammonia bicarbonate lixiviant shows that the earliest indicators of the presence of the lixiviant at a monitoring location are conductivity, chloride and/or total alkalinity (as HCO_3). Therefore, routine sampling for any other parameters is superfluous.

In the event that an excursion is indicated by the sampling plan described above, WMC would go to wider sampling, possibly including arsenic and/or selenium, in order to determine the extent and seriousness of the postulated problem.

35. Subparagraph 8.2.3.5 (page 8-6). (New information). The control limits presently agreed to between WMC and the State of Wyoming are 15% above baseline for HCO_3 , 10% above baseline for conductivity, and 5 ppm above baseline for chloride. If proven unworkable, these UCL's are subject to revision with the approval of the appropriate state agency.

These limits are more realistic and not subject to possible false alarms to the extent that the maximum observed concentration criteria (as proposed in the DEIS) would be. The geohydrologic distribution throughout the aquifer is such that natural variations in the concentration values for the chemicals of interest would surely occur. It is very likely that higher concentrations exist and would be swept to the sampling location. When coupled with sampling and analytical variability, a percentage of values in violation of UCL's as proposed in the DEIS would be statistically inevitable. Such high readings would not be valid indications of an excursion, but would require extensive additional sampling to provide assurance of that fact.

36. Subparagraph 8.2.3.6 (page 8-6). (Amplification). WMC recommends that the NRC restrict its discussion of corrective actions in the event of an excursion to an evaluation of the practicability of effective corrective action.

Details of the procedures to be followed, the timing, and the reporting requirements have been, and rightly should be established in accordance with the requirements of the State of Wyoming. In particular, certain well drilling to be performed by WMC must first be reviewed and approved by the Wyoming State Engineer's Office.

WMC would be happy to provide the staff with a copy of any generally available reports transmitted to the state agencies, to the extent that the NRC is interested in the phenomena of excursions, and as a courtesy by WMC.

37. Subparagraph 8.2.3.7 (page 8-7). (New information). WMC requests that this discussion be revised to state that after restoration has been completed the field will be sampled every 45 days for a six month period to verify restoration stabilization. Such a program provides the assurance necessary to satisfy the State of Wyoming.

38. Subparagraph 8.2.3.8 (page 8-7). (Clarification). This should be revised to state that after mining completion, selected monitor wells will be sampled quarterly until restoration is complete. The reference to the "life of the Irigaray project" is objectionable because sequential surface reclamation will be undertaken following sequential aquifer restoration. As a result, WMC plans to plug and seal all wells in, and to revegetate, some of the early mining areas while we are still mining and/or restoring others. The commencement of surface reclamation will mark the termination of all subsurface activities.



WYOMING MINERAL CORPORATION

P. O. Box 1038 BUFFALO, WYOMING 82834

IRIGARAY AREA

JOHNSON COUNTY, WYOMING

REVISED

DATE

BY

GEOLOGY BY

DRAWN BY: JH 3/17/78

COMPLETION DATE:

SECTIONS - T. 45 N., R. 77 W.
4, 5, 8, 9, 16, & 17

GENERAL MINE PLAN

(APPENDIX E)



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SHEET OF

Because of its extremely large size, this map has not been reproduced in Appendix A. However, it may be found in the NRC Public Document Room in Washington, D.C., and in Wyoming Mineral Corporation, Application for In Situ Permit to Mine for the Irigaray Site, submitted to the Wyoming Department of Environmental Quality, Land Quality Division, April 1978 (revised 6/23/78).



THE STATE OF WYOMING

Wyoming Recreation Commission

OFFICE OF THE WYOMING STATE ARCHEOLOGIST

DEPARTMENT OF ANTHROPOLOGY
LARAMIE, WYOMING 82071

UNIVERSITY OF WYOMING
TELEPHONE: 766-6334

ED HERSCHLER
GOVERNOR

PAUL H. WESTEDT
Director
Cheyenne, Wyoming 82002
777-7695

April 10, 1978

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Mr. Stephen Gash
Senior Engineer
Wyoming Mineral Corp.
Exploration and Mining Division
3900 S. Wadsworth Blvd.
Lakewood, Colorado 80235 Project #WY-100-78
Antiquities 76-WY-058

Dear Mr. Gash:

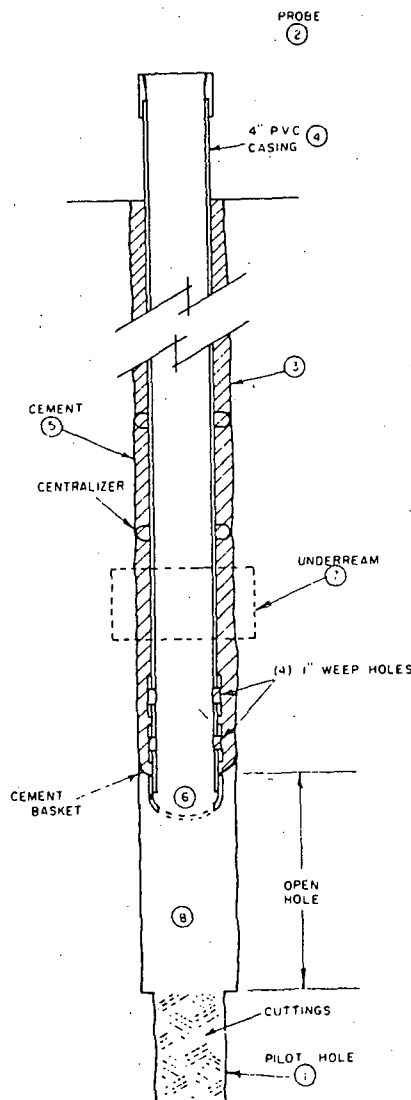
Archeological investigations were conducted on April 5 of approximately 600 acres of proposed permit area for the Wyoming Minerals Irigaray Project in Sections 5, 8 and 9, T45N., R77W., Johnson County, Wyoming. The areas inspected were within the "Permit Boundary" line as delineated by the company map which you supplied to us.

No archeological materials were found during the inspection and archeological clearance is recommended for this project with the stipulation that the Office of the State Archeologist be notified immediately if any archeological materials are encountered during construction activities. A bill for services is enclosed.

Sincerely,

Thomas K. Larson
Thomas K. Larson,
Assistant State Archeologist

TKL/mar
cc: Jan Wilson



TYP. WELL COMPLETION

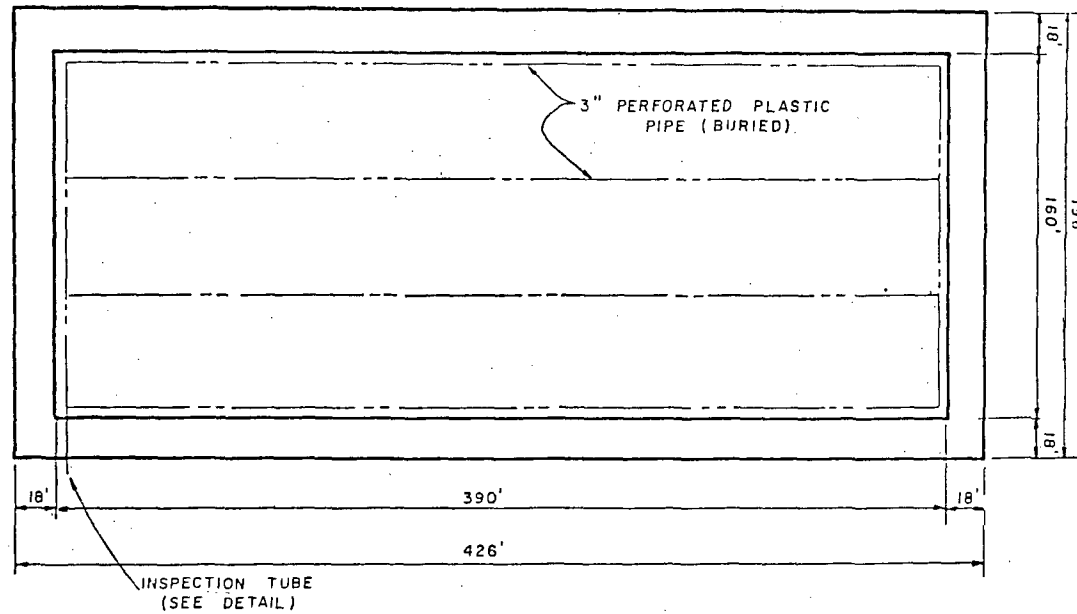
1. DRILL 5" PILOT HOLE
2. LOG & DETERMINE ORE THICKNESS & GRADE
3. REAM TO 6 3/4" TO BOTTOM OF MINERALIZED ZONE.
4. SET 4" PVC CASING TO TOP OF MIN. ZONE
5. CEMENT ANNULUS
6. DRILL OUT PLUG
7. UNDERREAM UPPER MIN. ZONE IF PRESENT
8. STIMULATE (FLUSH & STEAM)

OPEN HOLE INJ. WELL RESTRICTED TO MIN ZONE

OPEN HOLE PROD. WELL NOT RESTRICTED TO MIN ZONE BUT DETERMINED BY UPPER & LOWER ORE BOUNDARY IN INJ. WELLS

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MODEL RESERVOIR
 AREA = 1.75 ACRES CAPACITY = 6.3 ACRE FT.



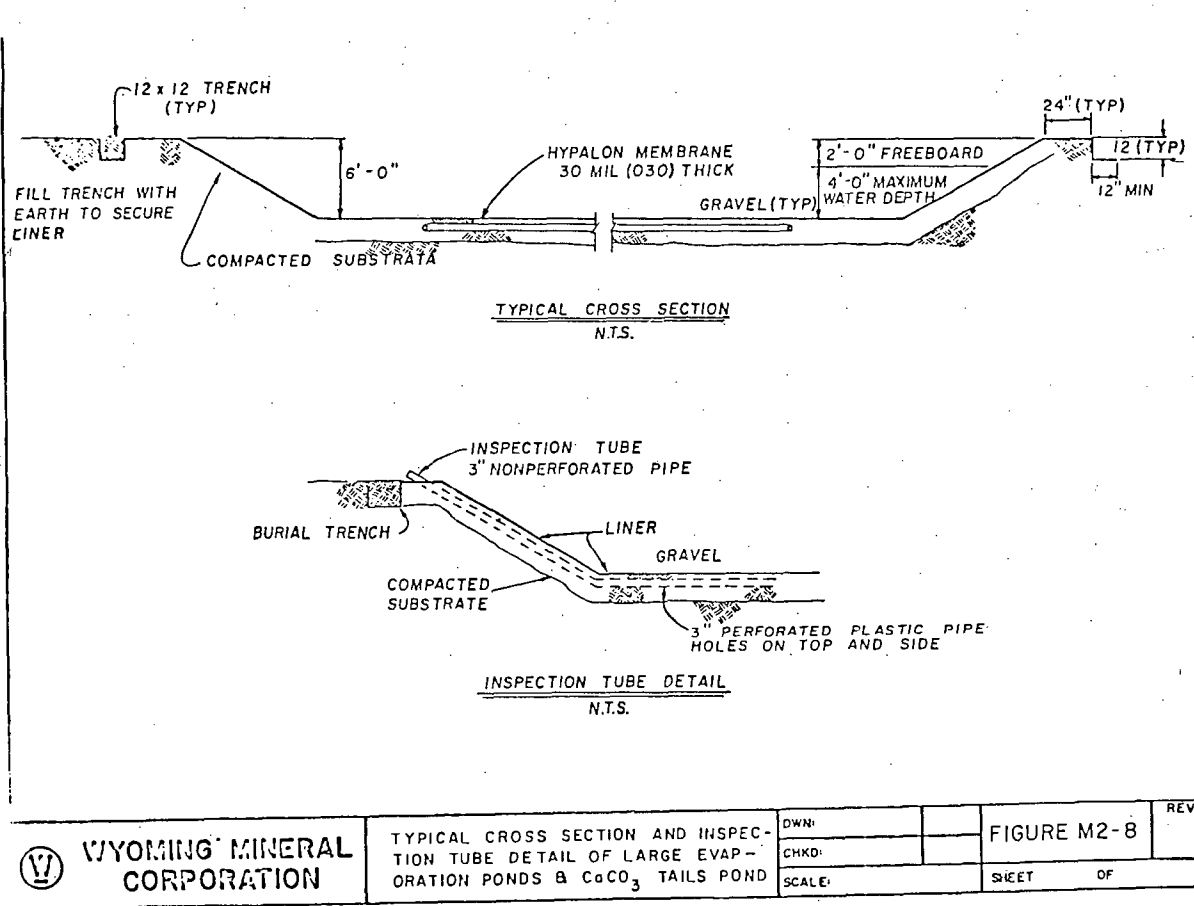
**WYOMING MINERAL
CORPORATION**

**DIMENSIONS OF RECTANGULAR
EVAPORATION PONDS**

OWN:	
CHKD:	
SCALE:	

FIGURE M2-7	
SHEET	OF

REV



1. Wyoming Mineral Corporation comment

Paragraph 2.5.2 (page 2-7) and Paragraph 6.2.4 (page 6-2). (New information). An archaeological survey of the proposed mining areas was conducted on April 5, 1978, by Mr. Thomas K. Larson, the Wyoming Assistant State Archaeologist. Mr. Larson found no archaeological materials and recommended archaeological clearance. (A copy of Mr. Larson's letter is enclosed.)

NRC response

The archaeological clearance letter is included in Appendix F of the FES.

2. Wyoming Mineral Corporation comment

Subparagraph 2.6.2.3 (pages 2-13 and 2-16). (Data correction). WMC has determined that the groundwater flow rate is only 14 feet per year rather than the 60 feet per year as stated on page 2-13. In this respect, we wish to point out that the hydraulic gradient for the Irigaray site should be given as an average of 0.005 ft/ft instead of the 0.033 ft/ft value used in the DEIS. We have established that the artesian head that the aquifer is under is to within approximately 60 feet of the surface.

NRC response

As noted in Sect. 2.6.2.3, local variations in the groundwater flow rate are to be expected. The 60 ft/year value is not cited as an average value nor is the hydraulic gradient value of 0.033 ft/ft. The values noted and calculations made from such values were from data supplied by the applicant to indicate the amount of variation that may be expected at the site.

3. Wyoming Mineral Corporation comment

Subparagraph 2.6.2.3 (page 2-16). (Clarification). WMC suggests that the NRC discuss the rationale for the statement that the data "suggests a leaky (locally unconfined) artesian system."

NRC response

The paragraph has been revised to clarify the staff's analysis of all available data.

4. Wyoming Mineral Corporation comment

Subparagraph 3.2.4.2 (page 3-4). (Clarification). Ion exchange resins currently are eluted continuously rather than periodically.

NRC response

Section 3 is a general discussion of solution mining, and information contained therein does not necessarily apply to WMC's specific process.

5. Wyoming Mineral Corporation comment

Subparagraph 3.2.4.4 (page 3-6). The uranium slurry entering the drying and packaging unit currently is not washed prior to dewatering. Also, the spent scrubber solution may be transferred to the evaporation ponds rather than being recycled.

NRC response

See response to previous comment pertaining to Sect. 3 (WMC comment 4).

6. Wyoming Mineral Corporation comment

Section 4.2 (page 4-1). (Clarification). WMC wishes to emphasize that the seven-spot cell configuration and corresponding spacings presently envisioned for use in production mining operations may be subject to change if geohydrological conditions warrant it.

NRC response

The text on page 4-1 of the DES has been revised.

7. Wyoming Mineral Corporation comment

Paragraph 4.3.1 (page 4-1), Figure 4.1 (page 4-2) and Subparagraph 4.3.4.2 (page 4-7). (New information). WMC's latest proposed mining schedule is shown on the drawing entitled "General Mine Plan," dated 3/17/78. This drawing is enclosed.

NRC response

Figure 4.1 and Sect. 4.3.4.2 have been revised to reflect this new information.

8. Wyoming Mineral Corporation comment

Paragraph 4.3.3 (page 4-4). (Clarification). The significant parameter from a production standpoint within a production cell is a balanced flow rate from various wells. This rate is a function of injection pressure injection flow and recovery flow. Statements referring to actual or implied injection pressure and flow rate limits should always be qualified to assure that they are considered within this context of balanced flow.

NRC response

Clarification has been made in the text.

9. Wyoming Mineral Corporation comment

Figure 4.5 (page 4-6). (Clarification). WMC has enclosed a drawing entitled "Revised Fig. 4.5 Diagram of Well Completion Methods" that more accurately describes the well completion method used at Irigaray.

NRC response

A notation has been made on Figure 4.5 referring to the revised figure.

10. Wyoming Mineral Corporation comment

(Paragraph 4.4.1 (page 4-7). (New information). Well field control buildings as currently planned will run at least 60' x 60'.

NRC response

The text has been changed to reflect this new information.

11. Wyoming Mineral Corporation comment

Figure 4.6 (page 4-9), Paragraph 4.4.3 (page 4-10), Section 4.5 (page 4-10). (Clarification). Please note that the governing parameter for the processing plant is the uranium output. Uranium output is dependent on the uranium concentration in the feed solution and the flow rate of that solution. For the recovery plant, the flow rate is adjusted by changing the number of production cells being pumped and fed into the recovery process. We wish to emphasize that the cell flow rates are not necessarily related to the plant flow rates. Also, the plant flow rate during production activities may deviate substantially, depending on the concentration of the dissolved uranium that occurs in the pregnant lixiviant. As well fields are drilled, and permeability and grade determinations are completed, flow adjustments will have to be made to maintain projected uranium output.

NRC response

The caption for Fig. 4.6 has been changed to indicate that the flows are approximate. Assumed flows are used by the staff for calculations to assess impacts from various operational point sources.

12. Wyoming Mineral Corporation comment

Table 4.3 (page 4-12). (New information). The latest values for the "Estimated Volumes of Liquid Effluents" should be those given below and in Attachment 8 to the revised license application.

<u>Source</u>	<u>Acre Feet Per Year</u>
1. Residual lixiviant left in the mined information prior to commencement of aquifer restoration	90
2. (Over production of the well field (Basis: Operating experience to date as projected for a 500,000 lb/yr. facility. Over production includes both programmed over-production (~0.6%) and contingent excursion over production (~0.4%).	14.6
3. Well cleaning to maintain injection flows (Basis: 10 acres land on 7 spot configuration, 40 ft. spacings (200 wells) with 1500 gallons/well once every two months required to accomplish cleaning).	5.5
4. Resin wash water for contaminant control.	Included in Item 2
5. Eluant bleed for contaminant control.	Included in Item 2
6. Plant and well field sanitary water used (Basis: estimated consumption rate of ~2,000 gpd).	2.1*
7. Monitor well sampling for any monitor wells on excursion status (~200 gallons/well is necessary to obtain a representative sample.	.2
Required Pond Capacity during Operations (Items 2, 3, and 7)	20.3 acre feet per year

* Goes to Sanitary Waste Field.

NRC response

These values are not significantly different from those used in the DES. The values in Table 4.3 in the DES were used in calculations related to impact assessment. For these reasons the staff does not believe that a change in the text is warranted.

13. Wyoming Mineral Corporation comment

Table 4.4 (page 4-12). (Clarification). The presently planned pond capacities at Irigaray should be those shown below and in Attachment 8 to the revised license application.

<u>Type</u>	<u>Number</u>	<u>Acres</u>	<u>Size</u>	<u>Freeboard Capacity</u>	<u>Total Capacity</u>
Calcite Waste	1	.57	100x250x6	2.7 acre-feet	4.4 acre-feet
Low TDS Waste	1	1.43	250x250x6	6.3 acre-feet	9.9 acre-feet
High TDS Waste	1	1.43	250x250x6	6.3 acre-feet	9.9 acre-feet
High TDS Waste	2	2.86	160x390x6	6.4 acre-feet, ea	10.0 acre-feet, ea

NRC response

Table 4.4 has been revised to incorporate this new information.

14. Wyoming Mineral Corporation comment

Figure 4.7 (page 4-13). (New information). Please note that the pond configurations given above and as shown on the enclosed drawing entitled "General Mine Plan" (see Comment 8) update the pond configurations shown in Figure 4.7.

NRC response

Figure 4.7 has been annotated to indicate that pond dimensions have been changed.

15. Wyoming Mineral Corporation comment

Figure 4.8 (page 4-14). (New information). The pond construction at Irigaray as currently planned is more appropriately described in the attached drawings designated "Dimensions of Rectangular Evaporation Ponds" and "Typical Cross Section and Inspection Tube Detail of Large Evaporation Ponds, etc."

NRC response

Figure 4.8 has been changed to reflect this new information.

16. Wyoming Mineral Corporation comment

Paragraph 4.6.3 (page 4-15). (Clarification). Please note that the category of solid wastes also includes such contaminated items as used filters, contaminated hardware, etc. These items will be disposed of offsite to a licensed disposal facility or to an active tailings pile.

NRC response

The text has been expanded to include this type of solid waste.

17. Wyoming Mineral Corporation comment

Paragraph 4.6.4 (page 4-15). (Clarification). Please see our comments on proposed license condition 7.f. that appears in Attachment 9 to the application for a license, Docket 40-8502. Those comments state:

WMC is particularly puzzled and concerned by the NRC proposal that the accumulation of calcite be limited to a two year period. The basis for this requirement is not provided anywhere in the DEIS. Imposition of this requirement could well cause us to abandon any concept of ponding calcite and instead force us to a routine drumming type operation. Such a procedure would obviously involve routine personnel exposures on a continuing basis. It also would mean that the calcite would be dispersed at the off-site tailing pile at regular intervals and would effectively prevent any subsequent processing to recover radium, uranium or other desirable constituents, should such processing be deemed advantageous at some future time.

We also find it uncomfortable to be unilaterally required by license condition to maintain a contractual arrangement with another mining organization for the disposal of radioactive wastes. WMC suggests that the NRC provide by license condition to all appropriate milling licensees that they be required to enter into suitable contractual arrangements with us. Such provisions would assure that we could then in fact make such arrangements on a reasonable basis. Lacking such mandatory provisions, we could well find ourselves totally at the mercy of our competitors. Of course, WMC could possibly convert to a conventional mining operation to assure us of access to a tailings pile.

NRC response

The basis for this requirement is discussed under Alternative 4 (Sect. 12.3). Basically, the requirement is to prevent the proliferation of waste ponds on the Irigaray property. To permit the applicant sufficient time to develop necessary procedures (e.g., prevention of liner damage, potential resource recovery), the "two-year period" on p. 4-15 has been revised to read a "five-year period," which is the duration of this proposed licensing action.

In addition to the licensed tailings site, the applicant has the alternative of shipping such wastes to a licensed burial ground. With the small quantity of wastes involved, the staff believes that there should be no problems in obtaining an agreement for disposal in a tailings pond.

18. Wyoming Mineral Corporation comment

Table 4.5 (page 4-16). (Correction and clarification). The emission rate for NH_4Cl from the calcite storage pond should read "9.5-10.5." This appears to be a transcription error. Also, WMC suggests that the calculations used to determine the radon-222 releases be provided or referenced.

NRC response

The emission rate for NH_4Cl has been corrected in Table 4.5. The radon calculations are addressed in the NRC response to Dr. Lochstet's letter (page A-64).

19. Wyoming Mineral Corporation comment

Paragraph 5.1.3 (page 5-5). (Clarification). WMC wishes to emphasize that the restoration program described in this paragraph is the optimum program as presently planned. The actual program for any given area may be modified to suit the individual requirements of that area so as to achieve the established water quality criteria.

As one explicit clarification, WMC suggests that in Figure 5.2, the block labelled "Ponding" be changed to read "Surge Pond." The fifth and sixth sentences of the paragraph above the figure also should be edited to indicate clearly that restoration water will be extracted, treated and reinjected on a continuing basis.

NRC response

The text has been edited, and Fig. 5.2 has been changed accordingly.

20. Wyoming Mineral Corporation comment

Paragraph 5.1.5 (page 5-7). (New information). WMC is aware of reverse osmosis plants with capacities of up to a million gallons per day that are in operation. Such capacities are not "developmental" installations.

WMC has proposed that the definition of the area to be included in initial restoration be separately defined in writing. This proposal is based on the difficulties associated with achieving full production at a new site. In the interests of meeting the demands of the State of Wyoming, WMC is also preparing a proposal to permit us to demonstrate restoration in an "equivalent and representative unit from demonstration or test areas." It is intended that the 517 site be considered as an "equivalent area."

NRC response

Reverse osmosis was initially developed for desalinization, and many large-scale units are in existence. Decontamination of uranium solution mining wastes, however, is a new application of this method. Groundwater quality restoration of a production-scale mining unit as discussed in Sect. 5.1.5 is a condition of the NRC source material license. While added data from restoration at the 517 test site will be useful, the staff considers that early restoration of a production well field is essential to demonstrate the required scale-up.

21. Wyoming Mineral Corporation comment

Paragraph 5.2.2 (page 5-8). (Clarification). The use of yellow sweet clover, alfalfa, and crested wheatgrass to help stabilize reclaimed areas rapidly, as suggested by the staff, would almost certainly preclude the development of a diverse plant community of native species to provide long-term stability and value as wildlife habitat. These species are dominant, intense competitors and would prevent the establishment of the native species listed in our reclamation plan.

We concur that the direct seeding of shrubs, particularly big sagebrush, would probably not be successful. Our reclamation plan will involve the direct planting of shrub seedlings which will result in a diverse stand of shrubs at the desired density. The transplantation of mature shrubs from surrounding areas as recommended by the staff is undesirable because of its extremely high cost (relative to direct plantings of shrubs or seedlings) and the subsequent impacts to areas from which shrubs are removed.

The details of our reclamation program are subject to approval by the State of Wyoming as a condition of issuing the mining permit.

NRC response

Section 5.3 has been revised to include the reclamation program submitted by WMC to the State of Wyoming Department of Environmental Quality.

22. Wyoming Mineral Corporation comment

Section 5.3 (page 5-8). (Amplification). WMC requests that the following exception be included. "If the surface owner requests the use of a structure as a ranch building after mining, the structure would be permitted to remain, subject to appropriate regulatory approvals."

NRC response

The NRC does not require that structures be torn down; they must, however, be decontaminated to permit their release for unrestricted use. This exception has been included in the text in Sect. 5.2.

23. Wyoming Mineral Corporation comment

Subparagraph 6.3.1.1 (page 6-3). (New information). WMC's latest mining schedule does not anticipate mining activities in the vicinity of Willow Creek until probably 1982.

NRC response

The date listed in the text on p. 6-3 of the DES has been changed accordingly.

24. Wyoming Mineral Corporation comment

Subparagraph 6.3.1.2 (page 6-3) and Subparagraph 6.3.2.2 (page 6-4). (Amplification). WMC submits that any assumption that WMC activities at Irigaray could be reflected in the Powder River is not credible. The effects of initial operations carried out on a limited scale present no hazard. Then, by the time operations approach the Powder River in the north, sufficient data on restoration, groundwater chemistry, and available lixiviants will have been accumulated to assure the absence of any credible threat to the water quality of the river.

We also submit that while it may not be "possible to predict which constituents would be removed from the contaminated water (during) movement through the aquifer," it is broadly known to the industry that clays will remove ammonia. At this time, WMC's restoration demonstrations have proven the capability to deal adequately with all other constituents of concern. Based on these considerations, no impact from our operations at any appreciable distance from the boundaries of mining operations can be credited.

NRC response

The staff concurs that the limited operation should pose no hazard to the Powder River.

The staff's awareness of the adsorption of ammonia by clays is contained on p. 6-7 and was a significant factor in the above conclusion.

25. Wyoming Mineral Corporation comment

Subparagraph 6.3.2.2 (page 6-7). (Clarification). To avoid confusion from a phrase out of context, WMC prefers that our proposal be phrased using the words on page 4-28 of the support document entitled "Irigaray Restoration Data Package - March 1978," that accompanied my letter designated in the DEIS as Reference 10. Those words on page 4-28 state, "It is concluded that 20-50 ppm ammonia as the residual level after restoration should be acceptable..." When WMC proposed "a minimum value in the 20-50 ppm (average) range" the discussion dealt with establishing a criterion, that is, the value for purposes of comparison did not have to be less than 20-50 ppm (average). Once the criterion was established, the values measured in a restored aquifer would have to be \leq 20-50 ppm (average), that is, the 20-50 ppm would be a maximum allowable.

As a minor comment, in the third line from the bottom of the page the valence sign of NO_2 should be negative.

NRC response

The text has been changed to indicate that the 20-50 ppm would be a maximum allowable. The valence sign of NO_2 has been corrected.

26. Wyoming Mineral Corporation comment

Subparagraph 6.3.2.2 (page 6-9). (Clarification). There is confusion regarding the contents of the section labelled Conclusions, particularly the first paragraph.

At the top of page 6-8, the staff determines that the total theoretical extent of oxidation, even under conditions described as "neither of which the staff considers likely," to produce only 3.2 ppm nitrogen in nitrates. Yet the Conclusions paragraph conditions the use of aquifer water with the phrase "unless partial nitrification resulted in concentrations of nitrate-nitrogen greater than 10 mg/liter," (i.e., greater than 10 ppm). In view of the earlier calculated results, we do not see the rationale for the later conditional statement. Similarly as discussed in Comment 24, effects on surface waters "(i.e., Powder River)" simply are not credible.

NRC response

The staff analysis is believed correct. However, additional operational data will provide the actual facts.

27. Wyoming Mineral Corporation comment

Paragraph 6.6.3 (page 6-11). (New information). The WMC mining schedule now postpones activities that might effect Willow Creek until 1982.

NRC response

The data has been changed in the text.

28. Wyoming Mineral Corporation comment

Subparagraph 8.1.5 (page 8-2). (Clarification). WMC can see no basis for the proposed "expanded baseline survey" at this time. Please refer to our discussion under Comment 24 regarding the credibility of subsurface activities in the licensed 50-acre well field having any effect on the Powder River. The present radiological sampling of surface waters is sufficient.

We will undertake to sample the Powder River for baseline at some future time, years into the future, prior to the commencement of mining operations in close proximity to surface water flow or in close proximity to natural drainage that may discharge to surface water flow. Such sampling would then be meaningful and would be subject to approval by the State of Wyoming.

NRC response

In context with its licensing activities and responsibilities under NEPA, the NRC will require baseline surveys as specified in Sect. 8 of the FES.

29. Wyoming Mineral Corporation comment

Subparagraph 8.1.5.2 (page 8-3). (Amplification). WMC will perform initial sampling of monitoring and designated production wells at a frequency of three samples over a period of two weeks.

Details of the WMC sampling techniques, stabilization criteria, analytical quality control procedures, etc., are maintained at the Irigaray site.

If data on repetitive measurements provides the necessary assurance of stability, stabilization may, at some future time, be established using a predetermined pumping time or pumped volume. The statistics and safety factor used for such a calculation will be documented and retained on site.

NRC response

The specific monitoring program accepted by the State of Wyoming Department of Environmental Quality in the Application for In Situ Permit to Mine for the Irigaray Site, Volume one (revised) has been reviewed by the NRC staff.

30. Wyoming Mineral Corporation comment

Table 8.3 (page 8-3). (Clarification). WMC does not accept the extensive list of parameters contained in this table for application to surface waters. Present radiological sampling for uranium, thorium-230, radium-226, and gross alpha are sufficient to establish any airborne effects on surface waters. When, or if, operations are commenced in close proximity to the Powder River, such that groundwater changes might effect it, the appropriate baseline parameters to be measured will be mutually established with the State of Wyoming.

NRC response

This list of parameters is from WMC's Environmental Report (Table 7.1). The text (p. 137) states that surface-water baseline will be consistent with this table.

Baseline is intended to characterize the preoperational environment, thereby providing a basis for determining the actual impact of the operations.

31. Wyoming Mineral Corporation comment

Table 8.4 (page 8-4). (Clarification). WMC proposes that the indicated sampling of the yellow-cake dryer stack (if drying is performed) be revised to read "Samples representative of a 24-hour release rate shall be collected from the exhaust stack of the calciner scrubber during normal operations of this equipment on a monthly basis." This requirement is consistent with the WMC application and current NRC practice.

In view of the requirements elsewhere that WMC maintain a liquid seal over the pond precipitates and that we monitor pond radiation levels, we see no justification for routinely sampling sediments. WMC will make the measurements necessary to properly protect personnel from radioactive material exposures prior to deliberately processing exposed sediments.

The proposal that monthly air samples be measured for the presence of radon-222 does not appear justified. The quantitative values of radon measured at the air monitoring sites, if any, would be only very slightly above background. The equipment required to detect these levels would be expensive, and if not portable, would have to be provided for each site. In view of the difficulty and expense involved in making measurements of no real value, WMC urges that this parameter be deleted.

NRC response

Essentially all airborne radioactive particulate releases from the proposed activities will be associated with the yellow cake drying and packaging operations (if drying is performed). Frequent measurements of this effluent stream at the point of release, the dryer stack, to determine quantities and concentrations released permit less extensive environmental monitoring. This may be contrasted with conventional uranium mills where environmental sampling assumes greater importance because of the difficulty or impracticability of direct measurement of sources of radioactive effluent to the environment (i.e., tailings piles and ore storage pads). Table 8.4 has been revised to require a 24-hr sample collected weekly during routine drying and packaging activities for uranium analysis. The staff believes that this sampling program will adequately characterize this effluent, with the following addition: radium-226 and thorium-230 concentrations are expected to be very low in the yellow cake product and therefore difficult to measure in the effluent stream. To determine the quantities of these radionuclides released through the dryer stack, periodic analyses will be required of the yellow cake product. The determined ratios of radium and thorium to uranium will then be applied to the uranium stack analyses for effluent data recording and reporting purposes.

With respect to the comment on sediment samples from the evaporation ponds, the staff agrees, and this requirement has been deleted from Table 8.4. However, it is suggested that periodic analyses be made of calcite wastes for uranium, radium and thorium.

The staff also agrees that the projected quantities and release rates of radon-222 do not justify environmental sampling. However, the applicant will be required to develop and conduct a measurement program to cover both the well field control buildings and the recovery plant to enable a quantitative estimate of the radon source term (uries per year).

Table 8.4 has been further modified to require annual analysis of vegetation samples, as well as soil, for radium-226 and lead-210 (the most important contributors to the ingestion pathway). In-plant air sampling for occupational exposure purposes has been deleted from Table 8.4 and is discussed in an added section on occupational exposure (Sect. 6.7.5).

32. Wyoming Mineral Corporation comment

Subparagraph 8.2.3.1 (page 8-5). (New information). WMC wishes to establish clearly that the State of Wyoming "Supportive Information Handout" is purely a recommendation. We feel that our program at Irigaray precedes the publication of that document. We also wish to point out that a subsequent Guideline, dated March 20, 1978, revises the criteria for the placement of monitor wells, stating "monitoring wells in the production zone should be located no more than sixty (60) meters from the boundaries of a given mine area.... Monitoring wells in the production zone

may be placed at distances greater than sixty (60) meters from the mine area if reliable hydro-logic data indicate that greater distances are necessary, or if trend wells are utilized between the mine area perimeter and the monitoring well. When trend wells are used, monitoring wells should not be placed at a distance greater than one hundred twenty (120) meters. Monitoring wells in non-production zones should be centrally located within the mine area."

WMC proposes to locate monitoring wells in accordance with this latest guide.

NRC response

The text has been revised to reflect the June 1, 1978 guidelines.

33. Wyoming Mineral Corporation comment

Subparagraph 8.2.3.3 (page 8-5). (Clarification). WMC takes exception to the proposed arbitrary requirement to provide deep and shallow monitor wells on a "per acre" basis. Deep and shallow monitoring wells will be located and provided as determined to be necessary based on data from electric logs.

NRC response

The integrity of the confining units, particularly the overlying unit, is of primary concern considering the number of injection and production wells that will be drilled. The potential for leakage as a result of poor well completion or casing failure is a relevant concern. Since monitor wells must effectively act as a control to contain the leach solution within the production zone, the staff's position is very reasonable and is consistent with the requirements of the State of Wyoming.

34. Wyoming Mineral Corporation comment

Subparagraph 8.2.3.4 (page 8-5). (Clarification). WMC proposes routinely to sample monitor wells only for water depth, conductivity, chloride, alkalinity and sulfate in accordance with the revised mine permit application submitted to the State of Wyoming.

The purpose of sampling the monitor wells is to detect an excursion. General industry experience with in-situ mining operations using an ammonium bicarbonate lixiviant shows that the earliest indicators of the presence of the lixiviant at a monitoring location are conductivity, chloride and/or total alkalinity (as HCO_3). Therefore, routine sampling for any other parameters is superfluous.

In the event that an excursion is indicated by the sampling plan described above, WMC would go to wider sampling, possibly including arsenic and/or selenium, in order to determine the extent and seriousness of the postulated problem.

NRC Response

Section 8.2.3.4 has been revised to recognize the requirements specified by the permit and license to mine approved by the State of Wyoming August 18, 1978.

35. Wyoming Mineral Corporation comment

Subparagraph 8.2.3.5 (page 8-6). (New information). The control limits presently agreed to between WMC and the State of Wyoming are 15% above baseline for HCO_3 , 10% above baseline for conductivity, and 5 ppm above baseline for chloride. If proven unworkable, these UCL's are subject to revision with the approval of the appropriate state agency.

These limits are more realistic and not subject to possible false alarms to the extent that the maximum observed concentration criteria (as proposed in the DEIS) would be. The geohydrologic distribution throughout the aquifer is such that natural variations in the concentrations values for the chemicals of interest would surely occur. It is very likely that higher concentrations exist and would be swept to the sampling location. When coupled with sampling and analytical variability, a percentage of values in violation of UCL's as proposed in the DEIS would be statistically inevitable. Such high readings would not be valid indications of an excursion, but would require extensive additional sampling to provide assurance of that fact.

NRC response

Section 8.2.3.5 has been revised to reflect the requirements of the permit and license to mine approved by the State of Wyoming August 18, 1978.

36. Wyoming Mineral Corporation comment

Subparagraph 8.2.3.6 (page 8-6). (Amplification). WMC recommends that the NRC restrict its discussion of corrective actions in the event of an excursion to an evaluation of the practicability of effective corrective action.

Details of the procedures to be followed, the timing, and the reporting requirements have been, and rightly should be established in accordance with the requirements of the State of Wyoming. In particular, certain well drilling to be performed by WMC must first be reviewed and approved by the Wyoming State Engineer's Office.

WMC would be happy to provide the staff with a copy of any generally available reports transmitted to the state agencies, to the extent that NRC is interested in the phenomena of excursions, and as a courtesy by WMC.

NRC response

The text has been revised to enable WMC adequate time to obtain approval from the State Engineer's Office for well drilling. In context with its licensing activities and responsibilities under NEPA, the NRC will require the reporting of excursions as specified in the DES.

37. Wyoming Mineral Corporation comment

Subparagraph 8.2.3.7 (page 8-7). (New information). WMC requests that this discussion be revised to state that after restoration has been completed, the field will be sampled every 45 days for a six month period to verify restoration stabilization. Such a program provides the assurance necessary to satisfy the State of Wyoming.

NRC response

Section 8.2.3.7, postrestoration monitoring, refers only to the first mining unit to be restored. This comment is appropriate to Sect. 8.2.3.8 and has been included in the text.

38. Wyoming Mineral Corporation comment

Subparagraph 8.2.3.8 (page 8-7). (Clarification). This should be revised to state that after mining completion, selected monitor wells will be sampled quarterly until restoration is complete. The reference to the "life of the Irigaray project" is objectionable because sequential surface reclamation will be undertaken following sequential aquifer restoration. As a result, WMC plans to plug and seal all wells in, and to revegetate, some of the early mining areas while we are still mining and/or restoring others. The commencement of surface reclamation will mark the termination of all subsurface activities.

NRC response

The three wells will only result in about 6 sq ft of disturbed area, which should not affect reclamation.

The text on p. 8-7 of the DES has been revised to indicate that these wells should be available throughout the duration of the license period.



WYOMING
EXECUTIVE DEPARTMENT
CHEYENNE

ED HERSCHLER
GOVERNOR

August 8, 1978

Leland C. Rouse, Chief
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Irigaray Uranium Solution
Mining Project

Dear Mr. Rouse:

Attached are additional comments regarding the
Irigaray Solution Mining Project. Please incorporate
these comments into the final environmental impact
statement.

Thank you.

State Planning Coordinator's
Office

CO



THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Department of Environmental Quality

Administration

TELEPHONE 307-777-7391

CHEYENNE, WYOMING 82002

HATHAWAY BUILDING

TO: State Planning Coordinators Office

FROM: Ardelle Kissler, Secretary to
Robert E. Sundin, DEQ Director

DATE: August 2, 1978

SUBJECT: Comments on "Draft Environmental Statement Related to
Operation of Wyoming Mineral Corporation Irigaray Solution
Mining Project"; April 1978, Docket No. 40-8502 (NUREG-0399).

Enclosed are comments from the DEQ Air and Water Quality Divisions. As soon
as the comments are received from the Land Quality Division, they will be
forwarded to your office, along with the plan.

A-85



THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Department of Environmental Quality

AIR QUALITY DIVISION


HATHAWAY BUILDING

CHEYENNE, WYOMING 82002

TELEPHONE 777-7391

MEMORANDUM

TO: Robert E. Sundin, Director
Dept. of Environmental Quality

FROM: Randolph Wood, Administrator 
Air Quality Division

DATE: June 21, 1978

SUBJECT: Comments on Wyoming Mineral Corporation
Irigaray Solution Mining Project
Environmental Statement

I have reviewed the subject environmental statement and find that the Air Quality discussions are generally adequate.

I would also like to point out that an Air Quality Construction Permit will be required prior to start of construction.

A-86



THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Department of Environmental Quality
Water Quality Division

HATHAWAY BUILDING

CHEYENNE, WYOMING 82002

TELEPHONE 307 777-7781

MEMORANDUM

TO: Robert E. Sundin
Director
Dept. of Environmental Quality

THROUGH: William L. Garland *WLG*
Administrator
Water Quality Division

FROM: A. J. Mancini *AJM*
Environmental Engineer
Water Quality Division

DATE: July 31, 1978

SUBJECT: Wyoming Minerals Irigaray Project

Early last month I submitted, as a memorandum, comments on the NRC draft EIS related to the Irigaray Solution Mining Project in Johnson County. I think it very appropriate for Water Quality Division to comment on this project, because the environmental impact on groundwater will be significant.

Some of us in Water Quality Division have had an opportunity to attend a seminar on solution mining, at the invitation of Wyoming Minerals; we have not been involved in any technical discussions with Wyoming Minerals concerning the Irigaray Project.

There are, in my opinion, several serious considerations which should be addressed by Water Quality Division before a permit or license for continuing operators should be granted, even though Chapters VIII, IX, and X of Water Quality Rules and Regulations are not yet in effect.

Considerations which should be addressed at this time:

1. The most important consideration is an acceptable restoration limit for ammonia. Wyoming Minerals (and NRC) evidently believe that a restoration procedure which results in a residual concentration 20-50 ppm (mg/l) ammonia in the groundwater is acceptable. I do not believe at this time that such a limit (50 mg/l) should be adopted as a standard for all

R. E. Sundin
July 31, 1978
Page 2

groundwaters. This concentration would be much too high for any water which is or could be a public water supply, and may not be advisable for other water supplies. It would be better for Chapter VIII regulations to be adopted before we attempt to establish arbitrary groundwater quality standards for ammonia or any other parameter. Incidentally, Wyoming Minerals has recognized that "the esthetic character, taste and odor of the water may be degraded due to the presence of 20-50 ppm NH_4^+ ".

2. The overall restoration philosophy of Wyoming Minerals is somewhat askew, relative to the philosophy of the proposed Chapter VIII regulations: Wyoming Minerals would restore a groundwater use, whereas the proposed regulations would require an intent to restore groundwater quality. In many cases a groundwater could be restored to a lesser quality and still be adequate for a pre-existing use. I realize that restoration criteria may be set a little higher than baseline; but there still is a significant difference between restoring quality and restoring use.

3. Wyoming Minerals is quick to point out that a particular groundwater is unfit for either domestic or livestock consumption; this kind of determination should not be based on Wyoming Minerals' judgement. Rather, it should be a decision of DEQ based on the provisions of Chapter VIII.

4. Monitoring procedures, excursion control, corrective action procedures and reporting are all important facets of the solution mining program. I think it is important that Wyoming Minerals knows what DEQ's requirements are, from the viewpoint of each Division. There will be more adequate consideration and evaluation, from the viewpoint of WQD's responsibilities and authorities, if the provisions of Chapters VIII, IX and X can be applied, and if Wyoming Minerals will comply with the applicable WQD requirements.

I feel that: (1) The Irigaray Project should remain dormant at least until the requirements of Chapters VIII, IX, and X become official and Wyoming Minerals complies with all applicable WQD permit requirements; or (2) Before operations (testing programs) resume, professional/technical people of Wyoming Minerals should meet with personnel of WQD and LQD for the purpose of designing a mutually acceptable program which will address the concerns expressed in this memorandum. The technical program would be subject to legal scrutiny and administrative approval after professional acceptance.

If there is a strictly technical meeting, Wyoming Minerals should know that WQD will want more facts on the potential effects of residual ammonia in groundwater.

cc: Jake Strohmam
Mike Weber, Attorney General's Office
State Planning Coordinator

AJM/sp

A-87



THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Department of Environmental Quality
Water Quality Division

HATHAWAY BUILDING

CHEYENNE, WYOMING 82002

TELEPHONE 307 777-7781

M E M O R A N D U M

TO: Robert E. Sundin
Director
Dept. of Environmental Quality

FROM: A. J. Mancini, Environmental Engineer, WQD

DATE: June 6, 1978

SUBJECT: Comments on "Draft Environmental Statement Related to
Operation of Wyoming Mineral Corporation Irigaray
Solution Mining Project"; April 1978, Docket No. 40-8502
(NUREG-0399).

Because of the concern expressed by the DEQ, the size of the mining area has been reduced from 50 acres as described in the subject report, to a smaller 30-acre site. Future operations supposedly will depend on the ability of WMC to comply with requirements of DEQ.

Section 1.4, Status of Reviews and Actions by State Agencies, probably should include reference to the construction of waste disposal or treatment ponds and/or the disposal of liquid wastes and the authorities of the Water Quality Division.

WQD is not certain at this time that the affected groundwater can be restored satisfactorily, and does not agree with the statement in Section 5.1, Restoration, which reads, "Although restoration technology is currently in the developmental stage, test results to date indicate that satisfactory levels of restoration can be achieved." The restoration level for ammonia has not yet proven to be satisfactory from WQD's viewpoint.

It is stated in Section 5.1.1, Restoration Criteria, that, "The quality of the groundwater is such that the water is unfit for either domestic or livestock consumption." This is a broad generalization based on levels of specific constituents, and is not appropos; available information indicates that the average baseline quality of the groundwater is better than what would be inferred from reading this section.

Memo
Mr. Sundin
June 6, 1978

A groundwater sweep test is reported on page 5-2. The test involved the use of a "hydraulic fence". Elsewhere a "water fence" is mentioned. The use of either terminology without further description leaves a lot to the imagination. Usable descriptions should be provided.

One could infer, after reading page 5-7, that the NRC staff believes that a restoration procedure which leaves a residual concentration of 20-50 ppm (mg/l) ammonia in the groundwater is acceptable. WQD thinks this is premature judgement on the part of NRC and does not agree that a residual ammonia concentration of 20-50 mg/l should be considered acceptable at this time.

In Section 8.2.1, Waste Pond Monitoring, it is stated that ponds will be monitored monthly to detect leaks. WQD recommends that monitoring of ponds be continuous and not just monthly.

The construction of a typical monitor well (Section 8.2.3.1) is not described. WQD would require that a monitor well be constructed so that only the zone of interest or concern is monitored; that the well is permanent for the life of the project; and that the well can be pumped if required.

Section 8.2.3.5, Upper Control Limit, is ambiguous and should be clarified. To say that the UCL "should approximate the concentration consistent with the potential use of the groundwater", is one thing; to follow with the UCL "should be the maximum concentration observed at each monitor well as determined during baseline sampling", is something else. In this regard, WQD would expect a UCL to be determined from a historical series of baseline measurements. Also, WQD would not expect a UCL to be established for a water level, in contrast to Sections 8.2.3.5 and 8.2.3.4 of the subject statement.

On page 8-7 are Postrestoration (PR) Monitoring and Postmining (PM) Monitoring. Both sections are confusing (to me). PR monitoring will be required "after completion of restoration of the first production unit". What is a production unit? Is it the same as a production area, or a production cell or a production field, or any of these? Will PR monitoring be required for other production units? How long will PR monitoring be required by NRC?

The concept of PM monitoring is not clear. Is this in conjunction with, after, before or the same as PR monitoring?

The practicality of groundwater restoration is probably the most important environmental consideration of insitu uranium mining. Throughout the subject statement, reference is made to restoring a groundwater use. A groundwater could be restored to inferior quality and still be adequate for a pre-existing use. Therefore, WQD would not agree with this philosophy, but would require the restoration of groundwater quality.

AJM/sp

A-88

Office of the Governor, Wyoming (Supplemental letter, State Planning Coordinator)

NRC response

The comments have been incorporated as requested.

Department of Environmental Quality, Administration memorandum to State Planning Coordinator's Office

NRC response

None required.

Department of Environmental Quality, Air Quality Division memorandum to R. E. Sundin, Director comment

I would like to point out that an Air Quality Construction Permit will be required prior to start of construction.

NRC response

Sect. 1.4, Status of Reviews and Actions by State Agencies, notes this requirement.

Department of Environmental Quality, Water Quality Division memoranda comments

1. There are, in my opinion, several serious considerations which should be addressed by Water Quality Division before a permit or license for continuing operators should be granted, even through Chapters VIII, IX, and X of Water Quality Rules and Regulations are not yet in effect.

Considerations which should be addressed at this time:

The most important consideration is an acceptable restoration limit for ammonia. Wyoming Mineral (and NRC) evidently believe that a restoration procedure which results in a residual concentration 20-50 ppm (mg/l) ammonia in the groundwater is acceptable. I do not believe at this time that such a limit (50 mg/l) should be adopted as a standard for all groundwaters. This concentration would be much too high for any water which is or could be a public water supply, and may not be advisable for other water supplies. It would be better for Chapter VIII regulations to be adopted before we attempt to establish arbitrary groundwater quality standards for ammonia or any other parameter. Incidentally, Wyoming Mineral has recognized that "the esthetic character, taste and odor of the water may be degraded due to the presence of 20-50 ppm NH_4^+ ".

NRC response

The permit and license to mine for Wyoming Mineral (WMC) approved August 18, 1978 by the Wyoming Department of Environmental Quality included the stipulation that "The ammonia concentrations to be achieved during restoration for groundwater aquifers that may be affected by the mining operation shall be less than or equal to any future ammonia concentration standard that may be developed consistent with the 'state of the art' for in-situ mining for Wyoming groundwater." The NRC staff, in its evaluation of the proposed WMC Irigaray Project, has not suggested that a limit of 50 mg/l for ammonia be adopted as a standard for all groundwaters. The staff's position with regard to residual ammonia for the limited area involved is expressed in Section 5.1.5. By requiring early restoration of the initial production well field, the methods and results can be evaluated by the appropriate agencies to assist in the development or modification of environmental standards and requirements for uranium in situ mining with small risk to the environment. In reaching this conclusion, the staff took into account the fact that the applicant can exercise long-term surveillance of the approved, limited area, as deemed necessary by the regulating agencies.

2. Water Quality Division comment

The overall restoration philosophy of Wyoming Mineral is somewhat askew, relative to the philosophy of the proposed Chapter VIII regulations: Wyoming Mineral would restore a groundwater use, whereas the proposed regulations would require an intent to restore groundwater quality. In many cases a groundwater could be restored to a lesser quality and still be adequate for a pre-existing use. I realize that restoration criteria may be set a little higher than baseline; but there still is a significant difference between restoring quality and restoring use.

NRC response

The staff agrees that restoration should be based on the "as low as reasonably achievable" concept in addition to meeting the criterion of restoring the groundwater quality to a condition consistent with its premining use (or potential use). The results of early restoration of a production-scale well field should provide data to enable better assessment of groundwater restoration in these terms, taking into account the premining quality.

3. Water Quality Division comment

Wyoming Mineral is quick to point out that a particular groundwater is unfit for either domestic or livestock consumption; this kind of determination should not be based on Wyoming Mineral's judgement. Rather, it should be a decision of DEQ based on the provisions of Chapter VIII.

NRC response

The staff agrees that such determinations should be based on applicable Wyoming State standards or EPA standards.

4. Water Quality Division comment

Monitoring procedures, excursion control, corrective action procedures and reporting are all important facets of the solution mining program. I think it is important that Wyoming Mineral knows what DEQ's requirements are, from the viewpoint of each Division. There will be more adequate consideration and evaluation, from the viewpoint of WQD's responsibilities and authorities, if the provisions of Chapters VIII, IX and X can be applied, and if Wyoming Mineral will comply with the applicable WQD requirements.

I feel that (1) the Irigaray Project should remain dormant at least until the requirements of Chapters VIII, IX, and X become official and Wyoming Mineral complies with all applicable WQD permit requirements; or (2) Before operations (testing programs) resume, professional/technical people of Wyoming Mineral should meet with personnel of WQD and LQD for the purpose of designing a mutually acceptable program which will address the concerns expressed in this memorandum. The technical program would be subject to legal scrutiny and administrative approval after professional acceptance.

NRC response

The Wyoming Department of Environmental Quality's approval of the Wyoming Mineral permit and license to mine was given August 18, 1978 with specified conditions. The NRC staff has concluded a source material license can be issued, subject to limitations and conditions described in this document. Both the Wyoming State action and the proposed NRC action have substantially reduced the scope of the applicant's initial proposal to enable assessment of the various factors involved with small risk to the environment before expanded operations are authorized. It is the NRC staff's understanding that the proposed WQD regulations referenced (Chapters VIII, IX and X) are presently under revision based upon comments received.

5. Water Quality Division Comment

Because of the concern expressed by the DEQ, the size of the mining area has been reduced from 50 acres as described in the subject report, to a smaller 30-acre site. Future operations supposedly will depend on the ability of WMC to comply with requirements of DEQ.

NRC response

The NRC staff does not believe that the above constitutes a significant inconsistency. The approvals will enable WMC to proceed with its mining project. It is the applicant's responsibility to develop the basis and justification for expansion of the project from the initial limitations.

6. Water Quality Division comment

Section 1.4, Status of Reviews and Actions by State Agencies, probably should include reference to the construction of waste disposal or treatment ponds and/or the disposal of liquid wastes and the authorities of the Water Quality Division.

NRC response

Table 1.1 in Section 1.4 includes reference to the WQD requirements.

7. Water Quality Division comment

WQD is not certain at this time that the affected groundwater can be restored satisfactorily, and does not agree with the statement in Section 5.1, Restoration, which reads, "Although restoration technology is currently in the developmental stage, test results to date indicate that satisfactory levels of restoration can be achieved." The restoration level for ammonia has not yet proven to be satisfactory from WQD's viewpoint.

NRC response

The text has been revised to note the possible exception of the ammonia parameter. Sections 5.1.7 and 6.3.2.2 discuss this aspect.

8. Water Quality Division comment

It is stated in Section 5.1.1, Restoration Criteria, that, "The quality of the groundwater is such that the water is unfit for either domestic or livestock consumption." This is a broad generalization based on levels of specific constituents, and is not appropos; available information indicates that the average baseline quality of the groundwater is better than what would be inferred from reading this section.

NRC response

The quoted statement is in reference to the quality of groundwater in contact with the uranium ore deposit, based upon the specified analyses and compared with applicable standards (see response to comment 3). The following paragraph in Section 5.1.1 notes the water quality of the aquifer outside the ore-bearing zone is generally suitable for drinking water.

9. Water Quality Division comment

A groundwater sweep test is reported on page 5-2. The test involved the use of a "hydraulic fence". Elsewhere a "water fence" is mentioned. The use of either terminology with further description leaves a lot to the imagination. Usable descriptions should be provided.

NRC response

The expressions "hydraulic fence" and "water fence" are synonymous. They were omitted from the glossary of terms in Sect. 3.3. A "hydraulic fence" is created by injecting natural water into an ore zone area to prevent groundwater from a mining or mined zone to move out of the zone especially during the restoration phase of the project.

10. Water Quality Division comment

One could infer, after reading page 5-7, that the NRC staff believes that a restoration procedure which leaves a residual concentration of 20-50 ppm (mg/l) ammonia in the groundwater is acceptable. WQD thinks this is premature judgement on the part of NRC and does not agree that a residual ammonia concentration of 20-50 mg/l should be considered acceptable at this time.

NRC response

See response to comment 1.

11. Water Quality Division comment

In Section 8.2.1, Waste Pond Monitoring, it is stated that ponds will be monitored monthly to detect leaks. WQD recommends that monitoring of ponds be continuous and not just monthly.

NRC response

The frequency has been revised to weekly monitoring. The staff believes this to be adequate.

12. Water Quality Division comment

The construction of a typical monitor well (Section 8.2.3.1) is not described. WQD would require that a monitor well be constructed so that only the zone of interest or concern is monitored; that the well is permanent for the life of the project; and that the well can be pumped if required.

NRC response

See NRC response to EPA comment 31. The wells can be pumped (wells will be pumped for a minimum

of one casing displacement to obtain representative samples). The staff believes that the proposed monitoring after restoration of a well field as described in Sect. 8.2.3.8 is adequate. Based on the results of this monitoring, a determination can be made on the desirability of longer term monitoring.

12. Water Quality Division comment

Section 8.2.3.4, Upper Control Limit, is ambiguous and should be clarified. To say that the UCL "should approximate the concentration consistent with the potential use of the groundwater", is one thing; to follow with the UCL "should be the maximum concentration observed at each monitor well as determined during baseline sampling", is something else. In this regard, WQD would expect a UCL to be determined from a historical series of baseline measurements. Also, WQD would not expect a UCL to be established for a water level, in contrast to Sections 8.2.3.5 and 8.2.3.4 of the subject statement.

NRC response

Sections 8.2.3.4 and 8.2.3.5 have been revised to be consistent with the requirements of the Wyoming State permit and license to mine.

13. Water Quality Division comment

On page 8-7 are Postrestoration (PR) Monitoring and Postmining (PM) Monitoring. Both sections are confusing (to me). PR monitoring will be required "after completion of restoration of the first production unit". What is a production unit? Is it the same as a production area, or a production cell or a production field, or any of these? Will PR monitoring be required for other production units? How long will PR monitoring be required by NRC?

The concept of PM monitoring is not clear. Is this in conjunction with, after, before or the same as PR monitoring?

NRC response

Section 8.2.3.7 discusses a continued monitoring program after restoration of the initial production well field (unit). The term of this monitoring is indefinite and termination is subject to approval of NRC who will consult with Wyoming DEQ. It is intended, in particular, to provide data on the residual ammonia. Section 8.2.3.8 describes the proposed monitoring program after restoration of subsequent well fields. Clearly, this latter program may be modified based on the monitoring data obtained from the monitoring of the initial well field, as well as results from the particular field at the end of the 6 month period.

14. Water Quality Division comment

The practicality of groundwater restoration is probably the most important environmental consideration of in situ uranium mining. Throughout the subject statement, reference is made to restoring a groundwater use. A groundwater could be restored to inferior quality and still be adequate for a pre-existing use. Therefore, WQD would not agree with this philosophy, but would require the restoration of groundwater quality.

NRC response

See response to comment 3.

Appendix B

WELL WATER QUALITY DATA

Table B.1. Water quality assays of WMC wells and private wells, 1974

In parts per million unless otherwise indicated
The locations of the wells are shown in Fig. 2.8

Determination	W-1 ^a	W-2 ^a	W-3 ^a	W-5	W-6	W-19	W-21	W-22	W-23
Alkalinity, total (as CaCO ₃)	133	172	105	82	162	172	98	1.0	114
Alkalinity, phenolphthalein (as CaCO ₃)	0	110	1.1	4.2	0	8.3	3.3	5.0	4.5
Aluminum	0.18	0.75	0.41	0.13	0.05	0.09	0.12	0.06	0.05
Ammonia (as N)	0.1	0.29	0.1	0.18	4.2	0.1	0.1	0.19	0.15
Arsenic	0.01	0.01	0.02	0.01	0.01	0.01	0.1	0.01	0.01
Barium	0.5	0.5	0.3	0.5	0.5	0.5	0.5	0.5	0.5
Bicarbonate (as CaCO ₃)	133	0	103	74	162	158	92	100	105
Boron	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cadmium	0.008	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Calcium	375	29	19	6.9	18	5.3	3.2	4.3	4.3
Carbonate (as CaCO ₃)	0	124	2	8	0	17	7	10	9
Chloride	123	10	12	11	11	10	9	9	10
Chromium, hexavalent	0.005	0.005	0.011	0.005	0.044	0.005	0.015	0.005	0.005
Copper	0.02	0.02	0.005	0.005	0.005	0.005	0.005	0.03	0.01
Cyanide	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fluoride	1.2	0.28	0.34	0.34	0.28	1.4	0.96	0.56	0.64
Hardness, total (as CaCO ₃)	1,355	74.0	55.3	20.0	65.0	15.0	9.7	12.9	12.0
Lead	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Iron	0.04	0.02	0.02	0.06	0.94	0.06	0.42	0.03	0.03
Magnesium	140	0.01	1.9	0.05	2.7	0.98	0.38	0.52	0.49
Manganese	0.16	0.005	0.005	0.01	0.45	0.01	0.0001	0.0001	0.0001
Mercury	0.0001	0.0006	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Molybdenum	0.07	0.04	0.1	0.04	0.08	0.04	0.04	0.04	0.04
Nickel	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrate (as N)	0.06	0.03	0.05	0.03	0.08	0.03	0.03	0.03	0.03
pH	7.0	10.9	8.5	8.9	7.4	8.8	8.7	8.8	8.8
Phosphorus, total (as P)	5.4	0.32	0.9	0.15	4.0	0.05	0.05	0.05	0.05
Potassium	52	3.9	2.8	2.0	9.7	1.8	1.4	1.3	1.3
Selenium	0.010	0.007	0.018	0.005	0.07	0.005	0.005	0.005	0.007
Silver	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sodium	850	149	137	137	139	146	123	126	122
Sulfate	2,600	155	224	193	159	137	112	135	124
Total dissolved solids (180°C)	4,600	440	452	325	492	470	329	354	376
Uranium, as U (ppb)	41.0	2.2	215	1.5	1.9	1.5	1.5	1.5	1.5
Vanadium	0.009	0.009	0.042	0.014	0.024	0.001	0.001	0.001	0.001
Zinc	0.04	0.14	0.04	0.03	1.7	0.005	0.02	0.005	0.12
Gross alpha ± precision ^b	35 ± 7	660 ± 30	540 ± 30	1.9 ± 1.9	2.7 ± 1.8	0.0 ± 0.7	0.8 ± 1.1	0.4 ± 0.7	1.3 ± 1.3
Gross beta ± precision ^b	91 ± 36	450 ± 20	410 ± 30	18 ± 8	30 ± 11	3 ± 8	5 ± 7	5 ± 7	15 ± 8
Ra-226 ± precision ^b	4.1 ± 2.8	22 ± 5	141 ± 12	0.5 ± 1.2	0.0 ± 0.9	0.0 ± 0.9	0.0 ± 0.8	0.0 ± 0.8	0.1 ± 0.4
Th-230 ± precision ^b	0.0 ± 1.9	0.0 ± 2.6	45 ± 7	0.0 ± 0.6	0.0 ± 0.7	0.0 ± 0.7	0.0 ± 0.6	0.0 ± 0.6	0.0 ± 0.6

^aWyoming Mineral Corporation well.^bVariability of the radioactive disintegration process (counting error) at the 95% confidence level 1.960.

**Table B.2. Baseline groundwater quality,
Irigaray test site 517**

See Fig. 2.8 for locations of wells

Determination	Baseline value ^a
As, ppm	<0.0025
Ba, ppm	0.12
B, ppm	0.16
Cd, ppm	<0.005
Cr, ppm	0.0135
Cu, ppm	0.019
Mn, ppm	0.12
Hg, ppm	0.0028
Ni, ppm	0.018
Se, ppm	0.013
Ag, ppm	<0.005
Zn, ppm	0.003
Total dissolved solids, mg/liter	798
Pb, ppm	0.0035
U ₃ O ₈ , ppm	0.098 ^b
NH ₃ , ppm	<1.0 ^b
HCO ₃ , mg/liter	139 ^b
Cl, ppm	10.75 ^c
Gross alpha, pCi/liter	168 ± 11
Gross beta, pCi/liter	164 ± 19
Ra-226, pCi/liter	26.8 ± 5.2

^a Average baseline value (9 wells, 517-2 to -6, M1 to M4)
taken as a once-only sample without variability.

^b Well baseline value (5 wells, M1 to M5).

^c Well baseline value (4 wells; W1 to W4).

Table B-3. Water quality data, Section 9 pilot-scale well field

Table represents mean values with estimate of standard deviation with $N = 5$. Samples taken from 11/9/76 to 2/24/77.

< indicates all data below detectable limits. All data reported as parts per million or milligrams per liter unless otherwise indicated.

	Trend well ^a zone (approximately 200 ft away from production well zone)					Production well ^a zone (mineralized zone)				Monitor well ^a zone (approximately 450–700 ft away from production well zone)				
	T1	T2	T3	T5	T6	P3	P4	P5	P10	M1	M2	M3	M4	M5
NH ₄	<0.2	0.24 ± 0.07	<0.2	<0.2	<0.2	0.18 ± 0.05	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.24 ± 0.07
As	0.01 ± .001	0.01 ± .002	<.01	.01	<.010	0.10 ± 0.01	.09 ± .01	<.01	<.010	<.010	.010	.01 ± .002	.01 ± .01	.01 ± .00
Ba	0.01 ± .0004	0.02 ± .003	<.01	.02	.01	0.01 ± 3.2	.02 ± .01	0.03 ± 0.01	.02 ± .004	.02 ± .01	.02 ± .01	.02 ± .02	.02 ± .01	.04 ± .02
HCO ₃	89.5 ± 10.0	9.1 ± 4.8	66.8 ± 5.5	67.4 ± 14.6	80.3 ± 5.4	80.70 ± 12.16	90.5 ± 18.6	38.9 ± 27.9	86.1 ± 11.0	42.1 ± 57.2	68.2 ± 27.0	92.1 ± 3.9	44.3 ± 40.2	72.5 ± 21
B	0.05 ± .01	0.02 ± 0.01	0.05 ± 0.01	.05 ± .01	.05 ± .01	0.12 ± 0.07	.10 ± .02	0.10 ± 0.03	.10 ± .04	.06 ± .02	.07 ± .02	.06 ± .01	.05 ± .02	.05 ± .02
Cd	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Ca	7.0 ± 0.8	1.9 ± 0.74	5.2 ± 0.9	5.1 ± 1.3	6.7 ± .3	7.88 ± 1.15	10.5 ± 2.4	2.8 ± 1.77	7.5 ± 1.0	3.4 ± 2.5	3.0 ± 1.7	4.5 ± .9	3.8 ± 3.0	6.5 ± .9
CO ₃	4.1 ± 3.5	17.0 ± 15.8	9.5 ± 8.6	11.2 ± 5.9	6.9 ± 7.0	5.93 ± 6.90	5.3 ± 4.9	19.4 ± 8.29	4.2 ± 5.5	18.8 ± 5.7	4.0 ± 11.2	6.1 ± 6.8	14.0 ± 7.7	4.1 ± 6.0
Cl	11.4 ± 1.1	12.1 ± 1.5	12.2 ± 1.3	13.2 ± 1.9	12.7 ± 1.5	11.62 ± 1.84	9.7 ± 4.8	11.94 ± 1.83	12.5 ± 2.1	17.0 ± 7.2	12.6 ± 1.0	12.1 ± 1.3	12.4 ± 1.4	17.6 ± 9.
Cr	<.002	<.002	.002 ± .001	<.002	<.002	<.002	<.002	.004	.004	<.002	<.002	<.002	<.002	.003 ± 0
Conductivity ^b	547 ± 45.6	647 ± 51	624 ± 68	595 ± 30.4	620 ± 60	613 ± 6.5	613 ± 56.7	618 ± 16.7	589 ± 10.3	685 ± 74	624 ± 28	571 ± 25	607 ± 41	610 ± 25
Cu	.005 ± .001	.006 ± .002	.08 ± 0.14	<.005	<.005	<.005	.01 ± .002	.006 ± .002	<.005	.006 ± .002	<.005	<.005	<.005	.01 ± .00
F	.25 ± .05	0.24 ± .03	.28 ± .05	.31 ± .04	.25 ± .03	.38 ± .20	.33 ± .02	0.28 ± .02	.29 ± .03	0.23 ± .04	0.29 ± .01	.28 ± .04	.23 ± .01	.22 ± .03
Gross alpha ^c	34.7 ± 39.0	1.7 ± 11.0	5.2 ± 4.3	4.3 ± 3.9	5.3 ± 7.4	1496 ± 462	6341 ± 3353	122.4 ± 139.2	389 ± 202	4.0 ± 4.3	2.9 ± 3.4	19.4 ± 14.2	3.5 ± 5.5	4.4 ± 6.5
Gross beta ^c	69.1 ± 101.3	107.3 ± 167.1	100.4 ± 137.3	81.2 ± 114.8	39.8 ± 85.1	493.3 ± 477.3	1644 ± 1621	117.8 ± 208.4	143.6 ± 186.8	65.9 ± 104.8	63.2 ± 123.8	66.6 ± 126.0	80.4 ± 160.0	102.0 ± 1
CaCO ₃	90.3 ± 1.5	95.4 ± 5.4	81.3 ± 2.1	91.3 ± 2.2	93.1 ± 4.9	93.9 ± 2.8	102.2 ± 3.6	88.9 ± 4.9	93.9 ± 2.8	97.9 ± 5.4	107.9 ± 13.0	93.7 ± 6.4	87.1 ± 2.5	96.2 ± 12
Fe	0.15 ± 0.08	0.13 ± .07	0.21 ± 0.12	.12 ± .10	.10 ± .02	.30 ± .22	.21 ± .25	0.18 ± 0.11	1.05 ± .73	0.19 ± 0.11	.12 ± .05	.12 ± .06	.09 ± .08	.38 ± .32
Pb	<.002	.003 ± .003	<.002	.004 ± .002	.02 ± .04	.006 ± .003	<.002	<.002	.004 ± .003	.01 ± .02	.003 ± .002	.01 ± .004	.003 ± .002	.004 ± 0
Mg	1.01 ± 0.11	0.2 ± .08	0.39 ± 0.08	.51 ± .16	.72 ± .03	.80 ± 0	1.0 ± .14	0.14 ± 0.08	1.00 ± .14	.27 ± .23	.38 ± .17	.51 ± .12	.33 ± .27	.48 ± .26
Mn	<.025	<.025	<.025	<.025	<.025	<.025	<.025	<.025	.03 ± .01	<.025	<.025	<.025	<.025	<.025
Hg	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002
Mo	<.02	<.02	<.02	<.02	<.02	<.02	.02 ± .01	<.02	<.02	.03 ± .01	<.02	<.02	<.02	<.02
Ni	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
NO ₃	0.54 ± 0.14	0.35 ± 0.10	0.32 ± 0.14	.91 ± 1.35	.40 ± .07	.40 ± .10	0.58 ± 0.10	0.32 ± 0.09	.38 ± .08	.55 ± .19	.57 ± .25	.53 ± .27	.42 ± .14	.78 ± .65
NO ₂	0.29 ± 0.24	<.02	0.13 ± 0.22	.11 ± .18	.31 ± .21	.08 ± .12	<.02	<.02	.08 ± .11	<.02	.03 ± .02	.13 ± .23	.04 ± .03	<.02
pH	8.71 ± 0.16	10.22 ± 0.97	9.04 ± 0.45	9.13 ± 0.45	8.78 ± .28	8.65 ± 0.27	8.79 ± 0.26	9.94 ± 0.43	8.59 ± .35	9.80 ± 1.00	9.31 ± .74	8.69 ± .31	9.51 ± .81	8.91 ± 1.
K	1.6 ± 0.2	5.6 ± 1.00	2.1 ± 0.3	1.9 ± 0.1	1.7 ± 0.1	2.3 ± .2	2.2 ± .3	4.3 ± 0.89	1.9 ± 0.3	3.9 ± 1.6	2.0 ± .40	2.0 ± .9	2.3 ± .6	2.5 ± 2.2
Ra-226 ^c	12.1 ± 12.0	3.0 ± 1.8	.8 ± .8	2.61 ± 1.7	0.4 ± 0.2	57.8 ± 15.0	144.3 ± 56.	23.5 ± 3.0	28 ± 8.4	6.8 ± 7.4	.7 ± .7	1.4 ± .9	.3 ± .3	1.6 ± 3.1
Se	<.010	<.010	<.01	<.01	<.01	.060 ± .08	0.73 ± 0.84	.088 ± .090	.027 ± .03	.02 ± .01	.02 ± .01	<.010	<.010	<.010
Si	2.74 ± 1.63	3.63 ± 0.43	3.70 ± 0.23	3.60 ± 0.21	3.54 ± 0.30	3.81 ± .06	4.38 ± 0.17	3.61 ± 0.38	3.54 ± .20	3.75 ± .06	3.86 ± .46	3.54 ± .41	3.73 ± .42	3.55 ± 0.
Ag	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
Na	129 ± 5.8	128 ± 5.3	126 ± 3.4	121 ± 6.5	129 ± 5.3	128.5 ± 3.9	131 ± 9.4	127.5 ± 2.1	126.0 ± 4.2	130 ± 2.2	127.8 ± 4.4	119.2 ± 4.5	123 ± 2.4	121.0 ± 2
SO ₄	182 ± 8.2	209 ± 28.3	181.2 ± 3.3	169.5 ± 10.1	187.6 ± 6.7	193.3 ± 6.2	204.8 ± 4.1	207 ± 23.4	188.0 ± 6.2	173.3 ± 41.2	167.0 ± 6.7	160.1 ± 2.9	188 ± 14.5	178.3 ± 8
Total dissolved solids	355 ± 26.8	340 ± 37	356 ± 20.4	356 ± 36.3	362.4 ± 29.2	376 ± 15.1	399.5 ± 25.7	340 ± 23.8	382 ± 23.2	393 ± 8.8	361 ± 22.6	333 ± 24.3	330 ± 24.3	364 ± 26
Th-230 ^b	0.2 ± .1	0.15 ± 0.17	0.3 ± 0.2	0.2 ± 0.1	.5 ± .4	1.0 ± .42	9.0 ± 14.7	0.2 ± 0.2	3.3 ± 3.3	0.9 ± 1.6	.1 ± .08	.23 ± .45	.1	.08 ± .05
Y	<.05	<.05	<.05	<.05	<.05	.06 ± .02	.34 ± .15	0.10 ± 0.01	.06 ± .01	<.05	<.05	<.05	<.05	<.05
U ₃ O ₈	0.08 ± .05	0.02 ± 0.02	0.02 ± 0.01	.02 ± .01	.01 ± .01	3.85 ± 0.88	13.57 ± 3.79	0.39 ± 0.12	1.16 ± 0.33	.05 ± .02	.05 ± .04	.10 ± .08	.04 ± .04	.02 ± .004
Zn	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	.02 ± .01	.02 ± .01	.02 ± .01	.02 ± .01

^a Well locations are shown in Fig. 4.4.^b Micromhos per centimeter.^c Picocuries per liter.

Appendix C

BIOLOGIC STUDY CONDUCTED FOR
WYOMING MINERAL CORPORATION

May, 1975

To: Wyoming Mineral Corporation
From: Dr. Jack C. Turner, Environmental Consultant
Subject: Report of Vertebrate Fauna, N. E. Sussex Site

INTRODUCTION

This report is concerned with a survey of the terrestrial vertebrate animals living within the sphere of influence of the proposed Wyoming Mineral Corporation mining site. The area is located in southeast Johnson County, Wyoming, in T44N, R77W approximately 11 miles NE of Sussex and 5 miles E of the Powder River.

Field studies commenced late November and extended through the middle of April. A total of 13 field days (10-15 hrs/day) were spent at 3 different time intervals during the study period. Field investigations were conducted from two to four consecutive days each visit to the study area.

I wish to acknowledge the cooperation of the Wyoming Game and Fish for certain information provided.

Scientific nomenclature and other terminology is according to the following authorities:

Long, C. A., 1965. The Mammals of Wyoming.
University of Kansas Publication, Museum
of Natural History 14(18): 493-758.

American Ornithologist Union, 1957. Check-list
of North American Birds. 5th Edition, and
A.O.U. 1973. Thirty-second supplement to
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of North American Birds, Auk, 90:411-419.

Baxter, G. T., 1947. The Amphibians and Reptiles
of Wyoming. Wyoming Wildlife, August and October.

Field Procedure

Transect trapping for rodents was done in the township. Transects were 300 meters long with two museum special traps set at 10 meter intervals. Each transect was trapped for two consecutive 24 hour periods for a total of 120 trap-nights per transect. Twelve transects consisting of 1440 trap-nights were trapped during the study period. Traps were baited with a mixture of peanut-butter, rolled oats, bacon grease and velveeta cheese. Transects were dispersed throughout the study area, most of which were placed into the specialized habitats of the study area. These areas included: ravine bottoms, rocky outcroppings, areas in which big sagebrush (*Artemisia tridentata*) predominated and areas of grass prairie.

General observations were made for all vertebrates on the study area. The study area was traversed on foot at least once each visit. Animal sign, feces, tracks, calls or songs, skeletal remains, burrows, etc., were taken as evidence of a species' presence as well as actual sightings of the animals.

RESULTS

Small Mammals

Twenty-two species of mammals belonging to ten families (five orders) were found to occur within the study area (Table C.1). Rodents comprised the most abundant group present, being represented by five families and eleven species. The deer mouse (*Peromyscus maniculatus*) was the most frequent rodent captured and was trapped in all habitat types, rocky areas being slightly preferred. A total of 197 *Peromyscus* sp. were captured in all transects, representing 91 percent of the total (217) rodents captured. *Peromyscus* sp. comprised a major fraction of the rodent biomass.

Table C.1. Taxonomic listing of mammals occurring within T44N, R77W (excluding bats).

Species	Common Name
Order: Insectivora	
Family: Soricidae	
<i>Sorex vagrans vagrans</i>	Vagrant Shrew
Order: Lagomorpha	
Family: Leporidae	
<i>Sylvilagus auduboni baileyi</i>	Desert Cottontail
<i>Sylvilagus nuttallii grangeri</i>	Nuttall's Cottontail
<i>Lepus townsendi camparius</i>	White-tailed Jackrabbit
Order: Rodentia	
Family: Sciuridae	
<i>Spermophilus tridecemlineatus pallidus</i>	Thirteen-lined Ground Squirrel
Family: Geomyidae	
<i>Thomomys talpoides bullatus</i>	Northern Pocket Gopher
Family: Heteromyidae	
<i>Perognathus fasciatus olivaceogriseus</i>	Olive-backed Pocket Mouse
<i>Dipodomys ordi terrosus</i>	Ord's Kangaroo Rat
Family: Cricetidae	
<i>Reithrodontomys megalotis dychei</i>	Plains Harvest Mouse
<i>Peromyscus maniculatus nebrascensis</i>	Deer Mouse
<i>Onychomys leucogaster missouriensis</i>	Northern Grasshopper Mouse
<i>Neotoma cinerea orolestes</i>	Bushy-tailed Wood Rat
<i>Microtus ochrogaster haydeni</i>	Prairie Vole
Family: Erethizontidae	
<i>Erethizon dorsatum bruneri</i>	Porcupine
Order: Carnivore	
Family: Canidae	
<i>Canis latrans latrans</i>	Coyote
<i>Vulpes vulpes regalis</i>	Red Fox
Family: Mustelidae	
<i>Mustela frenata nevadensis</i>	Long-tailed Weasel
<i>Taxidea taxus taxus</i>	Badger
<i>Mephitis mephitis hudsonica</i>	Striped Skunk
Family: Felidae	
<i>Lynx rufus pallescens</i>	Bobcat
Order: Artiodactyla	
Family: Cervidae	
<i>Odocoileus hemionus hemionus</i>	Mule Deer
Family: Antilocapridae	
<i>Antilocapra americana americana</i>	Pronghorn

Rabbits were abundant within the study area. The desert cottontail (*Sylvilagus auduboni baileyi*) and Nuttall's cottontail (*Sylvilagus nuttalli grangeri*) were sympatric, however, the desert cottontail was more abundant preferring ravines. The Nuttall's cottontail was sparsely distributed in open flat lands and in the sagebrush plant community. Jackrabbits (*Lepus townsendi campestris*) occur primarily within sagebrush cover.

Pocket gophers (*Thomomys talpoides bulbatus*) were evidenced by their mound building activity. They are widely distributed over the grass land habitat of the study area.

The skeletal remains of a porcupine (*Erethizon dorsatum bruneri*) was found on a dirt road within the study area. It is doubtful a viable population of these animals exists within the study area due to the lack of suitable habitat. Perhaps single individuals migrate into the area on a random basis.

Several mammalian predators have been observed. Coyotes (*Canis latrans latrans*) and badger (*Taxidea taxus taxus*) were frequently observed as was sign of their activity. The striped skunk (*Mephitis mephitis hudsonica*) was also abundant, especially in riparian habitats. Two long-tailed weasels (*Mustela frenata nevadensis*) were trapped in association with riparian habitat. Additionally, several active burrows were found with sign identified as red fox (*Vulpes vulpes regalis*). Tracks and feces of a medium sized felid, probably those of a bobcat (*Lynx rufus pallascens*) were observed around several rocky outcroppings.

Large Mammals

Pronghorn (*Antilocapra americana americana*) were the most conspicuous component of the mammalian biota. They were distributed through the entire

study area, being concentrated in areas of sagebrush habitat. Numbers of individuals observed ranged from 32 to 142 individuals per day with an average of 75 individuals per day. The average sex ratio was 6 females per male.

Mule deer (*Odocoileus hemionus hemionus*) populations were varied. Numbers of individuals observed ranged from 7 to 22 individuals per day with an average of 10 individuals per day. Most deer occurred in groups of 1 to 5 individuals. Deer were associated with riparian habitat and at the heads of draws in sagebrush habitat.

Birds

Twenty-seven species of birds representing 13 families were observed within the study area (Table C.2). Seven species of waterfowl (Anatidae) were observed, however, they were migratory. No resident waterfowl was observed. Similarly, seven species of hawks (Accipitridae) were observed, only one golden eagle (*Aquila chrysaetos*) appeared to be resident. Two great horned owls (*Bubo virginianus*) were observed in a small cluster of cottonwood trees (*Populus sargentii*) in a ravine bottom.

Although few sage grouse (*Centrocercus urophasianus*) were observed, their droppings occurred over much of the study area. No strutting grounds were found. Meadowlarks (*Sturnella neglecta*) and horned larks (*Eremophila alpestris*) were the most widespread and abundant birds on the study area.

Ectothermic Vertebrates

Owing to season and lateness of spring snows no observations were made of frogs, toads or reptiles as they had yet to emerge. Amphibians and reptiles which may occur in the study area according to Baxter (1917)

Table C.2. Birds observed within T44N, R77W from December to May.

Species	Common Name
Family: Anatidae	
<i>Branta canadensis</i>	Canada Goose
<i>Anas platyrhynchos</i>	Mallard
<i>Anas acuta</i>	Pintail
<i>Anas strepera</i>	Gadwall
<i>Anas discors</i>	Blue-winged Teal
<i>Anas cyanoptera</i>	Cinnamon Teal
<i>Oxyra jamaicensis</i>	Ruddy Duck
Family: Cathartidae	
<i>Cathartes aura</i>	Turkey Vulture
Family: Accipitridae	
<i>Accipiter gentilis</i>	Cooper's Hawk
<i>Circus cyaneus</i>	Marsh Hawk
<i>Buteo lagopus</i>	Rough-legged Hawk
<i>Buteo regalis</i>	Ferruginous Hawk
<i>Buteo jamaicensis</i>	Red-tailed Hawk
<i>Aquila chrysaetos</i>	Golden Eagle
<i>Falco sparverius</i>	Sparrow Hawk
Family: Strigidae	
<i>Bubo virginianus</i>	Great Horned Owl
<i>Asio flammeus</i>	Short-eared Owl
Family: Tetronidae	
<i>Centrocercus urophasianus</i>	Sage Grouse
Family: Rallidae	
<i>Fulica americana</i>	American Coot
Family: Caprimulgidae	
<i>Chordeiles minor</i>	Common Night Hawk
Family: Picidae	
<i>Colaptes auratus cafer</i>	Red-shafted Flicker
Family: Alaudidae	
<i>Eremophila alpestris</i>	Horned Lark
Family: Corvidae	
<i>Corvus brachyrhynchos</i>	Crow
Family: Fringillidae	
<i>Calamospiza melanocorys</i>	Lark Bunting
<i>Poocetes gramineus</i>	Vesper Sparrow
Family: Icteridae	
<i>Sturnella neglecta</i>	Meadowlark
Family: Mimidae	
<i>Oreoscoptes montanus</i>	Sage Thrasher

are included in Table C.3.

Vegetation

There is no commercially merchantable timber within the study area. Few trees are evident and are generally confined to ravine bottoms where at least semipermanent water is available. The plains cottonwood (*Populus sargentii*) is the dominant tree cover although sparsely distributed. Some stands of willow (*Salix* sp.) also exist in riparian situations which are minimal within the study area.

Vegetative cover of the entire study area consists of a series of interdigitating sagebrush and sagebrush-grass complexes. A compilation of the major plant species observed is found in Table C.4. Vegetation observed within the study area is consistent with that found on eastern short-grass prairies of Wyoming with the possible exception of big sagebrush (*Artemisia tridentata*) being more abundant than on most grassland areas.

Area of vegetative cover varied greatly over the study area. The average cover was 57 percent based three 10 ha. plots sampled by a stratified sampling technique. Cover ranged from 0 percent to a maximum of 78 percent.

Climate

A continental climate prevails over the study area. Few days during the year are without insolation. Wide fluctuations exist in the seasonal and diurnal temperatures (ambient). Summer extremes produce temperatures above 100°F; the winter produces minimums in excess of -25°F. Precipitation varies between 7 and 19 inches with a mean of 12 inches per year (10 year average).

Table C.3. Reptiles and amphibians which may occur within T44N, R77W
(after Baxter, 1947).

Species	Common Name
Reptiles	
<i>Phrynosoma douglassi</i>	Eastern Short Horned Lizard
<i>Sceloporus undulatus</i>	Northern Prairie Lizard
<i>Pituophis melanoleucus</i>	Common Bull Snake
<i>Crotalus viridis</i>	Prairie Rattlesnake
<i>Heterodon nasicus</i>	Western Hognose Snake
<i>Coluber constrictor</i>	Blue Racer
<i>Thamnophis ordinoides</i>	Wandering Garter Snake
<i>Thamnophis radix</i>	Plains Garter Snake
<i>Thamnophis sirtalis</i>	Red-sided Garter Snake
Amphibians	
<i>Pseudacris nigrita</i>	Swamp Cricket Frog
<i>Rana pipiens</i>	Leopard Frog
<i>Scaphiopus bombifrons</i>	Central Plains Spadefoot Toad
<i>Bufo woodhousii</i>	Rocky Mountain Toad

Table C.4. Major plant species observed within T44N, R77W.

Species	Common Name
<i>Agropyron smithii</i>	Western Wheat Grass
<i>Alopecurus carolinianus</i>	Carolina Foxtail
<i>Artemisia cana</i>	Silver Sagebrush
<i>Artemisia pedatifida</i>	Birdfoot Sagewort
<i>Artemisia tridentata</i>	Big Sagebrush
<i>Atriplex argentea</i>	Trampling Sagebrush
<i>Bouteloua gracilis</i>	Blue Grama Grass
<i>Bromus tectorum</i>	Cheatgrass Brome
<i>Carex douglasii</i>	Douglas Sedge
<i>Carex filiflora</i>	Threadleaf Sedge
<i>Chrysothamnus viscidiflorus</i>	Rabbitbrush
<i>Distichlis spicata</i>	Inland Saltgrass
<i>Eleocharis acicularis</i>	Slender Spikerush
<i>Eriogonum annuum</i>	Wild Buckwheat
<i>Eriogonum ovalifolium</i>	Cushion Buckwheat
<i>Franseria discolor</i>	Skeleton-leaf Bursage
<i>Hordeum jubatum</i>	Foxtail Barley
<i>Koeleria cristata</i>	Prairie Junegrass
<i>Opuntia polyacantha</i>	Plains Prickly Pear
<i>Poa ampla</i>	Big Bluegrass
<i>Poa pratensis</i>	Kentucky Bluegrass
<i>Populus sargentii</i>	Plains Poplar
<i>Salix sp.</i>	Willow
<i>Salsola kali</i>	Russian Thistle
<i>Stipa comata</i>	Needle and Thread Grass
<i>Yucca glauca</i>	Soapweed

DISCUSSION AND SUMMARY

The study area is within the Powder River faunal subdivision of the Great Plains Faunal Area. Much of the study area is of the Transitional Life Zone with an interdispersion of the Sonoran Life Zone. The fauna observed is consistent with that expected on the basis of the habitat and cover availability.

Vegetation is primarily that of a grassland prairie with a big sagebrush intrusion, the condition of which varies with season and the availability of moisture.

Bird populations probably increase as would diversity with the onset of spring. Passerine birds would probably be the majority of the breeding bird population with meadowlarks and horned larks being the most abundant. Due to the lack of suitable habitat, waterfowl and most raptors would not breed within the study area. However, the rodent and rabbit population would probably support several hawks, owls and/or eagles.

Sage grouse may also occupy the study area in greater numbers than observed. Sign (droppings) indicate sage grouse to be dispersed over much of the study area.

There is an abundant rodent and small mammal population. The diversity of which is probably greater than measured due to prevailing winter conditions during this study.

Deer and pronghorn are abundant within the study area and contribute to both the aesthetic and recreation considerations of the available land resources. Although the use of the area by deer is perhaps seasonal, winter range is the most important aspect of deer habitat. Pronghorn use of the area is year-around, although pronghorn herds wander on and off the study area in their daily movements.

Relative to the type and magnitude of the proposed mining operation, the fauna will be effected to a greater or lesser degree. Any activity will serve to displace some component of the vertebrate fauna. Exploitation of the resources will alter the present environment by actual removal of vegetation and subsequent loss of animal populations from the construction(s) sites, through loss of habitat by construction of transportation systems and through the various impacts of mining personnel in their activities, both job related and personal.

Bird populations will be effected to the extent of surface disturbance. Since most birds require vegetation for nesting activity and minimal human encroachment, breeding populations will diminish with proximity to mining activities. Probably least effected will be ground nesting species, such as the meadowlark and horned lark, whose nesting specificity is less rigorous than most other passerine species as well as being more abundant. Again, however, man's activities can greatly (adversely) effect fledging success.

Sage grouse will be adversely effected by removal of sagebrush by the loss of cover and food. Without adequate cover for the precocious chicks, survival will diminish within the sphere of influence of mining activity. The sage grouse will probably be eliminated.

Rodent populations will be altered with an increase in man's activities. The deer mouse and thirteen-lined ground squirrel will probably be least effected owing to their high reproductive rates and relative high abundance. Possibly, mining activities could serve to increase their populations. Other rodent populations will be displaced to the extent they are restricted to a particular habitat which is being altered. In some circumstances, components

of the rodent fauna will be extirpated. This will negatively influence the raptor diversity and abundance.

Rabbits are a conspicuous component of the grassland-sagebrush habitat. Jackrabbits are intolerant of human encroachment. Additionally, hunting pressure (year-around) will increase with increased access to the area, potentially eliminating this species very quickly. Cottontail rabbits would be less adversely effected due to seasonal hunting pressure. Although sensitive to habitat changes, cottontails appear to be more adaptive and tolerant of man and his activities than do the hares.

Carnivores are effected by availability of food and, as such, tend to be wide ranging and opportunistic in feeding behavior. The effect of reduced prey items will diminish predator population, but such reductions should be less obvious with the over-all effect on carnivores being less. This assumes that predators would not be totally reduced from increased hunting and trapping pressure as a result of increased access and human population.

Big game species, pronghorn and mule deer, are intolerant of man and his activities. Such species will move away from disturbances into neighboring habitat until spacial limitations restrict such movements. With increased growth of mining operations, the subsequent influx of people and the continued removal of suitable big game habitat, pronghorn and mule deer populations could be greatly reduced. Additionally, the influx of people not only provide a harassment factor but also contribute to an increased demand for game species. The accumulative impact can serve to diminish game populations, possibly to extirpation. Such impact could be reduced through habitat rehabilitation and game management activities.

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Appendix D

DETAILED RADIOLOGICAL ASSESSMENT

When evaluated in conjunction with Sects. 4.6.5 and 6.7, the following information permits a detailed analysis of the radiological impact of the Irigaray project and permits complete review and verification by qualified radiological scientists. Calculations of radiation doses have been made for radionuclides and receptors around the site.

D.1 MODELS AND ASSUMPTIONS

AIRDOS-II, a FORTRAN computer code¹ was used to estimate individual and population doses resulting from the continuous atmospheric release of airborne radioactive materials from the normal project operations and from accidental releases. Pathways to man include (1) inhalation of radionuclides in air, (2) immersion in air containing radionuclides, (3) exposure to ground surfaces contaminated by deposited radionuclides, (4) ingestion of food produced in the area, and (5) immersion (swimming) in water subjected to surface deposition from plumes. Doses are estimated for the total body as well as for the following organs: gastrointestinal tract, bone, thyroid, lungs, muscles, kidneys, liver, spleen, testes, and ovaries. The dose to the bronchial epithelium from radon daughters is also estimated.

The area surrounding the project was divided into 16 sectors. Each sector is bounded by radial distances of 0.8, 1.6, 3.2, 4.8, 6.4, 8.0, 16, 32, 48, 64, and 80 km (0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 10, 20, 30, 40, and 50 miles) from the point of release. Human population, numbers of beef and dairy cattle, and specifications as to whether each of the areas lying outside the plant boundary is used for producing vegetable crops or is a water area are required as input data.

The first part of AIRDOS-II is an atmospheric dispersion model (AIRMOD) that estimates concentrations of radionuclides in the air at ground level and their rates of deposition on ground surfaces as a function of distance and direction from the point of release. Annual average meteorological data for Casper, Wyoming, were supplied as input for AIRMOD.

AIRMOD is interfaced with environmental models within AIRDOS-II to estimate doses to man through the five pathways. One such model is a terrestrial model (TERMOD) developed by Booth, Kaye, and Rohwer² which estimates radionuclide intakes from ingestion of radionuclides deposited on crops, soil, and pastures. Such intakes result from drinking milk and eating beef and vegetable crops.

Population doses are summarized in the output tables of AIRDOS-II. Actual population distributions were summarized from 1970 Census Bureau tape records. The computer code PANS³ provides sector summaries which correspond to the same sectors and annuli in the 16 compass directions for which χ/Q values are calculated. The population dose is calculated for each division and then summed over the entire 80-km (50-mile) radius.

The dose conversion factors for the radionuclides are based on two ICRP reports.^{4,5} The method used in estimating radiation doses is given in a reference handbook.⁶

D.2 ATMOSPHERIC DISPERSION (METEOROLOGY)

The basic equation used to estimate atmospheric transport to the terrestrial environment is Pasquill's Equation⁷ as modified by Gifford.⁸ For particulate releases, the meteorological χ/Q values are used in conjunction with dry deposition velocities and scavenging coefficients to estimate air concentrations. Radioactive decay during plume travel is taken into account in AIRDOS-II.¹ Daughters produced during plume travel must be added to the AIRDOS-II source term. Concentrations of air for each sector are used to calculate the doses via inhalation and submersion in air. Ground-surface concentrations are used for external radiation exposure. The ground deposits are also assimilated into food which, when ingested, results in an additional dose via the food-chain pathway.

The meteorological data required for the calculations are joint frequency distributions of wind velocities and directions summarized by stability class. These data are shown in Tables D.1 and D.2 for the Casper, Wyoming, meteorology.

Table D.1. Frequencies of wind directions and true average wind speeds

Casper, Wyoming, meteorological data for 1967-1971 period

Wind direction (toward)	Frequency	Wind speeds for each stability class (m/sec)						
		A	B	C	D	E	F	G
N	0.023	1.80	3.09	4.29	6.19	3.98	2.54	0.0
NNW	0.011	2.63	2.95	3.99	4.48	3.99	2.64	0.0
NW	0.018	2.83	3.13	4.06	4.89	4.04	2.97	0.0
WNW	0.028	2.83	3.18	4.23	5.35	4.13	2.74	0.0
W	0.046	2.14	2.89	4.04	5.65	4.11	2.91	0.0
WSW	0.034	1.46	2.95	4.11	5.12	4.11	3.13	0.0
SW	0.043	2.83	3.36	4.12	5.50	4.06	2.97	0.0
SSW	0.061	2.42	3.30	4.19	5.80	4.05	3.15	0.0
S	0.057	2.83	3.21	4.19	5.74	4.04	2.78	0.0
SSE	0.037	2.83	3.22	4.78	5.13	4.04	2.99	0.0
SE	0.034	0.77	3.64	4.17	6.17	4.04	3.06	0.0
ESE	0.047	2.83	3.39	4.40	6.53	4.08	2.95	0.0
E	0.115	2.60	3.22	4.92	6.77	4.15	2.90	0.0
ENE	0.167	2.42	3.54	4.81	7.31	4.21	3.00	0.0
NE	0.183	1.46	3.34	5.21	8.27	4.19	2.81	0.0
NNE	0.095	2.32	3.40	4.73	8.50	4.18	2.74	0.0

Table D.2. Frequency of atmospheric stability classes for each direction

Casper, Wyoming, meteorological data for 1967-1971 period

Sector	Fraction of time in each stability class						
	A	B	C	D	E	F	G
N	0.0090	0.1613	0.1547	0.4835	0.0848	0.1267	0.0
NNW	0.0901	0.1832	0.1473	0.3179	0.1322	0.1292	0.0
NW	0.0112	0.1381	0.1498	0.4327	0.1468	0.1214	0.0
WNW	0.0108	0.0632	0.1199	0.5325	0.1641	0.1096	0.0
W	0.0066	0.0608	0.1043	0.5709	0.1439	0.1135	0.0
WSW	0.0091	0.0366	0.0884	0.5865	0.1416	0.1378	0.0
SW	0.0071	0.0402	0.0643	0.6417	0.1313	0.1153	0.0
SSW	0.0084	0.0387	0.0584	0.6702	0.1047	0.1197	0.0
S	0.0036	0.0384	0.0691	0.5698	0.1330	0.1861	0.0
SSE	0.0083	0.0695	0.0788	0.4326	0.1598	0.2510	0.0
SE	0.0060	0.0442	0.0916	0.4620	0.1685	0.2278	0.0
ESE	0.0110	0.0437	0.0937	0.4982	0.1642	0.1892	0.0
E	0.0080	0.0371	0.0842	0.4802	0.2303	0.1600	0.0
ENE	0.0031	0.0174	0.0636	0.6527	0.1985	0.0647	0.0
NE	0.0017	0.0165	0.0400	0.8456	0.0730	0.0233	0.0
NNE	0.0043	0.0223	0.0436	0.8425	0.0547	0.0327	0.0

The χ/Q values for the residences nearest the recovery plant and well field (Irigaray and Reculosa ranches) are shown in Table D.3.

Table D.3. χ/Q values at receptor points^a
Casper, Wyoming, meteorology

Location	χ/Q value (sec/m ³)	
	Particulates	Rn-222
Irigaray Ranch		
Well field		1.26E-8
Recovery plant ^a	5.65E-9 ^b	
Reculosa Ranch		
Well field		3.67E-8
Recovery plant ^a	2.31E-8	

^aStack height is 10.7 m (35 ft).

^bRead as 5.65×10^{-9} .

D.3 CONTRIBUTION OF RADIONUCLIDES, PATHWAYS AND VARIOUS OPERATIONS TO DOSE

The amounts of radionuclides routinely released (source terms) during a year's operation of the recovery plant and well field on which annual dose calculations to the individual and the population are based are shown in Table D.4. The dose conversion factors used in the radiological assessments for the processes are shown in Table D.5.

D.4 OTHER PARAMETERS USED IN RADIOLOGICAL ASSESSMENT

Other principal parameters used in the radiological assessment of the Irigaray project are shown in Table D.6.

Table D.4. Release rates for
radionuclides from well field and
recovery plant^a

Radionuclide	Release rate (Ci/year)
Recovery plant	
U-238	1.5E-1 ^b
U-234	1.5E-1
U-235	7.0E-3
Th-230	2.6E-3
Ra-226	1.0E-4
Pb-210	1.0E-4
Bi-210	1.0E-4
Po-210	1.0E-4
Well field	
Rn-222	7.6E1

^aEstimated based on information contained in the ER, pp. 27 and 38 (5.0×10^5 lb of U_3O_8 processed per year; 1000 lb of U_3O_8 released per year from dryer stack).

^bRead as 1.5×10^{-1} .

Table D.5. Dose conversion factors used in the radiological assessment for uranium mills

Radionuclide	Dose conversion factors				
	Total body	Bone	Lungs	Kidneys	Bronchial epithelium
Yellow cake stack effluents (rems/ μ Ci)					
U-234	3.0E-1 ^a	4.9	5.8E2	1.2	
U-235	2.9E-1	4.7	5.6E2	1.0	
U-238	2.7E-1	4.5	5.1E2	1.0	
Th-230	3.1E1	1.0E3	5.7E2	3.1E2	
Ra-226	2.4E1	2.4E2	1.3E2	2.4E1	
Pb-210	9.7E-1	3.0E1	1.7E1	2.5E1	
Po-210	1.7E-1	7.1E-1	4.9E1	5.2	
Releases from combined operations (millirem/year per picocurie per cubic meter of air)					
Ra-222 and daughters					0.625

^aRead as 3.0×10^{-1} .

Table D.6. Some parameters and conditions used in the radiological assessment of the Irigaray project's uranium ore handling facilities

Parameters	Process circuit
Plant life expectancy	10 years
Plant operating time	365 days/year
Process rate	500,000 lb of U_3O_8 per year
Emission rate	1000 lb of U_3O_8 per year
Stack height (mill)	10.7 m (35 ft)

REFERENCES FOR APPENDIX D

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-5245, Oak Ridge National Laboratory, Oak Ridge, Tenn., April 1977.
2. R. S. Booth, S. V. Kaye, and P. S. Rohwer, "A Systems Analysis Methodology for Predicting Dose to Man from a Radioactively Contaminated Terrestrial Environment," pp. 877-93 in *Proceedings of the Third National Symposium on Radioecology*, vol. 2, D. J. Nelson, Ed., Report CONF-710501, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1971.
3. P. R. Coleman and A. A. Brooks, *PANS: A Program to Tally Population by Annuli and Sectors*, Report ORNL/TM-3923, Oak Ridge National Laboratory, Oak Ridge, Tenn., October 1972.
4. International Commission on Radiological Protection, *Report of Committee II on Permissible Dose for Internal Radiation*, ICRP Publication 2, Pergamon Press, New York, 1959.
5. ICRP Task Group on Lung Dynamics, "Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract," *Health Phys.* 12: 181 (1966).
6. G. G. Killough and L. R. McKay, Eds., *A Methodology for Calculating Radiation Doses from Radioactivity Releases to the Environment*, Report ORNL-4992, Oak Ridge National Laboratory, Oak Ridge, Tenn., March 1976.
7. F. Pasquill, *Meteorol. Mag.* 90: 1063 (1971).
8. F. A. Gifford, Jr., "Use of Routine Meteorological Observations for Estimating Atmospheric Dispersion," *Nucl. Saf.*, 2(4): 47 (1961).

Appendix E

BASIS FOR NRC EVALUATION OF THE PROPOSED IRIGARAY PROJECT

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 the ore (uranium) from the ground, separating uranium from the waste, and converting the uranium to a chemically stable oxide (nominally U_3O_8);
2. conversion — changing the U_3O_8 to a fluoride (UF_6), which is a solid at room temperature but becomes a gas at slightly elevated temperatures, prior to enrichment;
3. enrichment — concentrating the fissionable isotope (uranium-235) of uranium from the naturally occurring 0.7% to 2-4% 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 the fissioning of uranium and plutonium for generating steam for the turbines;
6. spent fuel reprocessing — chemical separation of fissionable and fertile values (uranium-235, uranium-238, plutonium) from fission products (waste), with concurrent separation of uranium from plutonium;
7. waste management — storage of fission products and low-level wastes resulting from reprocessing in a manner that is safe and of no threat to human health or the environment.

This cycle is portrayed in Fig. E.1.

Nuclear reactor operation converts about 75% of the fissionable isotope (uranium-235) into fission products, thereby liberating thermal energy and creating plutonium, another fissionable element, in the process. The remaining quantities of fissionable uranium (uranium-235) (about the same concentration as exists in natural uranium) and the plutonium are recoverable for reuse in the cycle.

The spent fuel removed from the reactor is stored at the reactor site and later at the reprocessing plant to "cool" the spent fuel. The radioactivity of the fuel is reduced by a factor of about ten after 150 days storage.

The reprocessing of spent fuel would produce fissionable material that could be used in combination with new (virgin) material obtained by mining and milling. In the absence of reprocessing, all replacement fuel must come from the mining and milling of uranium ore.

USE OF NUCLEAR FUEL IN REACTORS

Two types of reactors are currently used to generate essentially all of the nuclear energy sold in the United States: the boiling-water reactor (BWR) and the pressurized-water reactor (PWR). Each reactor type is operated with a fuel management scheme designed to meet the requirements of the utility operator. Different fuel management schemes result in different fuel burnup rates which, along with other design parameters, affect the quantity of residual fissionable materials and the type and amount of radioactive wastes in the spent fuel. These differences, in turn, require specific treatment processes at the reprocessing plant; thus, for maximum overall

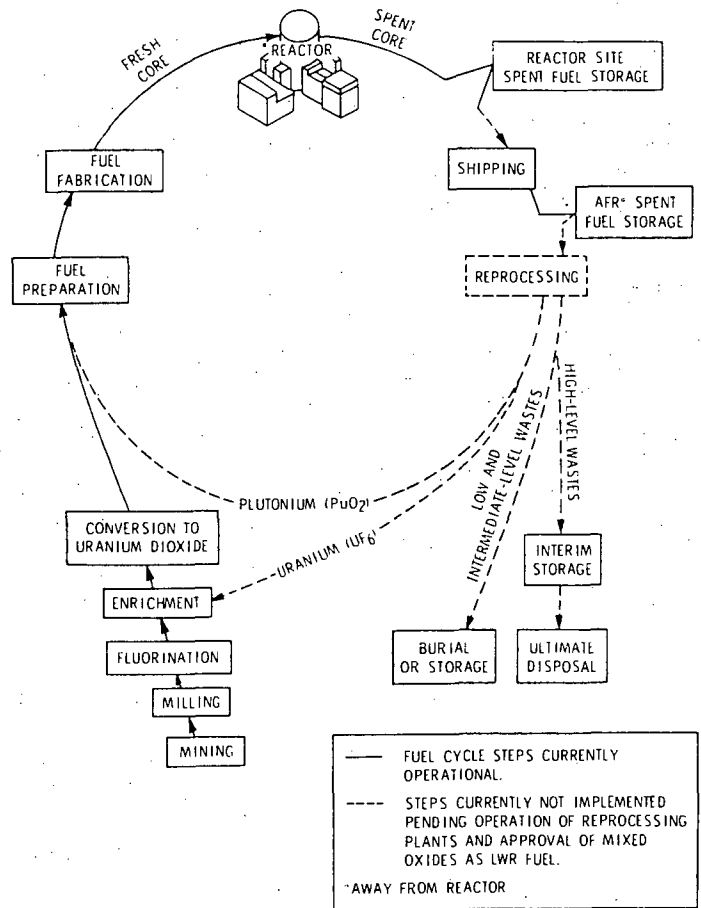


Fig. E.1. The LWR fuel cycle.

efficiency, the spent fuel is stored at reactor or reprocessing sites (or both) until a "campaign," using a process related to the individual spent fuels, can be undertaken.

No commercial reprocessing of spent fuel from power reactors has been carried out since late 1971, and only 244 metric tons of spent fuel (about two reactor core loadings, or six annual reloads) were processed between 1966 and 1971. Because the number of operating reactors has increased tenfold in the last decade and is expected to double by 1980, the need for mining and milling capacity will continue to increase. If reprocessing facilities were available to handle the spent fuel as it is generated, the rate of increase would be more moderate.

The general need for uranium as a fuel for generating electrical power in the United States over the next decade has been addressed in Sect. 1.5, item 5, of this Statement. The specific need for the proposed Irigaray project is outlined below.

Current mill capacity in the United States is 26,700 tons of ore per day. These mills operated at 85% of capacity in 1975. Uranium oxide output was approximately 11,500 lb, equivalent to slightly less than 3 lb U_3O_8 per ton of ore. The ores at the Irigaray site generally have an average U_3O_8 content below the national average.

Forecasting U_3O_8 requirements over the next decade depends entirely on estimates of the rate at which new nuclear generating capacity is installed. Estimating U_3O_8 requirements for the next five years is somewhat easier because those reactors which will need fuel in that time period are either operating now (1978) or are well along in construction and will operate prior to 1981. Table E.1 shows the cumulative nuclear capacity forecasted for Project Independence by the FEA.¹ (The staff considers this forecast, on the basis of licensing time required, to be reasonable, though somewhat optimistic.²) If a vigorously conservative position is taken that no installation of nuclear capacity will occur after 1985, the minimum need for fuel, and hence for U_3O_8 , can be computed from the data in Table E.1, on the basis of various assumptions.

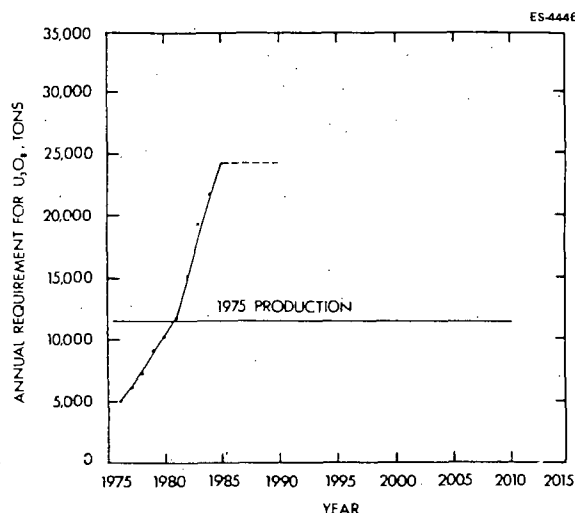
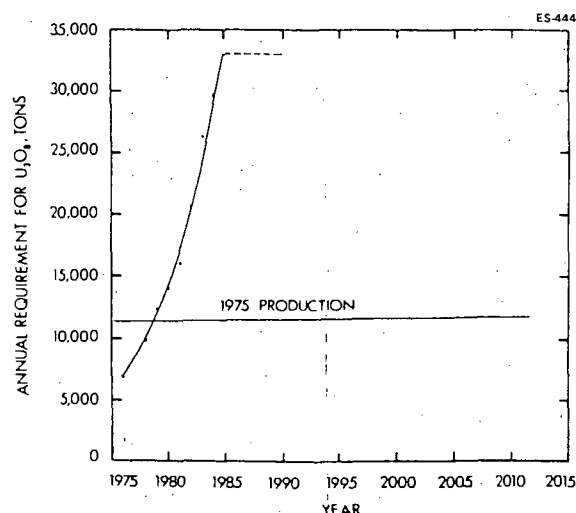
Table E.1. Forecast of nuclear capacity

Year	Gigawatts
1976	29.2
1977	35.7
1978	42.2
1979	53.2
1980	60.0
1981	68.6
1982	88.5
1983	112.5
1984	126.8
1985	142.0

Source: *National Energy Outlook, 1976*,
Federal Energy Administration, 1976.

Fuel usage in nuclear reactors depends on the power generated, which is conventionally expressed as a decimal or percent, and called "plant factor" or "capacity factor." The staff has chosen 0.6 as a minimum plant factor and 0.8 as a maximum to give a range of requirements for U_3O_8 over the next decade.*

Figure E.2 shows projected fuel requirements, assuming a minimum user rate; Fig. E.3 shows maximum requirements. At minimum usage, current milling capacity could be exceeded in 1980; maximum usage would advance the negative imbalance to 1979. Licensing the Irigaray project would help eliminate the forecasted shortage of nuclear fuel in two ways: (1) by providing additional supply and (2) by enabling further development of a mining method that can be used on small low-grade ore deposits. These deposits can not be extracted economically with conventional methods.

Fig. E.2. Minimum annual U_3O_8 requirements.Fig. E.3. Maximum annual U_3O_8 requirements.

REFERENCES FOR APPENDIX E

1. *National Energy Outlook, 1976*, Federal Energy Administration, 1976.
2. *NRC Yellow Book*, NUREG 00306, U.S. Nuclear Regulatory Commission, July 1976.

* A 1000-MWe reactor will require about 22 metric tons of uranium fuel per year at a plant factor of 0.6 and about 30 metric tons of uranium fuel at a plant factor of 0.8. For a 3% enriched fuel and 0.25 tails assay, metric tons of fuel convert to tons of U_3O_8 as follows: (metric tons of fuel)(7.9) = tons of U_3O_8 .

Appendix F
HISTORICAL AND ARCHAEOLOGICAL CLEARANCES

THE STATE OF WYOMING



ED HERSCHLER
GOVERNOR

Wyoming Recreation Commission

604 EAST 25TH STREET

CHEYENNE, WYOMING 82002

PAUL H. WESTEDT
Director
777-7695

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1507 West Spruce
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BILL NATION

2221 Van Lennen Avenue
Cheyenne 82001

October 3, 1975

Mr. Alan D. Luck, Licensing Engineer
Westinghouse Electric Corporation
3900 S. Wadsworth Boulevard
Lakewood, CO 80235

Dear Mr. Luck:

The enclosed lists, subject to frequent additions, show places in Johnson County and Carbon County, Wyoming which are either already enrolled in the National Register of Historic Places or are considered probable subjects for future enrollment therein. In either case, enrolled or likely candidates for future enrollment, they are accorded identical protection under the National Historic Preservation Act, The National Environmental Policy Act and E.O. 11593.

If we can be of further service to you please do not hesitate to ask us.

Sincerely,

Paul H. Westedt, Director
and SHPO

A handwritten signature in dark ink, appearing to read "Ned Frost".

by Ned Frost, Chief
Historic Division

PHW:NF/1m1

WYOMING 565

ran, to Fort Laramie, then north to Rawhide Buttes and Running Water. It served as a main artery to the Black Hills goldfields. Rawhide Springs, between the two stage stations, possessed water and grass in quantity and so became a favorite camping spot along the trail. The Cheyenne-Black Hills Stage Company carried mail to the Black Hills, and numerous robberies of gold and mail by armed desperadoes occurred along the route. The coming of the railroad brought an influx of settlers, but it meant the end of the stage line. Today the Running Water Station is marked only by stone ruins, but the Rawhide Buttes Station still stands and is used as a ranch.

Municipal/private

HOT SPRINGS COUNTY
Thermopolis vicinity
WOODRUFF CABIN SITE

26 miles northwest of Thermopolis,
18 miles west on County Route 0900
from the intersection with Wyo. 120
1871

The cabin of John Dwight Woodruff was the first recorded white man's dwelling in the Big Horn basin, the entire northwestern corner of Wyoming. Only the cabin site remains today, marked by a rock and mortar monument. From pictures it has been estimated that the cabin measured 12 feet wide by 20 feet long, was constructed of logs, and covered with several inches of dirt on the roof to absorb moisture. Woodruff used the cabin in the winter, spring, and early summer as a headquarters while trapping and prospecting. He eventually introduced both sheep and cattle into the area, and the cabin may have served as a ranch house. Woodruff sold his cabin in the early 1880's, and buildings of the Embar Ranch presently form a semicircle around the cabin site.

State

JOHNSON COUNTY
Story vicinity
FORT PHIL KEARNEY AND
ASSOCIATED SITES

On secondary road west of U.S. 87
1866

In and around Fort Phil Kearney the Sioux Indians fought successfully to prevent invasion of their hunting grounds by prospectors and wagon trains bound for the Montana gold fields. From 1866 to 1868 the fort was held under virtual siege as the focus of the Red Cloud War, which resulted in relinquishment of military control of the area and the abandonment of the Bozeman Trail. The natural setting of Fort Phil Kearney has suffered comparatively little encroachment. In 1938 a

peeled-log reproduction of an officers' quarters and a seven-foot slab stockade were erected here.

Multiple public/private
NHL

JOHNSON COUNTY
Sussex vicinity
FORT RENO

SE 1/4 SE 1/4 NW 1/4 sec. 33, T. 45
N., R. 78 W.
1865-1868

Fort Reno, established in August, 1865, as Fort Connor, was situated on the left bank of the Powder River. It was one of three forts (Fort Phil Kearney and Fort C. F. Smith) constructed by the Army to protect travelers along the Bozeman Trail. The Bozeman Trail ran along the eastern base of the Big Horn Mountains before turning east to Virginia City, and portions of it ran through a sacred hunting ground of the Sioux. A cottonwood stockade contained the quartermaster's and the commissary storehouses. Outside were two barracks, two officers' quarters, a post hospital, shops, teamsters' quarters, and two sutler's buildings. The fort was renamed (November, 1865) for General Jesse L. Reno, and in 1868 it was abandoned and later burned.

State

LARAMIE COUNTY
Cheyenne
ST. MARK'S EPISCOPAL CHURCH
1908 Central Avenue
1886-1888, Henry M. Congdon

St. Mark's Episcopal Church is the second structure of that name erected in Cheyenne. The first St. Mark's was built in 1868. The need for larger facilities caused the parish to embark upon a building program in the 1880's. The exterior is stone with pointed-arch windows and massive buttresses. Eleven of Wyoming's 26 governors have been members of St. Mark's congregation.

Private

LARAMIE COUNTY
Cheyenne
WYOMING GOVERNOR'S MANSION
300 E. 21st Street
1904

The Wyoming Governor's Mansion is a Georgian Revival brick house which originally contained a large drawing room and dining room, five bedrooms and a bath on the second floor, and three bedrooms and a bath on the third floor. Extensive interior remodeling was done in 1937. The Wyoming Executive Mansion has the distinction of being the first in the nation to have been occupied by a

woman, Nellie Tayloe Ross, governor from 1925 to 1927.

State

LARAMIE COUNTY
Cheyenne vicinity
FRANCIS E. WARREN AIR FORCE
BASE

Bounds against the west side of
Cheyenne, the two are roughly
separated by Int. 25

The present Air Force base was established in 1867 as Fort David A. Russell. In 1930, upon the death in office of Senator Francis E. Warren, the post was renamed in his honor. Originally the federal government used Fort Russell, located at the eastern base of the Rocky Mountains, to protect the transcontinental railroad which ran through nearby Cheyenne. When the Indian wars were over, Fort Russell was considered important enough to be made a permanent post by the War Department (1885). In 1906 it was enlarged to brigade size, and in 1947 the name was changed a second time to Francis E. Warren Air Force Base. It is presently under the control of the Strategic Air Command. All buildings reflect the growth and changing role of the post. Most are red brick.

Federal

LINCOLN COUNTY
La Barge vicinity
NAMES HILL
On the Green River, 5 miles south of
La Barge and just west of U.S. 189
19th century

Names Hill on the Green River is one of three places (Register Cliff on the North Platte and Independence Rock on the Sweetwater) along the Oregon-California Trail where emigrants carved their names or left messages and greetings for those following. In 1844 Jim Brieger, famous trapper and mountain man, left his name here. The earliest dated name is 1822, which is earlier than any dated inscription at either of the other two locations. Names Hill was a popular camping spot for westward moving emigrants.

State

NATRONA COUNTY
Casper vicinity
INDEPENDENCE ROCK
60 miles southwest of Casper on
Wyo. 220

Called "the great registry of the desert," Independence Rock was a well-known natural landmark on the Oregon Trail. This oblong mass, over 1900 feet long and 850 feet wide, lies near the Sweetwater

JOHNSON COUNTY

ASTORIAN ROUTE (HUNT PARTY).

BOZEMAN TRAIL.

CLARKE RANCH. Sec. 2, T52N, R83W.

CLOUD PEAK. T51N, R86W.

CRAZY WOMAN BATTLEFIELD. T48N, R80W.

DeSMET MONUMENT. Sec. 18, T52N, R82W.

DULL KNIFE BATTLEFIELD. Sec. 16, T45N, R83W.

FORT MCKINNEY. 3 miles west of Buffalo on U.S. 16.

FORT PHIL KEARNY. Sec. 26, T53N, R83W.

FORT RENO. Sec. 33, T45N, R78W.

FREWEN CASTLE SITE. 4 miles below Kaycee on Powder River.

HOLE-IN-THE-WALL. 12 miles west of Kaycee on Barnum Road.

HORTON RANCH. Sec. 19, T52N, R83W.

LITTLE MEDICINE WHEEL. Sec. 16, T45N, R85W.

PHILLIPS MONUMENT. Sec. 26, T53N, R83W.

PORTUGUESE HOUSES. 10.5 miles east of Kaycee on County Road 1002.

→ RENO CANTONMENT. Sec. 17, T44N, R78W.

T A RANCH. 13 miles south of Buffalo.

TRABING TRADING POST. Buffalo.

THE STATE



OF WYOMING

ED HERSCHLER
GOVERNOR

Wyoming Recreation Commission

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TELEPHONE: 766-6334PAUL H. WESTEDT
DirectorCheyenne, Wyoming 82002
777-7695

April 10, 1978

Mr. Stephen Gash
Senior Engineer
Wyoming Mineral Corp.
Exploration and Mining Division
3900 S. Wadsworth Blvd.
Lakewood, Colorado 80235 Project #WY-100-78
Antiquities 76-WY-058

Dear Mr. Gash:

Archeological investigations were conducted on April 5 of approximately 600 acres of proposed permit area for the Wyoming Minerals Irigaray Project in Sections 5, 8 and 9, T45N., R77W., Johnson County, Wyoming. The areas inspected were within the "Permit Boundary" line as delineated by the company map which you supplied to us.

No archeological materials were found during the inspection and archeological clearance is recommended for this project with the stipulation that the Office of the State Archeologist be notified immediately if any archeological materials are encountered during construction activities. A bill for services is enclosed.

Sincerely,

Thomas K. Larson,
Assistant State Archeologist

TKL/mar
cc: Jan Wilson



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUL 19 1978

FCPF:SM
40-8502

Ms. Jan L. Wilson, Acting Director
Wyoming Recreation Commission
604 East 25th Street
Cheyenne, Wyoming 82002

Dear Ms. Wilson:

In April 1978, the Nuclear Regulatory Commission published a Draft Environmental Statement (DES) related to the operation of the Wyoming Mineral Corporation's Irigaray Solution Mining Project (copy enclosed). In accordance with Section 106 of the National Historic Preservation Act and Section 800.4 of 36 CFR 800 "Procedure for the Protection of Historic and Cultural Properties," we are requesting your assistance in the identification of any properties within the area of the project's environmental impact eligible for inclusion in the National Register.

In the referenced DES, page 6-2, we stated that no archeological survey had been conducted on the site. Subsequent to the publication of the DES, we learned that an archeological survey had been conducted on the site, and that a letter (copy enclosed) had been written by Thomas Larson, Assistant State Archeologist to Steve Gash of Wyoming Mineral Corporation recommending archeological clearance for the site with stipulations.

If you have any questions regarding this matter please contact Mr. Steve Manger of my staff at 301-427-4103.

Sincerely,

A handwritten signature in cursive script, reading "Leland C. Rouse".

Leland C. Rouse, Chief
Fuel Processing & Fabrication Branch
Division of Fuel Cycle and
Material Safety

Enclosures
As stated

Note: In response to the above inquiry, the Wyoming Recreation Commission provided a copy of its letter of September 9, 1977 to the Wyoming State Clearinghouse (attached).

THE STATE



OF WYOMING

ED HEHSCHLER
GOVERNOR

Wyoming Recreation Commission

604 EAST 25TH STREET

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E. LAWSON SCHWOPE

900 Fayer Avenue
Cheyenne 82001

September 9, 1977

Mr. Dick Hartman
Wyoming State Clearinghouse
2320 Capitol
Cheyenne, Wyoming 82002

Dear Mr. Hartman:

The Wyoming State Historic Preservation Officer (SHPO) has reviewed State Identifier Number 77-139R, Environmental Report: Irigaray Project, Johnson County, Wyoming.

The SHPO comments that the Wyoming Mineral Corporation's proposal for uranium solution mining will not affect any property currently enrolled in the National Register of Historic Places, nor will it affect any property listed in the Wyoming Inventory of Historic Sites (which might qualify for future enrollment in that "Register"). The Corporation has signified its intention, should some unknown cultural value be discovered during the course of its mining activities, to immediately notify the State Archeologist and await his advice before further activity in the immediate area.

There is no cultural-value reason why this proposal should not be activated.

Sincerely,

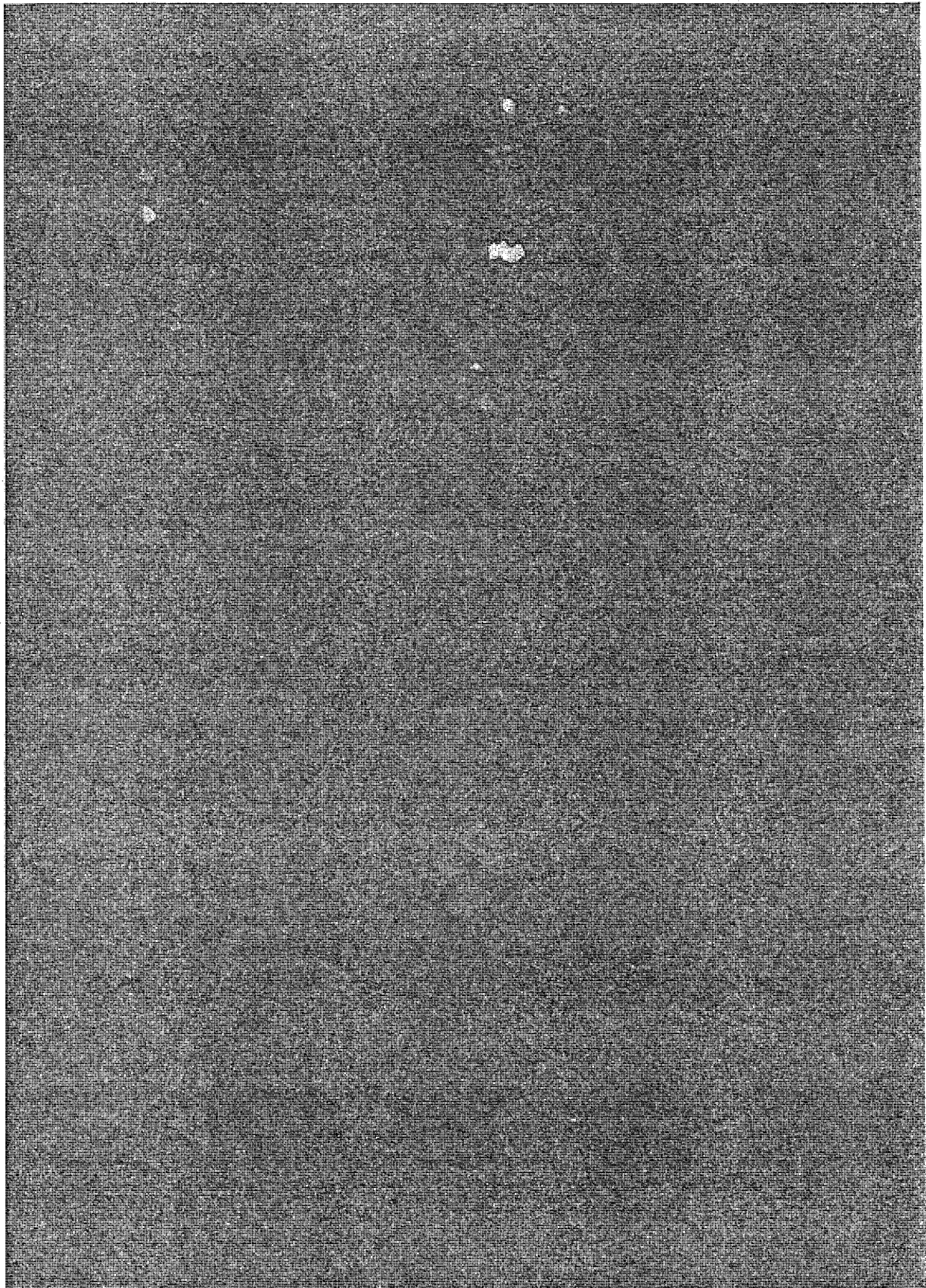
Paul H. Westedt, Director and
Wyoming State
Historic Preservation Officer
By:

Ned Frost, Chief
Historical Division

PHW/NMF/mlr

PAUL H. WESTEDT
Director
777-7635

NRC FORM 335 (7-77)		U.S. NUCLEAR REGULATORY COMMISSION BIBLIOGRAPHIC DATA SHEET		1. REPORT NUMBER (Assigned by DDC) NUREG-0481	
4. TITLE AND SUBTITLE (Add Volume No., if appropriate) Final Environmental Statement related to operation of Irigaray Uranium Solution Mining Project - Wyoming Mineral Corporation Docket 40-8502				2. (Leave blank)	
7. AUTHOR(S)				3. RECIPIENT'S ACCESSION NO.	
9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code) U. S. Nuclear Regulatory Commission Office of Nuclear Material Safety and Safeguards Washington, DC 20555				5. DATE REPORT COMPLETED MONTH _____ YEAR _____	
12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code) Same as above				DATE REPORT ISSUED MONTH _____ YEAR _____	
13. TYPE OF REPORT Final Environmental Statement				6. (Leave blank)	
15. SUPPLEMENTARY NOTES				8. (Leave blank)	
16. ABSTRACT (200 words or less) A Final Environmental Statement for Wyoming Mineral Corporation related to application for a source material license for the Irigaray uranium solution mining project to be located in Johnson County, Wyoming (Docket No. 40-8502), has been prepared by the Office of Nuclear Material Safety and Safeguards. This statement provides (1) a summary of environmental impacts and adverse effects of the proposed action, and (2) a consideration of principal alternatives. Also included are comments of governmental agencies and other organizations on the Draft Environmental Statement for this project, and staff responses to these comments. The NRC has concluded that, after weighing the environmental, economic, technical, and other benefits of the Irigaray uranium solution mining project against environmental and other costs and considering available alternatives, the action called for is issuance of a source material license subject to conditions stipulated in the license.				10. PROJECT/TASK/WORK UNIT NO.	
17. KEY WORDS AND DOCUMENT ANALYSIS				11. CONTRACT NO.	
17a. DESCRIPTORS				14. (Leave blank)	
17b. IDENTIFIERS/OPEN-ENDED TERMS					
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