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CROW BUTTE URANIUM PROJECT
Dawes County, Nebraska

Application and Supporting Environmental
Report for Research and Development
Source Material License

Volume I

Submitted to:
United States Nuclear Regulatory Commission
Washington, D.C.

February 11, 1983

Prepared and Submitted by:
Wyoming Fuel Company
445 Union Boulevard, Suite 310
Lakewood, Colorado 80228
(303) 989-5037

00081

Wyoming Fuel Company

445 Union Boulevard • Suite 310 • Lakewood, Colorado 80228 • Telephone (303) 989-5037

PAUL C. JONES
President

February 9, 1983

Mr. John Linehan
Branch Chief of Licensing Branch 1
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Application For Source Material License
Research And Development Facility
Crow Butte Uranium Project
Dawes County, Nebraska

Dear Mr. Linehan:

We are pleased to submit, herewith, our application for a Research and Development Plant Source Material License for our Crow Butte Uranium Project located near Crawford, Dawes County, Nebraska.

This application covers the development of two well field patterns, a 100 GPM maximum capacity uranium recovery plant, and related facilities. The proposed facility is to be located in N/2, SE/4, Section 19, Township 31 North, Range 51 West, Dawes County, Nebraska, approximately four miles southeast of Crawford, the nearest community. It is our desire to begin operation of the facility in the fourth quarter of 1983 with restoration of one well pattern being completed during the fourth quarter of 1984. Restoration of the second pattern is planned during 1985.

Attached is our check in the amount of $2,000.00 for initial application fees. Hand delivered with this letter are ten copies of the permit application. An additional five duplicate copies of the application will be delivered Monday, February 14, 1983 to Mr. Howard Rose in your Lakewood, Colorado office at your request.

The designated contact person at Wyoming Fuel Company concerning any questions or comments your staff may have regarding this application is Mr. Dave Stout, Environmental Coordinator. Dave is in our Lakewood, Colorado office at telephone number 303/989-5037 extension 25.

Our staff, and related consultants, look forward to working with you and your staff in your review of this permit application. We will be available, at your convenience, to discuss any portion of the application.

It is our hope this application will receive an expeditious review and that the permit issuance will allow our schedule to be maintained.

Very truly yours,

Paul C. Jones

PCJ:au
cc: Steve Collings
Dave Stout
J. Robert Wilson
Elmer J. Jackson
Thor Gjelsteen
Eugene Pendery

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INTRODUCTION

Wyoming Fuel Company is pleased to submit this application for a Source and Byproduct Material License to the U.S. Nuclear Regulatory Commission (USNRC) for their consideration. This application is for a research and development in situ uranium mining facility in Dawes County, Nebraska. The source material license is required under provisions of Title 10 Code of Federal Regulations Part 40 "Domestic Licensing of Source Material" to recover uranium by in situ solution mining techniques (in situ leaching). This application is being submitted to the USNRC because the State of Nebraska, although an agreement state, has at the request of the Governor relinquished its authority over the milling of uranium and the concentration of uranium from in situ mining to the USNRC. As a result of this action, the USNRC has the sole authority to issue a license for the milling and concentration of source material in Nebraska, by virtue of the Atomic Energy Act of 1954, as Amended, 68 Stat 923. The State of Nebraska, under the Nebraska Department of Environmental Control (NDEC), pursuant to Nebraska Rev. Stat. Section 81-1505A Supp. 1981, and the Federal Safe Drinking Water Act (42 USC 300F et seq) has adopted regulations governing underground injection control (UIC) in Nebraska effective Feburary 16, 1982. The NDEC therefore, has authority to regulate the water quality aspects of in situ uranium mining in Nebraska.

On November 10, 1982, the USNRC and the NDEC signed a memorandum of understanding for the purpose of providing effective communication and coordination between their respective staffs for the regulation of extraction of uranium by in situ leaching in Nebraska. Under the memorandum, the State and the NRC will cooperate in using procedures to minimize duplication of effort avoid delays in decision making, and insure the exchange of needed information during the regulatory process for in situ uranium mining.

To avoid duplication of effort by Wyoming Fuel Company the reader will note that various sections in this application reflect information gathered for both the NRC source material license and the NDEC Underground Injection Control permit for Class III wells. A separate application will, however, be filed with the NDEC dealing specifically with the requirements of the Nebraska UIC program.

The reader will also note that premining baseline objectives were to collect information to fulfill the requirements of a USNRC Research and Development Application and a USNRC Commercial Scale application. Wyoming Fuel Company believes to date, adequate baseline data have been collected for the Research and Development phase. Studies are continuing into 1983 to collect further data to be included in a Commercial Scale License Application. No immediate plans have been made for submittal of the Commercial Scale application. Submittal of this application will depend largely on the success of the Research and Development phase.

ACKNOWLEDGEMENTS

Wyoming Fuel Company acknowledges Fred Harrington and Associates for managing and conducting the ecological studies; Espey, Huston and Associates for their preparation of the Socioeconomic and Population Distribution sections; the Department of Archeology, University of Nebraska for their work on the historical and archeological aspects of this document; and Fisher, Harden and Fisher for their work in hydrologic investigations, radiological and non-radiological assessments and engineering design work of proposed operations; and the staff of Wyoming Fuel Company for diligence in collection of pre-mining baseline data and assembling this application.

Wyoming Fuel Company also wishes to thank our joint venture partners, Mr. Thor Gjelsteen and Mr. Eugene Pendery of Ferret Exploration Company, Inc., for their continued support.

FORM NRC-2
(7-77)
10 CFR 40

Approved by GAO
R0203

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR SOURCE MATERIAL LICENSE

Pursuant to the regulations in Title 10, Code of Federal Regulations, Chapter 1, Part 40, application is hereby made for a license to receive, possess, use, transfer, deliver or import into the United States, source material for the activity or activities described.

1. (*Check one*)
- [X] (*a*) New license
- [ ] (*b*) Amendment to License No. ______
- [ ] (*c*) Renewal of License No. ______
- [ ] (*d*) Previous License No. ______

2. NAME OF APPLICANT
Wyoming Fuel Company

3. PRINCIPAL BUSINESS ADDRESS
445 Union Boulevard, Suite 310
Lakewood, Colorado 80228

4. STATE THE ADDRESS(ES) AT WHICH SOURCE MATERIAL WILL BE POSSESSED OR USED
Approximately 4 miles (6.4 km) southeast of Crawford, Nebraska; Section 19, Township 31 North, Range 51 West, Dawes County, Nebraska

5. NAME OF PERSON TO BE CONTACTED CONCERNING THIS APPLICATION
David M. Stout/Environmental Coordinator

6. TELEPHONE NO. OF INDIVIDUAL NAMED IN ITEM 5
(303) 989-5037 Extension 25

7. DESCRIBE PURPOSE FOR WHICH SOURCE MATERIAL WILL BE USED
Wyoming Fuel Company will be operating a uranium Research and Development in situ leach facility. This facility will concentrate U_3O_8. The U_3O_8 may be sold for processing to UF_6.

8. STATE THE TYPE OR TYPES, CHEMICAL FORM OR FORMS, AND QUANTITIES OF SOURCE MATERIAL YOU PROPOSE TO RECEIVE, POSSESS, USE, OR TRANSFER UNDER THE LICENSE

(*a*) TYPE	(*b*) CHEMICAL FORM	(*c*) PHYSICAL FORM (*Including % U or Th.*)	(*d*) MAXIMUM AMOUNT AT ANY ONE TIME (*kilograms*)
NATURAL URANIUM	U_3O_8	Solution or 10-60% U (slurry)	9090
URANIUM DEPLETED IN THE U-235 ISOTOPE	NA	NA	NA
THORIUM (ISOTOPE)	NA	NA	NA

(*e*) MAXIMUM TOTAL QUANTITY OF SOURCE MATERIAL YOU WILL HAVE ON HAND AT ANY TIME (*kilograms*)
9090

9. DESCRIBE THE CHEMICAL, PHYSICAL, METALLURGICAL, OR NUCLEAR PROCESS OR PROCESSES IN WHICH THE SOURCE MATERIAL WILL BE USED, INDICATING THE MAXIMUM AMOUNT OF SOURCE MATERIAL INVOLVED IN EACH PROCESS AT ANY ONE TIME, AND PROVIDING A THOROUGH EVALUATION OF THE POTENTIAL RADIATION HAZARDS ASSOCIATED WITH EACH STEP OF THOSE PROCESSES.
The process in which the source material (U_3O_8) will be mined and handled is described in Section 3.0, Description of Proposed Facility of this application. The amount of U_3O_8 at each process step is defined in the material balance of this section. Section 5.0, Operations and Section 7.3, Radiological Effects evaluate potential radiological hazards at the process steps.

10. LIST THE NAMES AND ATTACH A RESUME OF THE TECHNICAL QUALIFICATIONS INCLUDING TRAINING AND EXPERIENCE OF APPLICANT'S SUPERVISORY PERSONNEL AND THE PERSON RESPONSIBLE FOR THE RADIATION SAFETY PROGRAM (OR OF APPLICANT IF AN INDIVIDUAL). Section 5.0, Operations includes a resume of the minimum qualifications of the Radiation Safety Officer.

11. DESCRIBE THE EQUIPMENT AND FACILITIES WHICH WILL BE USED TO PROTECT HEALTH AND MINIMIZE DANGER TO LIFE OR PROPERTY AND RELATE THE USE OF THE EQUIPMENT AND FACILITIES TO THE OPERATIONS LISTED IN ITEM 9. INCLUDE: (*a*) RADIATION DETECTION AND RELATED INSTRUMENTS (including film badges, dosimeters, counters, air sampling, and other survey equipment as appropriate. The description of radiation detection instruments should include the instrument characteristics such as type of radiation detected, window thickness, and the range(s) of each instrument).
A description of the radiation detection equipment is provided in Section 5.7, Radiation Safety Controls and Monitoring.

(*b*) METHOD, FREQUENCY, AND STANDARDS USED IN CALIBRATING INSTRUMENTS LISTED IN (*a*) ABOVE, INCLUDING AIR SAMPLING EQUIPMENT (for film badges, specify method of calibrating and processing, or name supplier).
The methods, frequency and calibration standards for the above equipment are described in Section 5.7, Radiation Safety Controls and Monitoring.

11(c). VENTILATION EQUIPMENT WHICH WILL BE USED IN OPERATIONS WHICH PRODUCE DUST, FUMES, MISTS, OR GASES, INCLUDING PLAN VIEW SHOWING TYPE AND LOCATION OF HOOD AND FILTERS, MINIMUM VELOCITIES MAINTAINED AT HOOD OPENINGS AND PROCEDURES FOR TESTING SUCH EQUIPMENT

No specific ventilation equipment is required other than plant venting of radon gas which is addressed in Section 5.7, Radiation Safety Controls and Monitoring.

12. DESCRIBE PROPOSED PROCEDURES TO PROTECT HEALTH AND MINIMIZE DANGER TO LIFE AND PROPERTY AND RELATE THESE PROCEDURES TO THE OPERATIONS LISTED IN ITEM 9; INCLUDE: (a) SAFETY FEATURES AND PROCEDURES TO AVOID NONNUCLEAR ACCIDENTS, SUCH AS FIRE, EXPLOSION, ETC., IN SOURCE MATERIAL STORAGE AND PROCESSING AREAS

A description of Wyoming Fuel Company's safety programs for nonradiological effects is described in Section 5.0 Operations, Effects of nonradiological accidents is presented in Section 7.5, Effects of Accidents.

(b) EMERGENCY PROCEDURES IN THE EVENT OF ACCIDENTS WHICH MIGHT INVOLVE SOURCE MATERIAL.

Emergency procedures involving source material are described in Section 7.5, Effects of Accidents.

(c) DETAILED DESCRIPTION OF RADIATION SURVEY PROGRAM AND PROCEDURES.

Section 5.7, Radiation Safety Controls and Monitoring provides a detailed description of the radiation survey program and procedures.

13. WASTE PRODUCTS: *If none will be generated, state "None" opposite (a), below. If waste products will be generated, check here* ☒ *and explain on a supplemental sheet:*
(*a*) Quantity and type of radioactive waste that will be generated.
(*b*) Detailed procedures for waste disposal.

14. IF PRODUCTS FOR DISTRIBUTION TO THE GENERAL PUBLIC UNDER AN EXEMPTION CONTAINED IN 10 CFR 40 ARE TO BE MANUFACTURED, USE A SUPPLEMENTAL SHEET TO FURNISH A DETAILED DESCRIPTION OF THE PRODUCT, INCLUDING:
(*a*) PERCENT SOURCE MATERIAL IN THE PRODUCT AND ITS LOCATION IN THE PRODUCT.
(*b*) PHYSICAL DESCRIPTION OF THE PRODUCT INCLUDING CHARACTERISTICS, IF ANY, THAT WILL PREVENT INHALATION OR INGESTION OF SOURCE MATERIAL THAT MIGHT BE SEPARATED FROM THE PRODUCT.
(*c*) BETA AND BETA PLUS GAMMA RADIATION LEVELS (*Specify instrument used, date of calibration and calibration technique used*) AT THE SURFACE OF THE PRODUCT AND AT 12 INCHES.
(*d*) METHOD OF ASSURING THAT SOURCE MATERIAL CANNOT BE DISASSOCIATED FROM THE MANUFACTURED PRODUCT.

CERTIFICATE

(This item must be completed by applicant)

15. *The applicant, and any official executing this certificate on behalf of the applicant named in Item 2, certify that this application is prepared in conformity with Title 10, Code of Federal Regulations, Part 40, and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.*

WYOMING FUEL COMPANY

BY: [signature]
(Signature)

Dated February 10, 1983

Paul C. Jones
(Print or type name)

President
(Title of certifying official authorized to act on behalf of the applicant)

WARNING: 18 U.S.C. Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

SUPPLEMENT TO

APPLICATION FOR SOURCE MATERIAL LICENSE

13(a) The quantity and type of radioactive waste and procedures for waste disposal and handling is described in Section 3.0, Description of Proposed Facility, Section 4.0, Effluent Control Systems and Section 6.0, Ground Water Quality Restoration, Surface Reclamation and Plant Decommissioning.

14. No products will be generated from this facility for general public distribution.

SECTION 1.0

PROPOSED ACTIVITIES

1.0 PROPOSED ACTIVITIES

Wyoming Fuel Company proposes to operate a uranium in situ leach Research and Development (R&D) facility located in northwest Nebraska, approximately 4 miles (6.4 km) southeast of Crawford in the N/2 SE/4 of Section 19, Township 31 North, Range 51 West, Dawes County, Nebraska.

The land for development of the R&D facility has been leased by Wyoming Fuel Company.

Construction of the R&D facility is planned for September, 1983. Time of construction prior to operation of the plant is estimated at three (3) months. The surface area to be affected by the R&D project will be approximately 6.7 acres (2.7 ha). Facilities will include a plant building, solar evaporation ponds, parking, access roads and wellfields.

Uranium will be recovered by in situ leaching from the Basal Chadron Sand at a depth of approximately 650 ft (197.6 m). The overall width of mineralization in the R&D area ranges from less than 100 ft (30.4 m) to greater than 250 ft (76 m). The Basal Chadron Sand in the area of the R&D ore body has a total thickness of about 40 ft (12.2 m). The ore body ranges in grade from .10-.40% U_3O_8.

Wyoming Fuel Company is planning to operate two (2) wellfields. Wellfield No. 1 will consist of an array of wells oriented to allow spacing variations from 93 ft (28 m) to 132 ft (40 m). Wellfield No. 2 will be a five spot with the dimensions of 35 ft (10.6 m) by 35 ft (10.6 m).

The in situ leaching process will consist of an oxidation step and a dissolution step. The most probable oxidants to be used in the R&D facility will either by hydrogen peroxide or gaseous oxygen. A sodium bicarbonate lixivant will be used for the dissolution step. The sodium bicarbonate lixivant will be used at a strength ranging from 0.5 to 5.0 g/l and a range of .01 to 1.5 g/l hydrogen peroxide or oxygen equivalent will be used for the oxidation step.

The uranium bearing solution resulting from the leaching of uranium underground will be recovered and uranium will be extracted in a process plant. The plant process will utilize the following steps:

A. loading of uranium complexes onto an ion exchange resin

B. reconstitution of the solution by addition of sodium bicarbonate and oxygen

C. Elution of the uranium complexes from the resin using a sodium chloride/bicarbonate eluant and the precipitation of uranium using H_2O_2.

The plant will be designed to operate at a maximum of 100 gallons per minute. Estimated U_3O_8 production will range from 14,000 to 18,000 lbs (6363 to 8181 kg) annually during the R&D phase.

The operation of the R&D facility will result in three sources of liquid waste. They are: filter backwash, eluant bleed and reverse osmosis brine. Since this is an R&D operation, the composition of process waste will vary as leach chemistry varies and also as efforts are made to improve the process. Two solar evaporation ponds will be utilized to handle liquid waste.

Wyoming Fuel Company proposes to initially select Wellfield No. 2 for demonstration of restoration. Wellfield No. 1 may be incorporated into the commercial scale wellfield if all ore is not recovered during the R&D phase. If the commercial operations are not feasible, Wellfield No. 1 will be restored following restoration of Wellfield No. 2.

During restoration, a reverse osmosis unit will be used to filter the contaminates out of the discharge water and the purified water will be recycled through injection wells into affected zones and recovered by pumping. The fresh water recycle approach will very likely be used for aquifer restoration. It is presently estimated that 10 to 15 pore volumes may have to be recirculated through the wellfield pattern to accomplish restoration of Wellfield No. 2. The net withdrawal from the aquifer is estimated at 2 pore volumes. Wyoming Fuel Company's restoration program is designed to return the water quality of the affected zone to a chemical quality consistent with its highest potential pre-mining use. Presently, the water in the mineralized zone is not suitable for human consumption as a result of high total dissolved solids and radionuclides.

After groundwater restoration has been completed, all injection and recovery wells will be reclaimed using appropriate abandonment procedures. Furthermore, Wyoming Fuel Company will implement a land reclamation and revegetation program on the site. This reclamation will be performed on all disturbed areas of the site, including the plant, wellfield, ponds and roads. Specifics on the reclamation plan and abandonment of wells are presented in the following sections.

Wyoming Fuel Company will maintain financial responsibility for ground water restoration, plant decommissioning and surface reclamation. This responsibility will be in the form of a surety bond with USNRC and/or the State of Nebraska. This surety will be based on the costs of the aforementioned activities.

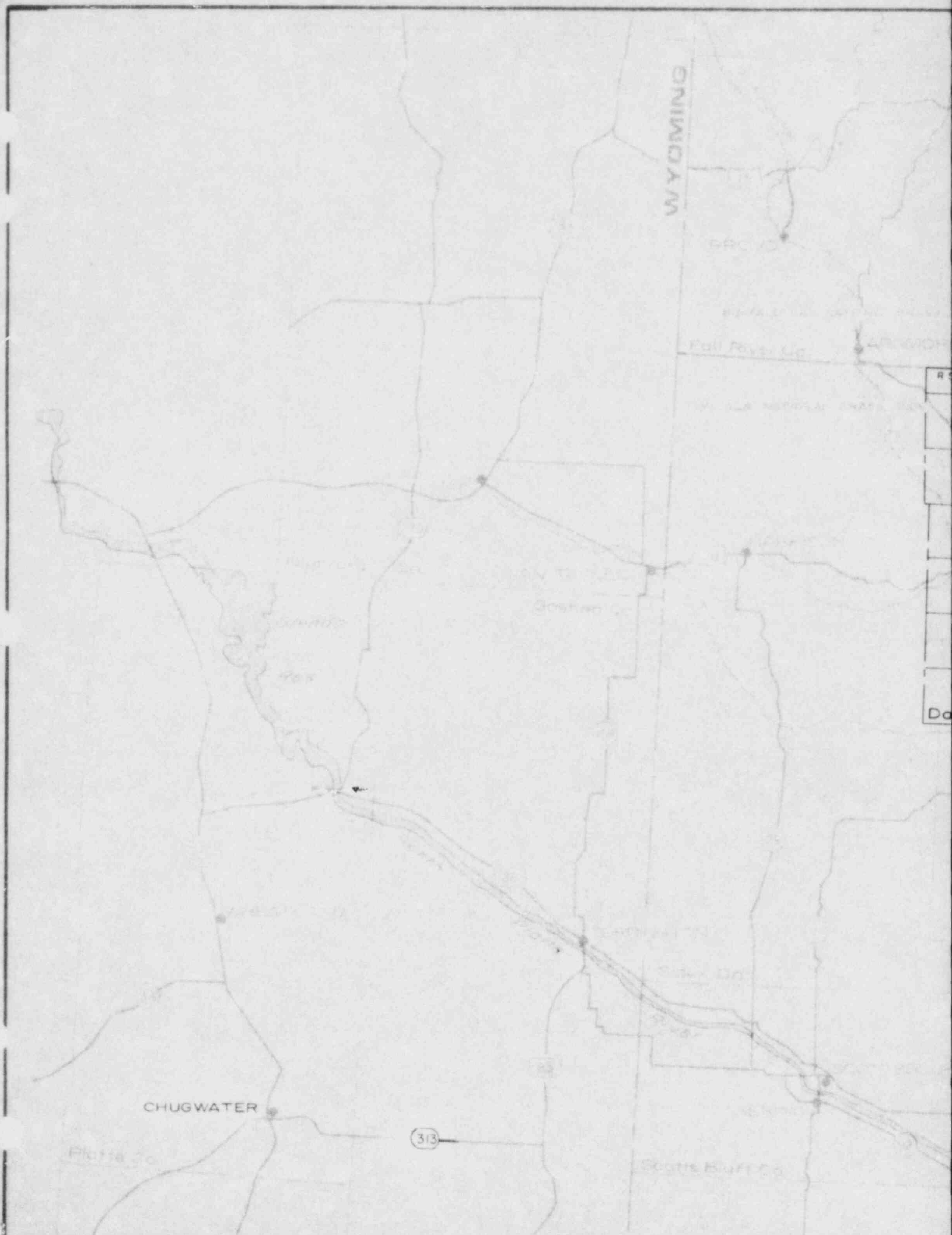
SECTION 2.1

SITE LOCATION AND LAYOUT

2.1 SITE LOCATION AND LAYOUT

The location of the proposed R&D facility will be in the N/2 SE/4 of Section 19, Township 31 North, Range 51 West, Dawes County, Nebraska as shown on Figure 2.1-1. The wellfield, plant and pond locations as well as the Restricted Area Boundary (RAB), land status, transportation, access and other landmarks are shown on Figure 2.1-2.

For further details on actual land use in and surrounding the proposed facility please see Section 2.2.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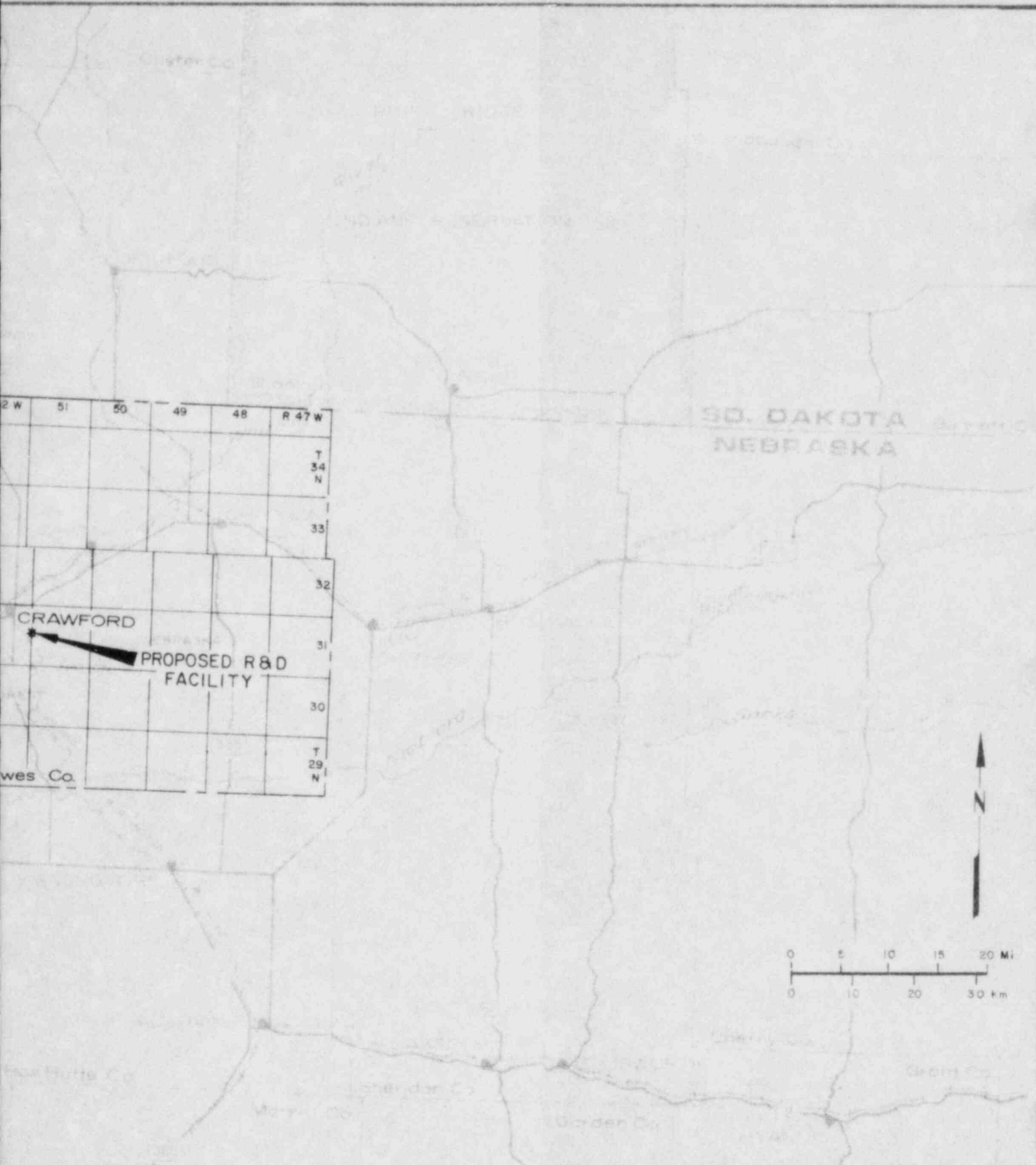
313



REV	BY	DATE

WYOMING FUEL COMPANY

CROW BU"TE PROJECT
Northwes ern Nebraska

PROJECT LOCATION

PREPARED BY DMStout

DWN BY SADavis — DATE Jan.20,1983 — FIG. 2.1-1

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2.2
USES OF ADJACENT LANDS AND WATERS

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2.2 USES OF ADJACENT LANDS AND WATERS

The information provided in this section provides relevant information concerning the physical, ecological and social characteristics of the proposed R&D site and surrounding environs for uranium in-situ mining. This information was developed for use by the Nuclear Regulatory Commission (NRC) to determine the potential effects of the proposed Wyoming Fuel Company Crow Butte in-situ uranium mine activities upon the health and safety of the public and the environment.

In accordance with NRC Regulatory Guidelines (Draft 3.46, 1980; Final 3.46, 1982), this section indicates the nature and extent of present and project land and water use and trends in population or industrial patterns. The information of this section was developed over a 9-month period. Preliminary data were obtained from secondary sources followed by field studies to collect on-site data and to ground proof land uses. Interviews with various state and local officials provided additional useful information.

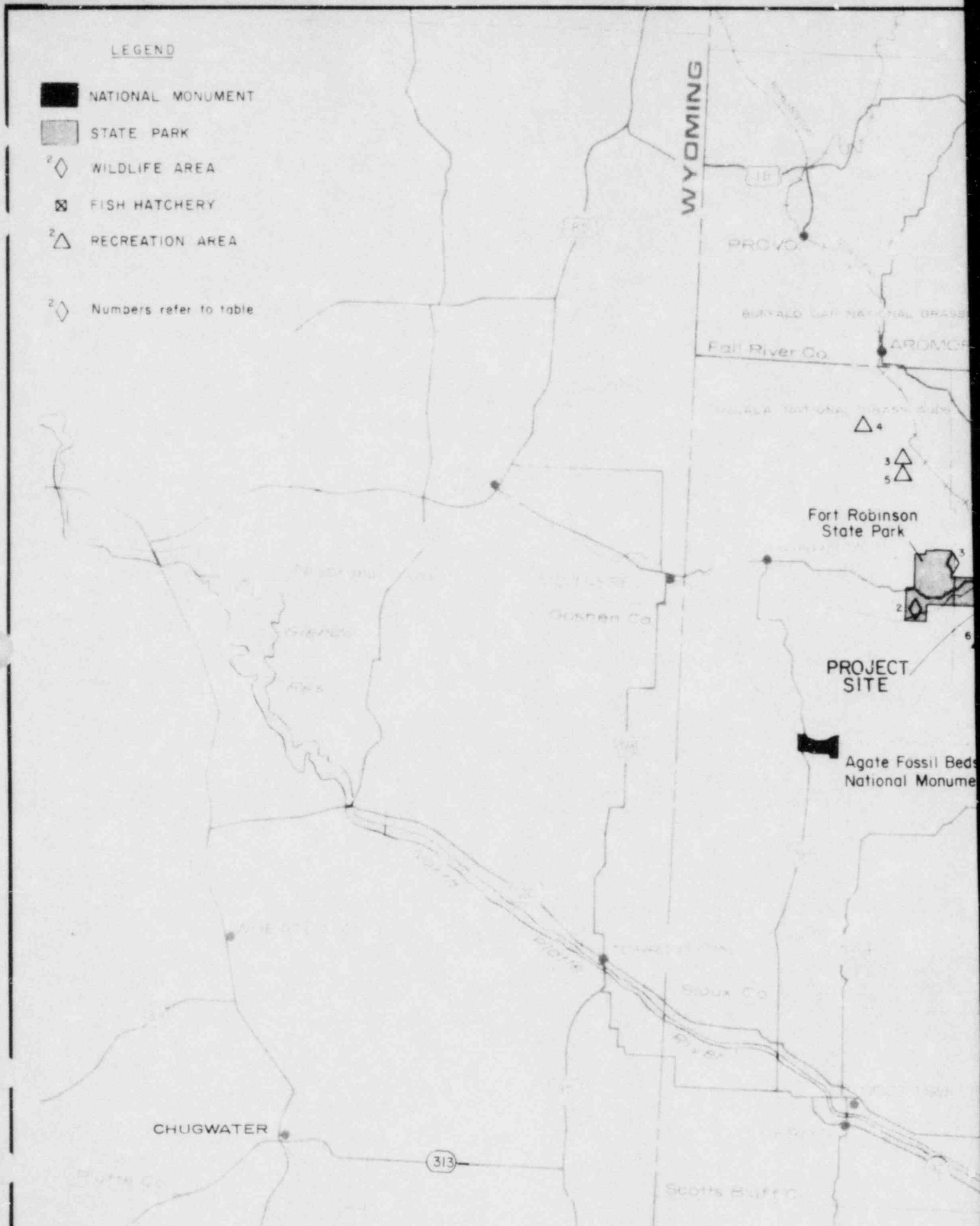
The land and water use information included in this section considers the area within an 8-km radius of the designated center point of the R&D activities.

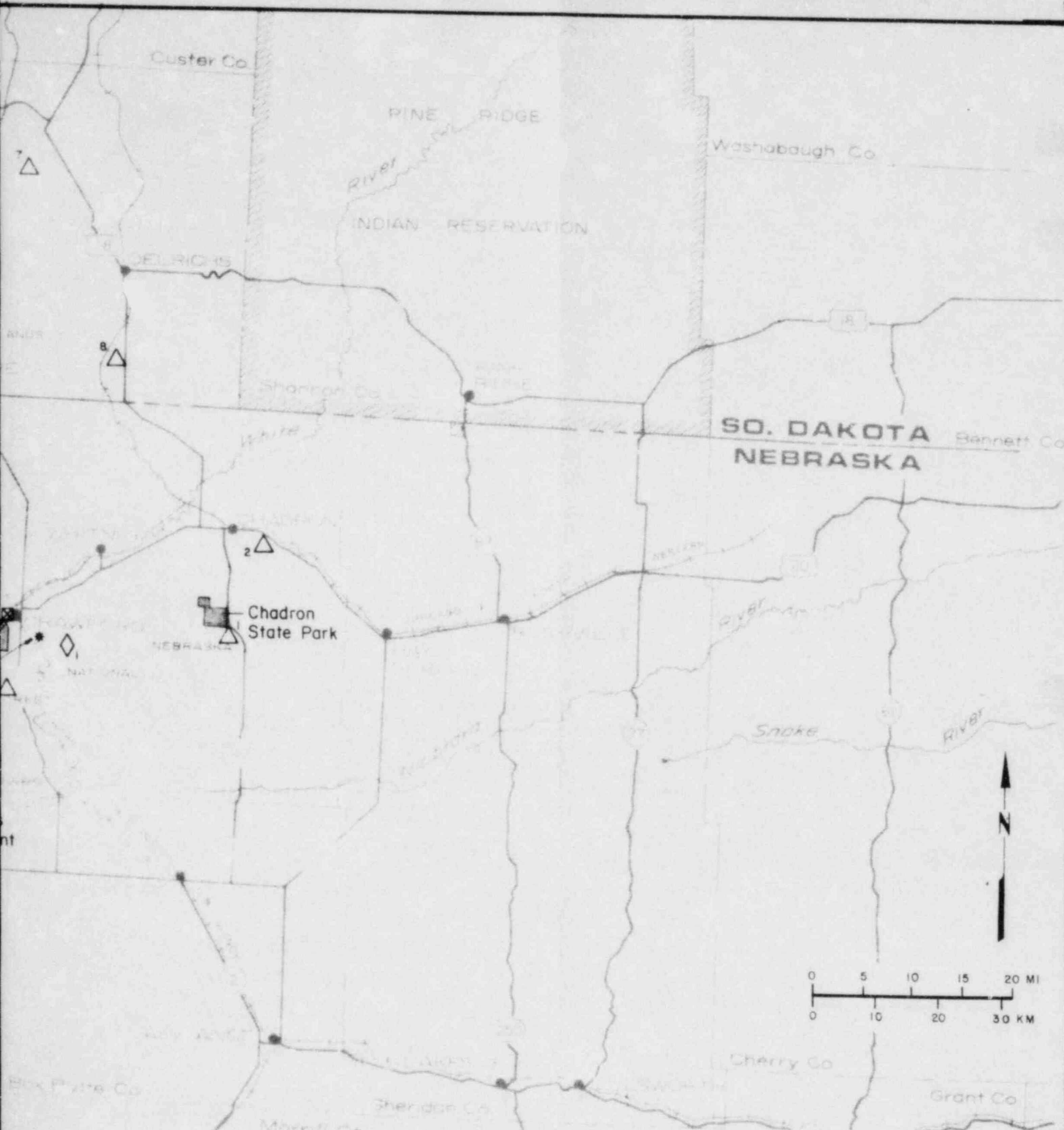
This designation of the 8-km area is in compliance with the NRC draft Regulatory Guide (July, 1980). The final version of the NRC Regulatory Guide (June, 1982) request that the information be limited to a study area of 3.3-km (2 mi) radius for a commercial-scale license and a 0.8 km (0.5 mi) radius for R&D operations. The information in this section is of sufficient detail to allow an examination of the proposed project environs within both the general and immediate study area.

2.2.1 General Setting

The Crow Butte project site is located in west-central Dawes County, Nebraska, just north and west of the Pine Ridge Area. Much of the surrounding lands are designated as National Forest. Figure 2.2-1 shows the general location of the proposed RAB permit area. The Crow Butte project site is about 4.5 miles southeast of the City of Crawford via Squaw Creek Road. State Highway 71 provides access to the project area from points north and south of Crawford. U.S. Highway 20 provides access to Crawford and the project area from points east and west.

Approximately 4 percent of the area within a 8-km radius of the project site is located within the Nebraska National Forest. Also identified as the Pine Ridge, this area is covered with mixed evergreens and Ponderosa pines. The predominant land use in Dawes County, as well as the RAB permit area, is livestock raising. An annual average of 56,833 cattle valued at approximately $21.35 million were reported on Dawes County farms for the years 1978, 1979 and 1980 (Nebraska Crop and Livestock Reporting Service, 1980; 1981). Cropland is used primarily for the production of winter wheat, alfalfa, and oats. Native grasslands are used for grazing or for cut hay.


LEGEND
NATIONAL MONUMENT
STATE PARK
WILDLIFE AREA
FISH HATCHERY
RECREATION AREA
Numbers refer to table
WYOMING
18
PROVO
Fall River Co.
Fort Robinson
State Park
PROJECT
SITE
Agate Fossil Beds
National Monume
Goshen Co.
Sioux Co.
CHUGWATER
313
Scotts Bluff C



REV	BY	DATE

WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Dawes County, Nebraska

LOCATION MAP

PREPARED BY: S. HICKS

DWN BY: F. DAVIS | DATE: 9/82 | FIG 2.2-1

Recreational lands are also prevalent in Dawes County (see Fig. 2.2-1 and Table 2.2-1). Fort Robinson State Park, the largest state park in Nebraska, is located just outside the Crow Butte 8-km radius. Facilities at the park consist of lodging, showers, electrical hookups, pit toilets, ski and snowmobile trails, a rodeo arena, and museum. Visitors to the park may go hunting, fishing, hiking, swimming, or horseback riding. Other recreational facilities in Dawes County include the Ponderosa Wildlife Area, Chadron State Park, Soldier Creek Management Unit, Cochran Wayside Area, and the Red Cloud Picnic Area and associated trails in the Nebraska National Forest (Nebraska Game & Parks Commission, 1982).

Urban land uses in the county are concentrated within the city limits of Crawford and Chadron. Approximately 73 rural occupied dwellings are located within the 8-km project area radius (USGS, 1980; EH&A, 1982).

2.2.2 Land and Mineral Ownership.

Approximately 4.0 percent of land within the 8-km radius is owned by the federal government, while another 9.0 percent is owned by the state or local government (Bump Abstract, 1979). Except for lands within the City of Crawford, private land is predominantly owned by ranching families. Approximately 90 percent of all minerals leased in Dawes County are on private lands (Mathis, 1982).

TABLE 2.2-1

RECREATIONAL FACILITIES IN THE CROW BUTTE PROJECT AREA

Symbol	Name of Recreational Facility	Distance from Site (km)
Δ1	Red Cloud Picnic Area	26.0
Δ2	Museum of the Fur Trade	16.3
Δ3	Toadstool Park	28.3
Δ4	Warbonnet Battlefield	36.4
Δ5	Hudson-Meng Bison Kill Site	26.0
Δ6	Cochran State Wayside Area	9.1
Δ7	Angostora Reservoir	72.8
Δ8	Pioneer Roadside Park	45.5
1	Ponderosa Wildlife Area	1.5
2	Peterson Wildlife Area	15.6
3	Soldier Creek Management Unit	10.4
	Crawford National Fish Hatchery	5.2

[a] Refers to symbols shown on Fig. 2.2-1.

[b] Symbols include:

Δ Recreational Area.
Wildlife Area.
Fish Hatchery.
* Project site.

Source: Nebraska Dept. of Roads, 1981. South Dakota Division of Tourism, 1981.

2.2.3 Land Uses Within the 8-km Project Site Area.

The Crow Butte R&D project site area is defined as all lands within a 8-km radius of the proposed project's designated centerpoint. Figure 2.2-2 shows the land uses within the R&D project area (see map pocket). Table 2.2-2 presents a detailed breakdown of land use by sector while Tables 2.2-3 presents the land uses by percentages and square kilometers. Land use categories and definitions are developed from both U.S. Geological Survey and U.S. Office of Surface Mining land use definitions (see Table 2.2-4).

The information presented for the project site area is based on information gathered from recent local and state publications, USGS quadrangle map sheets, a Dawes County U.S. Soil Conservation survey, and telephone interviews with various knowledgeable officials. The information was verified during an on-site field investigation conducted in early May 1982.

Agriculture. Several of the soil types found on the Crow Butte project area are classified as prime farmland (Dixon, 1982). A listing of these soil types can be found in Section 2.6.1 of this application. However, in Dawes County soils are classified by the U.S. Soil Conservation Service (SCS) as prime only if irrigated. According to 1978, 1979 and 1980 Nebraska State Agricultural Statistics, only 2% of Dawes County land is irrigated, and about 18% of that irrigated acreage is harvested cropland acreage. The remainder of the irrigated land is used for pasture, habitat, or rangeland (Nebraska Crop and Livestock Reporting Service, 1980; 1981). Applying these same percentages

TABLE 2.2-2

LAND USE OF THE CROW BUTTE 8-km RADIUS, BY SECTOR AND CATEGORY[a]

(in acres)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Subtotal
Cropland																	
0-1.8	70.9	64.8	76.8	118.8	86.5	+	33.4	—	—	30.4	73.3	89.7	64.8	8.2	57.4	27.1	802.1
1.8-3.6	323.7	90.2	17.8	8.3	5.5	—	—	—	74.5	64.8	233.0	276.4	267.8	166.6	292.0	246.9	2067.5
3.6-5.4	308.9	522.5	380.7	87.2	—	—	42.5	5.6	20.8	358.8	240.6	457.2	503.6	523.7	235.1	367.1	4054.3
5.4-7.2	334.0	824.8	636.6	123.9	—	98.2	130.4	151.6	—	164.4	—	384.9	148.0	70.8	495.8	552.9	4116.3
7.2-8.0	297.1	442.9	247.1	238.8	—	175.1	131.1	0	—	0	.2	313.8	43.1	—	156.7	178.3	2224.2
Subtotal	1334.6	1945.2	1359.0	577.0	92.0	273.3	337.4	157.2	95.3	618.4	547.1	1522.0	1027.3	769.3	1237.0	1372.3	13264.4
Commercial/Services																	
0-1.8												—		—	—	—	—
1.8-3.6												—		—	—	—	—
3.6-5.4												2.8		0.9	13.8	—	17.5
5.4-7.2												—		—	103.1	—	103.1
7.2-8.0												—		—	7.4	5.4	12.8
Subtotal												2.8		0.9	124.3	5.4	133.4
Forested Land																	
0-1.8	0.9	—	—	2.7	0.9	10.8	5.3	8.6	—	0.9	+	0.9	1.8	3.6	9.4	11.4	57.2
1.8-3.6	—	58.9	230.4	361.4	—	—	104.5	304.5	53.0	10.8	—	—	4.5	—	—	7.2	1135.2
3.6-5.4	—	—	35.7	169.9	53.9	—	512.6	556.7	472.7	31.5	11.1	—	—	—	13.8	3.6	1861.5
5.4-7.2	—	—	15.7	237.7	579.9	717.7	675.5	567.8	804.5	392.2	370.2	27.7	—	—	8.4	30.8	4428.1
7.2-8.0	6.4	—	.9	82.8	411.8	377.4	176.0	360.0	394.3	501.7	284.5	30.4	—	—	33.0	36.9	2696.1
Subtotal	7.3	58.9	282.7	854.5	1046.5	1105.9	1473.9	1797.6	1724.5	937.1	665.8	59.0	6.3	3.6	64.6	89.9	10178.1

TABLE 2.2-2 (Cont'd)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Subtotal
Habitat																	
0-1.8				—	25.1	57.8	15.8	—							—		98.7
1.8-3.6				67.9	466.0	471.5	361.6	1.8							—		1368.8
3.6-5.4				241.7	716.6	656.9	102.5	1.9							—		1719.6
5.4-7.2				—	160.1	103.7	—	—							3.7		267.5
7.2-8.0				—	—	—	—	—							1.8		1.8
Subtotal				309.6	1367.8	1289.9	479.9	3.7							5.5		3456.4
Industrial																	
0-1.8															—		—
1.8-3.6															—		—
3.6-5.4															—		—
5.4-7.2															13.9		13.9
7.2-8.0															—		—
Subtotal															13.9		13.9
Mines, Quarries, or Gravel Pits																	
0-1.8										3.6		—	3.6	+	5.7		12.9
1.8-3.6										—		—	—	—	—		—
3.6-5.4										—		0.9	—	—	6.4		7.3
5.4-7.2										—		—	—	—	—		—
7.2-8.0										—		—	—	—	—		—
Subtotal										3.6		0.9	3.6	+	12.1		20.2
Pastureland																	
0-1.8	85.3	92.4	80.4	35.6	44.6	88.5	102.7	148.5	157.2	122.3	83.8	66.6	87.0	145.4	84.7	118.7	1543.7
1.8-3.6	147.7	320.4	148.6	33.9	—	—	3.6	83.5	344.0	395.9	233.0	195.0	199.3	304.9	176.7	217.4	2803.9
3.6-5.4	477.1	263.6	365.1	287.2	15.5	98.5	93.3	94.2	234.5	395.7	531.4	325.0	282.4	261.4	508.7	129.7	4363.3
5.4-7.2	752.6	273.7	448.1	656.8	145.4	28.5	294.5	221.0	29.2	440.0	717.9	687.7	158.1	122.9	118.8	758.3	5853.5
7.2-8.0	279.5	147.0	347.9	268.8	41.1	5.6	246.6	—	—	—	243.8	246.3	174.1	—	121.6	377.0	2584.3
Subtotal	1742.2	1097.1	1390.1	1282.3	246.6	221.1	740.7	632.2	764.9	1353.9	1809.9	1520.6	900.9	834.6	1010.5	1601.1	17148.7

TABLE 2.2-2 (Cont'd)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Subtotal
Rangeland																	
0-1.8		—	—	—	—	—	—	—	—	—	—						—
1.8-3.6		1.8	74.7	—	—	—	1.8	81.6	—	—	—						159.9
3.6-5.4		—	—	—	—	30.7	35.1	127.7	58.0	—	—						251.5
5.4-7.2		—	—	82.0	215.0	152.3	—	160.0	266.6	103.8	6.6						986.3
7.2-8.0		—	—	—	137.5	31.4	36.7	144.6	192.9	84.1	61.9						689.1
Subtotal		1.8	74.7	82.0	352.5	214.4	73.6	513.9	517.5	187.9	68.5						2086.8
Recreational																	
0-1.8		—				—					—		—	—	—		—
1.8-3.6		—				—					—		—	—	—		—
3.6-5.4		—				—					—		—	—	—		—
5.4-7.2		—				—					6.6		794.2	890.0	127.2		1818.0
7.2-8.0		1.8				.9					—		382.9	594.5	256.1		1236.2
Subtotal		1.8				.9					6.6		1177.1	1484.5	383.3		3054.2
Urban Residential																	
0-1.8															—		—
1.8-3.6															—		—
3.6-5.4															—		—
5.4-7.2															229.4		229.4
7.2-8.0															9.2		9.2
Subtotal															238.6		238.6
Water																	
0-1.8	—	—									—			—	—	—	—
1.8-3.6	—	—									5.6			—	2.8	—	8.4
3.6-5.4	—	—									2.8			—	8.3	18.8	29.9
5.4-7.2	13.8	1.8									—			16.8	—	12.7	45.1
7.2-8.0	7.4	-0-									—			—	—	2.3	9.7
Subtotal	21.2	1.8									8.4			16.8	11.1	33.8	93.1

TABLE 2.2-2 (Concluded)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
All Land Uses[a]																	
C	1334.6	1945.2	1359.0	577.0	92.0	273.3	337.4	157.2	95.3	618.4	547.1	1522.0	1027.3	769.3	1237.0	1372.3	13264.4
C/S	—	—	—	—	—	—	—	—	—	—	—	2.8	—	0.9	124.3	5.4	133.4
F	7.3	58.9	282.7	854.5	1046.5	1105.9	1473.9	1797.6	1724.5	937.1	665.8	59.0	6.3	3.6	64.6	89.9	10178.1
H	—	—	—	309.6	1367.8	1289.9	479.9	3.7	—	—	—	—	—	—	5.5	—	3456.4
I	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13.9	—	13.9
M	—	—	—	—	—	—	—	—	—	3.6	—	0.9	3.6		12.1	—	20.2
P	1742.2	1097.1	1390.1	1282.3	246.6	221.1	740.7	632.2	764.9	1353.9	1809.9	1520.6	900.9	834.6	1010.5	1601.1	17148.7
R	—	1.8	74.7	82.0	352.5	214.4	73.6	513.9	517.5	187.9	68.5	—	—	—	—	—	2086.8
RC	—	1.8	—	—	—	.9	—	—	—	—	6.6	—	1177.1	1484.5	383.3	—	3054.2
UR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	238.6	—	238.6
W	21.2	1.8	—	—	—	—	—	—	—	—	8.4	—	—	16.8	11.1	33.8	93.1
Total[b]	3105.3	3106.6	3106.5	3105.4	3105.4	3105.5	3105.5	3104.6	3102.2	3100.9	3106.3	3105.3	3115.2	3109.7	3100.9	3102.5	49687.8

+ less that one-tenth of one acre.

[a] See Table 2.2-5 for land-use definitions.

[b] Calculations used in this table for each of the 22½% compass points:

0 - 1.8 km	=	157.158	acres
1.8 - 3.6 km	=	471.474	acres
3.6 - 5.4 km	=	786.038	acres
5.4 - 7.2 km	=	1100.354	acres
7.2 - 8.0 km	=	590.407	acres
Total 8 km	=	3,105.431	acres

[c] Actual area of the 8-km radius is equal to 49,682.7 acres. However, multiplying the total acreage used for each compass point (3105.43) by 16 equals 49,686.9 acres. Differences between this total as well as other subtotals in the table due to rounding.

TABLE 2.2-3

LAND USE WITHIN THE CROW BUTTE PROJECT AREA
(8-km RADIUS)

Category	Acres	km^2	% of Total Area
Cropland (C)	13,263.9	53.7	26.7
Commercial and Services (C/S)	116.9	0.5	0.2
Forested Land (F)	10,159.3	41.1	20.5
Habitat (H)	3,456.4	14.0	7.0
Industrial (I)	13.9	0.1	*
Mines, Quarries, or Gravel Pits (M)	20.2	0.1	*
Pastureland (P)	17,189.5	69.5	34.6
Rangeland (R)	2,085.9	8.4	4.2
Recreational (RC)	3,045.9	12.3	6.1
Urban Residential (UR)	238.4	1.0	0.5
Water (W)	96.3	0.4	0.2
Total	49,686.6	201.1	100.0

* Less than one-tenth of one percent.

TABLE 2.2-4

CROW BUTTE PROJECT LAND AND WATER USE DEFINITIONS

Croplands (C): Harvested cropland, including grasslands cut for hay; cultivated summer-fallow and idle cropland.

Commercial and Services (C/S): Those areas used predominantly for the sale of products and services. Institutional land uses, such as various educational, religious, health, and military facilities are also components of this category.

Forested Land (F): Areas with a tree-crown density of 10 percent or more, are stocked with trees capable of producing timber or other wood products, and exert an influence on the climate or water regime. This category does not indicate economic use.

Habitat (H): Land dedicated wholly or partially to the production, protection or management of species of fish or wildlife.

Industrial (I): Areas such as rail yards, warehouses and other facilities used for industrial manufacturing or other industrial purposes.

Mines, Quarries, or Gravel Pits (M): Those extractive mining activities that have significant surface expression are included in this category.

Pastureland (P): Land used primarily for the long-term production of adapted, domesticated forage plants to be grazed by livestock or occasionally cut and cured for livestock feed.

Rangeland (R): Land, roughly west of the 100th meridian, where the natural vegetation is predominantly grasses, grasslike plants, forbs or shrubs; which is used wholly or partially for the grazing of livestock. This category includes wooded areas where grasses are established in clearings and beneath the overstory.

Urban Residential (UR): Residential land uses range from high density, represented by multi-family units, to low density, where houses are on lots of more than one acre. These areas are found in and around Crawford and Ft. Robinson. Areas of sparse residential land use, such as farmsteads, will be included in categories to which they are related.

Water (W): Areas of land mass that persistently are water covered.

TABLE 2.2-4 (Concluded)

Recreational (RC):	Land used for public or private leisure-time use, including developed recreational facilities such as parks, camps and amusement areas, as well as areas for less intensive use such as hiking, canoeing, and other undeveloped recreational uses.

Sources: U.S.G.S., 1976; U.S. Department of Interior, 1979.

to the Crow Butte 8-km area, approximately 994 acres of the land is irrigated, of which 179 acres can be classified as harvested cropland. All of the irrigated lands within the study area occur in the north and northwest sectors where aqueducts flow from the White River to the south and west.

Tables 2.2-5 through 2.2-8 show agricultural productivity within the 8-km project radius as well as Dawes County. Winter wheat and hay are the major crops grown on croplands within the study area. Most of these crops are used for livestock feed while the remaining crops are commercially sold. The livestock inventory found within the study area is similar to the rest of Dawes County, with cattle accounting for over 80% of all livestock.

Habitat. As defined in Table 2.2-4, these lands are dedicated wholly or partially to the production, protection or management of species of fish or wildlife. Significant areas classified as habitat include the Crawford National Brude Stock Fish Hatchery and the Ponderosa State Wildlife area. The hatchery produces mainly Brook and Brown trout eggs, which are sent to other fish hatcheries throughout the United States (Litzinger, 1982). Deer and turkey hunting is permitted within the Ponderosa State Wildlife Area.

Residential. According to 1980 USGS quad sheets and on-site field investigations, 73 occupied dwelling units are located in the rural area of the Crow Butte 8-km project area (see Table 2.2-9). Interviews with local citizens were conducted to find actual rural population counts within a 10-km radius. The average persons per household estimate

TABLE 2.2-5

AGRICULTURAL YIELDS (kg/km^2) FOR CROPLANDS

IN DAWES COUNTY, 1978-1980 AVERAGE

	Planted	Harvested		Production		Yield
	Acres	Acres	km^2	Bu/Tons	Kgs	Kgs/km^2
Corn						
for grain (bu)		2,333	9.44	229,867	5,838,622	618,498
for silage (tons)		767	3.10	9,650	8,754,287	2,823,964
other		67	.27	843	765,696	2,823,964[c]
Subtotal	3,233[b]	3,167	12.81	240,360	15,358,605	1,198,954.3
Sorghum for Grain (bu)	100	100	0.40	3,750	95,250	238,125
Oats (bu)	7,033	4,367	17.67	162,800	2,360,600	133,593
Barley (bu)	1,500	1,333	5.39	53,300	1,161,940	215,573
Rye (bu)	467	233	0.94	5,367	136,322	145,023
All hay[d] (tons)	69,967	69,967	283.15	100,453	91,128,953	321,840
Wheat (bu)	53,167	47,334	191.56	1,506,000	40,963,200	213,840
Total	135,467	126,501	511.94	—	151,204,870	295,356.6
Irrigated	n/a	3,067	12.41	—	—	—

n/a = not available.

[a] 1 acre = .0040469 km^2.

[b] Total for grain, silage and forage or pastured.

[c] Used the same kgs/km^2 yield as corn for silage.

[d] Includes wild and tame alfalfa.

TABLE 2.2-6

POTENTIAL AGRICULTURAL PRODUCTION FOR CROPLAND IN THE CROW BUTTE 8-km STUDY RADIUS

	Percent of Total Planted[a]	Total Cropland (Acres)	Percent of Planted/ Harvested[a]	Harvested (Acres)	Harvested (km^2)[b]	County Yield (kgs/km^2)[a]	Production, 8-km Radius (kgs)
Corn	2.39	317.0	97.96	310.5	1.26	1,198,954	1,510,682
Sorghum	0.07	9.3	100.00	9.3	0.04	238,125	11,906
Oats	5.20	689.7	62.09	428.2	1.73	133,593	231,116
Barley	1.11	147.2	86.67	127.6	0.52	215,573	112,098
Rye	0.35	46.4	49.89	23.1	0.09	145,023	13,052
Hay	51.55	6,837.8	100.00	6,837.8	27.67	321,840	8,905,313
Wheat	39.33	5,216.9	89.03	4,644.6	18.80	213,840	4,041,576
Total	100.0	13,264.4	93.34	12,381.1	50.11	(295,864)[c]	14,825,743

[a] Same as Dawes County.

[b] 1 acre = .0040469 km^2.

[c] Average yield for all crops harvested in the 8-km project radius.

TABLE 2.2-7

LIVESTOCK INVENTORY, DAWES COUNTY
JANUARY 1, 1978-1980
3-YEAR AVERAGE

	Number	% of Total	Animal Units[a] lbs.	Animal Units[a] % of
All cattle, except dairy	56,510	82.1	56,510	97.2
Dairy cattle	323	0.5	323	0.5
Hogs	5,100	7.4	1,122	1.9
Sheep	843	1.2	169	0.3
Chickens[b]	6,050	8.8	31	0.1
Total animals	68,826	100.0	58,155	100.0
Milk production (000's lb)	3,400			
Egg production (000's lb)	1,250			

[a] Animal unit conversions:

1 cattle	=	1,000	lbs.
1 hog	=	220	lbs.
1 sheep	=	200	lbs.
1 chicken	=	5	lbs.
1 animal unit	=	1,000	lbs.

[b] Chickens on farms December 1 of previous year.

Source: Nebraska Crop and Livestock Reporting Service, 1980; 1981.

TABLE 2.2-8

ESTIMATED AVERAGE YIELDS FOR NATIVE GRASSLANDS (RANGELAND) AND IMPROVED PASTURELAND FOR THE CROW BUTTE 8-km PROJECT SITE AREA

	Total	Total Yield		Potential Animal Units[c]	
	Land Use	Acres	Tons[a]	Kgs.[b]	Per Month[d]
Rangeland	2,086.8	1,043.4	946,552	1,043	5,215
Pastureland	17,148.7	25,723.1	23,335,482	13,719	68,595
Total	19,235.5	26,766.5	24,282,034	14,762	73,810

[a] Yield for rangeland is .5 tons/acre, yield for improved pasture is 1.5 tons/acre.

[b] 1 ton = 907.18 kg.

[c] 1 animal unit = 1,000 lbs.

[d] 1 acre of rangeland supports .5 animal units in a month (aum); 1 acre of improved pasture supports .8 aum.

[e] Grazing season in Dawes County lasts approximately 5 months.

Source: D. Huls, 1982. Dawes County Agricultural Extension agent.

TABLE 2.2-9

RESIDENCE COUNT AND DISTANCE
TO NRC DESIGNATED CRITERIA[a]
(8-km RADIUS OF CROW BUTTE PROJECT CENTERPOINT)

Sector	Structures Count[b]	Nearest Residence (km)	Nearest Vegetable Garden (km)	Nearest Project Boundary (km)
N	2	5.7		2.4
NNE	1	4.0		2.0
NE	3	4.3		2.5
ENE	6	.6	.6	2.1
E	0	—		2.1
ESE	5	.6		1.4
SE	6	3.7		1.6
SSE	1	4.5		2.9
S	3	3.8		4.0
SSW	2	5.0		2.3
SW	3	1.6		1.5
WSW	3	3.1		1.3
W	3	2.5		1.3
WNW	38[c]	4.4		1.3
NW	608[c]	3.1		5.4
NNW	10	1.1	1.1	2.4

[a] As designated in the U.S. NRC Draft Regulatory Guide and Value/Impact Statement, July 1980.

[b] Residences.

[c] U.S. Census Bureau reported 621 housing units within the City of Crawford. As with the Sectorial population, housing units for Crawford are allocated as 5% for the WNW sector and 95% for the NW sector.

Sources: USGS, 1980; EH&A, 1982; U.S. Dept. of Commerce, 1981.

for the known rural households were then used to estimate the population of the remaining households located in the 10-km radius. As a result, an estimated 181 persons reside within the rural portions of the 8-km project radius. An additional 1,315 persons reside in Crawford, approximately 6.5 km (4 miles) from the site centerpoint (U.S. Bureau of the Census, 1982). Two dwelling units are within one-km (0.62 miles) and another five dwelling units are within two km (1.24 miles) of the centerpoint of the proposed permit site.

Commercial and Services. Retail and commercial establishments are located in both Crawford and Ft. Robinson. The three largest establishments include the Crawford Community Memorial Hospital, the Ponderosa Villa Nursing Home and the City of Crawford's sewage treatment plant.

Industrial/Mine. Eight gravel pits are found within the 8-km radius of the Crow Butte project area (see Fig. 2.2-2). Most of the pits are inactive, although a few are mined periodically for local road construction purposes. Besides Wyoming Fuel, Conoco, Ferret Exploration and Union Carbide have also drilled exploratory testing holes in the project area. The exact locations of their test holes are currently confidential (Roberts, 1982).

Other industrial facilities within the 8-km radius includes the railroad station and maintenance yard in the City of Crawford.

Recreational. The Ponderosa State Wildlife area, located less than two miles from the Crow Butte permit boundary area, is open to the public for hunting. Although no park sites in the Nebraska State Forest are found within the 8-km project area, the area is open for hiking and camping. The Cochran State Wayside Area, located 7 km (4.34 miles) southwest of the site, is a primitive camping area with ten campsites, hiking trails, and scenic views. A small portion of Fort Robinson State Park is within 8 km of the R&D site. Urban recreational facilities in the R&D project area include a golf course and city park in Crawford.

Aesthetics. The Crow Butte Project Area is visually enhanced by land form and color variation. Crow Butte provides a scenic backdrop along south and west approaches to the R&D site. Ponderosa pines and mixed evergreens offer scenic views while approaching from north of the project site. As the project area has been used historically for grazing, it is unlikely that any undisturbed areas exist within the R&D boundary. Human influence is evidenced by scattered farmhouses and some fencing; however, little previous industrial development has taken place.

Transportation and Utilities. Nebraska Highway 2 and U.S. Highway 20 converge in Crawford. 1980 average daily traffic counts range between 625-825 on Nebraska Highway 2 and between 1,190-1,125 on U.S. Highway 20 within the project area (Nebraska Department of Roads, 1981). Although unpaved, Squaw Creek Road provides access to the Crow Butte site. A Burlington Northern Railroad runs in a northwesterly direction approximately 1.2-km (0.75 miles) west of the site. Another railroad, the Chicago and Northwestern, travels from the southwest to the northeast through

Crawford. Several transmission lines traverse the project area, including one less than 1 km west of the designated centerpoint.

Other. Three cemeteries are within the R&D site area, one within two km of the site centerpoint. Two radio towers and two schools are also located in the area.

2.2.4 Water Uses Within the 8-km Project Site Area

The Crow Butte project site is drained by Squaw Creek and is within the White River Watershed. Squaw Creek is used by local landowners for irrigation, livestock watering, and domestic purposes, and by fish and wildlife habitat. Warm-water fishing and hunting also occur downstream from the Crow Butte Project.

The White River is used to support agricultural production, wildlife habitat, and both warm and cold-water fish. Within 10-km of the project, the White River also supplies drinking water to the citizens of Crawford. In 1981, average daily water usage ranged from a low of 199 gallons per day (gpd) in February to a high of 508 gpd in July. The maximum recorded daily water usage in Crawford was nearly one million gallons. The city also pumps water from Dead Man's Creek (McGennis, 1982).

Lake Crawford, as well as approximately 20 unnamed reservoirs ranging from 1 to 17 acres of surface area, is also located within the 10 km radius.

Ground water in the 8-km study area is supplied by either the Brule or the Chadron formations (Williams, 1982). A water well survey conducted by Fisher, Harden & Fisher Consultants indicates that most of the groundwater pumped from 123 wells surveyed within 2-1/4 miles of the proposed commercial study area is used either to water livestock or for domestic purposes. Two springs, located at Ft. Robinson State Park, produce an average of 576,000 gpd and a maximum of 864,000 gpd. Any excess water is pumped into ponds at the Crawford National Fish Hatchery. A spring-fed pond provides the hatchery with the rest of their water needs (Rotherham, 1982).

Specific water user information including abandoned wells and projected withdrawal rates surrounding the R&D facility can be found in Section 2.6.1 of this application.

Future water use within an 8-km radius of the project site will likely be a continuation of present use. It is unlikely that any additional irrigation development will occur due to the shortage of existing water. The City of Crawford has been trying to upgrade their existing surface water supply system and to obtain additional underground water supplies. A geologic study done for Ft. Robinson indicates that approximately 2,000 gallons of water from the White River are discharged every minute into the ground near Ft. Robinson. It is anticipated that a means to collect this lost groundwater for the City of Crawford will be developed (Williams, 1982).

2.2.5 Land & Water Uses Within the Resticted Boundary (RAB) Area

Table 2.2.10 identifies land use, by category, in the RAB area. Current land uses include pastureland (92.5%), forested land (5.0%) and cropland (2.5%). There are no irrigated lands within the RAB area. Two residences and one vegetable garden are located within 0.8 km (0.5 mi) of the RAB area (Table 2.2-9).

Squaw Creek travels in a north-south direction along the western boundary of the RAB area.

TABLE 2.2-10

LAND USE WITHIN THE RAB[a] PERMIT AREA

Category	Acres	km^2	% of Total Area
Cropland	1.84	0.00745	2.5
Forested Land	3.67	0.01485	5.0
Pastureland	67.95	0.27499	92.5
Total	73.46	0.29729	100.0

1 sq. kilometer = 247.1 acres.

[a] Restricted Area Boundary.

2.2.6 REFERENCES

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2.3
POPULATION DISTRIBUTION

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2.3 POPULATION DISTRIBUTION

This section includes information in accordance with the Nuclear Regulatory Commission's draft (1980) and final (1982) regulatory guides concerning environmental reports for in-situ uranium mining activities. This section corresponds to Sec. 2.3 of the NRC guidelines, entitled "Population Distribution". Information presented in this section concerns those demographic and social characteristics of the environs that may be affected by Wyoming Fuel's proposed Crow Butte operations. Data were obtained through the 1980 U.S. Census of Population and discussions with State and Local agency personel.

2.3.1 Demography

2.3.1.1 Regional Population. The 80-km (50-mile) area surrounding the project site includes portions of six counties in northwestern Nebraska, two counties in southwestern South Dakota, and two counties in western Wyoming. Because the 80-km boundary extends only slightly into two very rural counties in Wyoming (with populations less than 2,000 persons) the regional demography in through Wyoming is not discussed in detail beyond that summarized in the Tables 2.3-1 through 2.3-3.

Historical and current population trends in the project area counties and communities are contained in Table 2.3-1. Between 1960 and 1980, Box Butte County exhibited the fastest rate of growth with over a 17.0 percent population increase, largely occurring in the latter half of the 1970's. Population growth has been concentrated in the City of Alliance in

TABLE 2.3-1

HISTORICAL AND CURRENT POPULATION CHANGE FOR
COUNTIES AND TOWNS WITHIN 80 KM
OF THE CROW BUTTE PROJECT SITE, 1960-1980

State / County / City	Population 1960	Population 1970	Population 1977	Population 1980	Annual % Change 1960-1970	Annual % Change 1970-1977	Annual % Change 1977-1980
Nebraska							
Dawes	9,536	9,761	8,890	9,609	.23	-1.33	2.63
Chadron	5,079	5,921	5,049	5,933	1.55	-2.25	5.53
Crawford	1,588	1,291	1,254	1,315	-2.05	-0.41	1.60
Box Butte	11,688	10,094	11,202	13,696	-1.46	1.50	6.93
Alliance	7,845	6,862	7,997	9,869	-1.33	2.21	7.26
Hemingford	904	734	801	1,023	-2.06	1.26	8.50
Scotts Bluff	33,809	36,432	37,510	38,344	0.75	0.42	0.74
Scottsbluff	13,377	14,507	13,813	14,156	0.81	-0.70	0.82
Sheridan	9,049	7,285	7,464	7,544	-2.15	0.35	0.36
Hay Springs	823	682	627	794	-1.86	-1.19	8.19
Rushville	1,228	1,137	1,192	1,217	-0.77	0.68	0.69
Sioux	2,575	2,034	1,925	1,845	-0.24	-0.78	-1.40
Harrison	448	377	384	361	-1.71	0.26	-2.04
Morrill	7,057	5,813	6,200	6,085	-1.92	0.93	-0.62
South Dakota							
Fall River	10,688	7,505	8,344	8,439	-3.47	1.53	0.38
Hot Springs	4,943	4,434	4,759	[illegible]42	-1.08	1.02	-0.12
Oelrichs	132	94	145	124	-3.34	6.39	-5.08
Ardmore	73	14	17	16	-15.22	2.81	-2.00
Shannon	6,000	8,198	8,494	11,323	3.17	0.51	10.06
Wyoming							
Goshen	11,941	10,885	12,139	12,040	-0.92	1.57	-0.27
Niobrara	3,750	2,924	2,953	2,924	-2.46	0.14	-0.33
Lusk	1,890	1,495	1,710	1,650	-2.32	1.94	-1.18

Sources: U.S. Bureau of the Census, 1972a, 1972b, 1972c, 1979, 1981.

TABLE 2.3-2

POPULATION BY AGE AND SEX FOR COUNTIES
WITHIN THE 80-KM RADIUS OF THE CROW BUTTE PROJECT AREA, 1980

State/County	Age	Male	Female	Total	Total % Breakdown*
Nebraska					
Dawes	Under 1	79	94	173	1.8
	1-4	280	236	516	5.4
	5-13	552	542	1,094	11.4
	14-17	360	259	619	6.4
	18+	3,453	3,754	7,207	75.0
	Total	4,724	4,885	9,609	100.0
Box Butte	Under 1	164	153	317	2.3
	1-4	526	510	1,036	7.6
	5-13	975	935	1,910	13.9
	14-17	396	409	805	5.9
	18+	4,778	4,850	9,628	70.3
	Total	6,839	6,857	13,696	100.0
Scotts Bluff	Under 1	371	333	704	1.8
	1-4	1,290	1,227	2,517	6.6
	5-13	2,873	2,697	5,570	14.5
	14-17	1,430	1,342	2,772	7.2
	18+	12,633	14,148	26,781	69.8
	Total	18,597	19,747	38,344	99.9

TABLE 2.3-2 (Cont'd)

State/County	Age	Male	Female	Total	Total % Breakdown*
Nebraska (Concluded)					
Sheridan	Under 1	83	67	150	2.0
	1-4	256	225	481	6.4
	5-13	506	503	1,009	13.4
	14-17	281	248	529	7.0
	18+	2,539	2,836	5,375	71.2
	Total	3,665	3,879	7,544	100.0
Sioux	Under 1	11	15	26	1.4
	1-4	61	48	109	5.9
	5-13	109	118	227	12.3
	14-17	66	90	156	8.5
	18+	678	649	1,327	71.9
	Total	925	920	1,845	100.0
Morrill	Under 1	55	58	113	1.9
	1-4	200	194	394	6.5
	5-13	423	414	837	13.7
	14-17	208	205	413	6.8
	18+	2,123	2,205	4,328	71.1
	Total	3,009	3,076	6,085	100.0
South Dakota					
Fall River	Under 1	81	89	170	2.0
	1-4	262	262	524	6.2
	5-13	564	516	1,080	12.8
	14-17	274	274	548	6.5
	18+	3,207	2,910	6,117	72.5
	Total	4,388	4,051	8,439	100.0

TABLE 2.3-2 (Cont'd)

State/County	Age	Male	Female	Total	Total % Breakdown*
South Dakota (Concluded)					
Shannon	Under 1	183	208	391	3.5
	1-4	602	565	1,167	10.3
	5-13	1,400	1,261	2,661	23.5
	14-17	585	547	1,132	10.0
	18+	2,915	3,057	5,972	52.7
	Total	5,685	5,638	11,323	100.0
Wyoming					
Goshen	Under 1	95	111	206	1.7
	1-4	391	362	753	6.3
	5-13	851	762	1,613	13.4
	14-17	441	430	871	7.2
	18+	4,110	4,487	8,597	71.4
	Total	5,888	6,152	12,040	100.0
Niobrara	Under 1	28	18	46	1.6
	1-4	87	84	171	5.8
	5-13	190	192	382	13.1
	14-17	80	108	188	6.4
	18+	1,032	1,105	2,137	73.1
	Total	1,417	1,507	2,924	100.0

TABLE 2.3-2 (Concluded)

State/County	Age	Male	Female	Total	Total % Breakdown*
Total	Under 1	1,150	1,146	2,296	2.1
	1-4	3,955	3,713	7,668	6.9
	5-13	8,443	7,940	16,383	14.6
	14-17	4,121	3,912	8,033	7.2
	18+	37,468	40,001	77,469	69.3
	Total	55,137	56,712	111,849	100.0

* Percentages may not equal to 100.0% due to rounding errors.
Source: U.S. Bureau of the Census, 1981a, 1981b, 1981c.

TABLE 2.3-3

POPULATION PROJECTIONS FOR COUNTIES WITHIN AN
80-KM RADIUS OF THE CROW BUTTE PROJECT AREA, 1980 - 2020

County	Actual 1980	Projected 1980	1985	1990	1995	2000	2010	2020
Box Butte	13,696	9,465	9,442	9,529	9,528	9,453	9,327	9,216
Dawes	9,609	10,078	10,098	10,218	10,390	10,549	10,752	10,905
Scotts Bluff	38,334	39,620	41,214	42,695	43,854	44,869	46,950	48,657
Sheridan	7,544	6,790	6,758	6,811	6,789	6,723	6,635	6,581
Sioux	1,845	1,926	1,933	1,950	1,943	1,926	1,893	1,851
Morrill	6,085	5,635	5,818	6,077	6,284	6,485	7,019	7,690
Fall River	8,439	9,784	11,085	12,485	13,900	15,404	—	—
Shannon	11,323	8,397	8,049	7,724	7,456	7,172	—	—
Goshen	12,040	12,030	12,900	13,632	—	—	—	—
Niobrara	2,924	2,912	3,047	3,148	—	—	—	—

Sources: University of South Dakota, Bureau of Business Research, 1981.
University of Nebraska-Lincoln, Bureau of Business Research, 1981.
Wyoming Department of Administration and Fiscal Control, 1981.

southeastern Box Butte County, approximately 72 km (45 miles) south of the project site. The City of Alliance recorded a 1980 population of 9,869. Hemingford, also within the project site radius, showed population growth between 1977 and 1980, increasing to 1,023 by 1980.

With the exception of Scotts Bluff County, the other Nebraska counties comprising the project area experienced slight growth or actual population decline. Dawes County had a 1980 population of 9,609, only 0.8 percent above its 1960 level, although Chadron, its largest urban area, increased by nearly 17 percent over the last two decades. Chadron is located approximately 40 km (25 miles) northeast of the project site with a 1980 population of 5,933. The community of Crawford, within 10 km (6.3 miles) of the site, had a 1980 population of 1,315.

Sheridan, Sioux and Morrill counties experienced overall population losses between 1960 and 1980, although the small communities of Hays Springs and Rushville increased slightly in the latter half of the 1970's.

Scotts Bluff County experienced gradual population growth over the two-decade period with a 1980 population of 38,344, 14,156 of which is found in the City of Scottsbluff, located beyond the 80-km area.

The two South Dakota counties in the 80-km project area include Fall River and Shannon. Fall River County declined by nearly 2,000 persons between 1960 and 1980, with a gradual upturn evident by 1975. Shannon County, on the other hand, grew by 5,323 persons since 1960 to over 11,300 by 1980. Most of the increase occurred between 1977 and 1980. Only the very southern portions of both counties are included within the 80-km project area.

2.3.1.2 Population Characteristics. 1980 population by age and sex for counties within 80 km of the Crow Butte project area shown in Table 2.3-2. Overall, 69.1 percent of the population in the region are over 18 years of age. Dawes County reported the highest percentage of persons over 18 with 75 percent. About 2.1 percent of the population were less than one year old in 1980. Shannon County reported the youngest population, with 3.5 percent less than one year old and nearly half (47.3 percent) under 18 years of age. Females slightly outnumbered males, 50.7 percent to 49.3 percent.

In 1980 nearly 85 percent of the ten-county population were classified as white. Indians and persons with Spanish origin comprised 11.0 percent and 6.3 percent, respectively of the total population. Over 80 percent of the Indians were Sioux, living on the Pine Ridge Reservation in Shannon County, South Dakota.

2.3.1.3 Population Projections. The projected population for selected years by county within the 80-km radius of the proposed Crow Butte Project is shown in Table 2.3-3. Actual versus projected population for 1980 are either too high or too low for counties in Nebraska and South Dakota. Box Butte, Sheridan, and Shannon counties reported much higher 1980 population counts than those projected, while Dawes, Scotts Bluff, and Fall River population counts were lower than the projected numbers. The recent boom in activity uranium and oil and gas production in the area may not have been accounted for in these projections, thus causing the discrepancies.

2.3.1.4 Seasonal Population. In 1981, approximately 376,997 people visited Fort Robinson State Park. This number represents a 28.8 percent increase from 1980 and over a 100 percent increase from 1978 total visitors to the park. Fort Robinson officials estimate that total visitors to the park should at least equal that of 1981 (Rotherham, 1982; Foster, 1982). The majority of these visitors will be Nebraskan families, staying between 3 and 4 days.

The Trooper National Recreation Trail within the Nebraska National Forest recorded 1,800 visitor days in 1980 (Foster, 1982). Visitor statistics are not recorded for the Ponderosa Wildlife Area. However, some idea of the number visiting these areas can be assessed through the number of hunting permits issued. Most hunters and hikers visit the Ponderosa Wildlife Area and surrounding Nebraska National Forest during the spring and fall turkey season and the fall deer season. On the opening day of turkey season, approximately 20 hunters are allowed into the area. This daily number eventually falls to between 5-8 hunters. For opening day of deer season, approximately 40-50 hunters are permitted to hunt the area. This number also drops as the season progresses (Lemmons, 1982).

Another source of seasonal population in this region is Chadron State College, located approximately 35 km from the site. During the 1982 spring semester, 2000 students were officially enrolled at the college (Datson, 1982).

2.3.1.5 Sectorial Population. Existing population for the 80-km radius was estimated for 16 compass sectors, by annual rings of 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, and 80 km (a total of 208 sectors), as stipulated in the Final NRC Regulatory Guide and Value/Impact Statement (U.S. NRC, 1982). Subtotals by sector and compass points as well as the total population are shown in Table 2.3-4 and in Fig. 2.3-1.

Population Within the 10-km Radius

Population in the 10-km radius was estimated in the following manner:

a) 1980 U.S. census of population estimates of 1315 for the City of Crawford was used to estimate urban population in the 10-km radius.
b) The radius was drawn on a 1980 USGS Quad Map (1" = 2000'); the location of houses indicated on the map was then compared with an aerial photograph of the 10-km radius area.
c) A "windshield survey" of the area was conducted to check each rural house for occupancy. Obviously abandoned homes were excluded resulting in a total of 102 occupied rural housing units.
d) To estimate the number of rural residents, local citizens were interviewed. Actual persons per household estimates were used if the persons

TABLE 2.3-4

CURRENT POPULATION WITHIN AN 80-KILOMETER (50-MILE) RADIUS OF THE CROW BUTTE PROJECT SITE

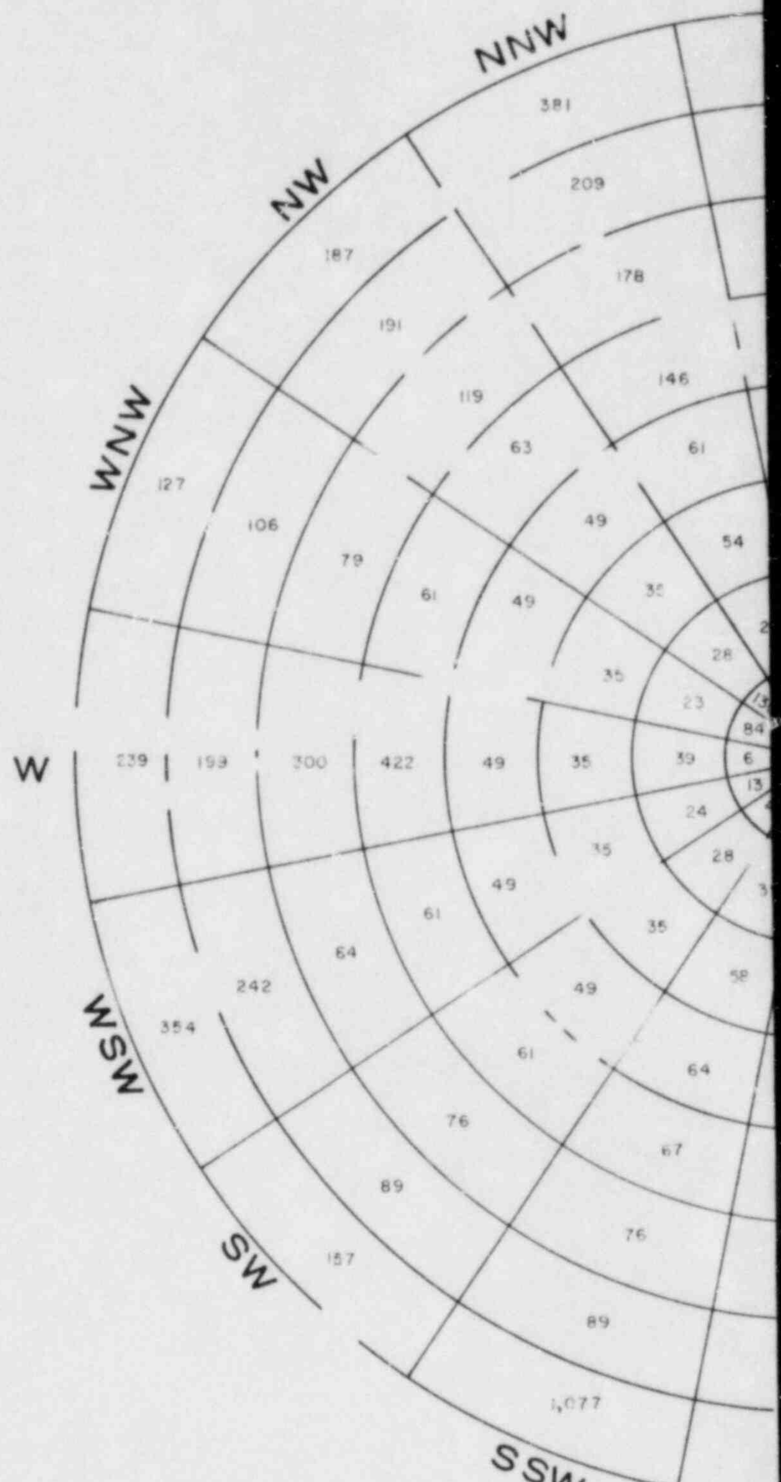
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80
N	0	0	0	0	0	15	39	65	95	145	178	210	242
NNE	0	0	0	0	1	2	111	65	92	142	185	400	365
NE	0	0	0	0	1	6	39	65	91	124	290	488	572
ENE	4	0	0	0	0	10	39	65	5,982	157	232	647	3,077
E	0	0	0	0	0	0	39	65	91	140	1,047	302	1,563
ESE	2	2*	3	0	0	5	39	65	91	125	249	302	348
SE	0	0	0	4*	4*	13	39	65	142	238	301	338	364
SSE	0	0	0	0	6	1*	39	94	91	1,367	301	354	10,290
S	0	0	0	0	0	10	39	110	192	243	283	299	1,186
SSW	0	1	0	0	0	5	39	58	64	67	76	89	1,077
SW	0	2*	4	0	0	4*	28	35	49	61	76	89	157
WSW	0	0	0	2*	0	13*	24	35	49	61	84	242	354
W	0	0	6*	0	0	6	39	35	49	422	300	199	239
WNW	0	0	0	0	2	84*[b,c]	23	35	49	61	79	106	127
NW	0	2	0	2*	0	1,308[b]	28	35	49	63	119	191	187
NNW	0	2	2*	0	5	21*	21	54	61	146	178	209	381
TOTAL	6	9	15	8	19	1,503	625	946	7,237	3,562	3,978	4,465	20,529

[a] An actual head count was conducted for the population living within 10-km of the mine site. These figures were supplemented by interview. people and 1980 census data for Dawes County and the City of Crawford. Current population living between 10-80 km of the mine site were esti 1980 census data. See Sec. 2.3.1.5 for a detailed description of EH&A's methodology.

[b] WNW sector includes 5% of the 1980 Crawford population; NW sector includes 95% of the 1980 Crawford population.

[c] Total persons residing at Ft. Robinson State Park.

* The average persons per household number for known rural households in the 10-km radius was used to estimate the population of the remaining located in the 10-km radius.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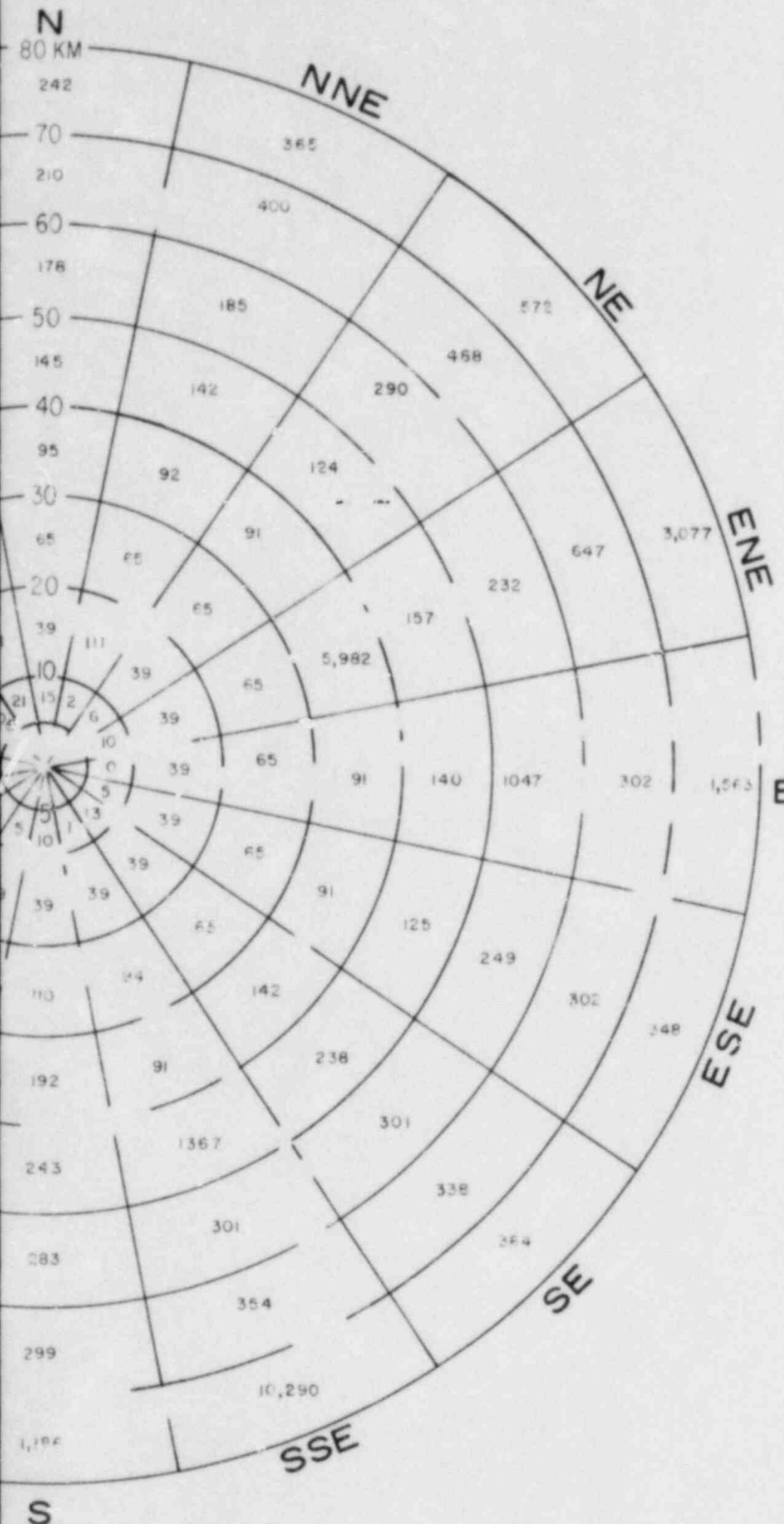

REV	BY	DATE	WYOMING FUEL COMPANY	
			CROW BUTTE PROJECT Dawes County, Nebraska	
			CURRENT POPULATION WITHIN AN 80-KILOMETER RADIUS BY SECTOR	
			PREPARED BY: S. HICKS	
			DWN BY: F. DAVIS DATE: 9/82	FIG. 2.3-1

interview agreed on the number of residents in a household.

e) The average persons per household for all known rural households in the 10-km radius was then used to estimate the population of the remaining occupied households located in the 10-km radius. 245 persons were identified in this manner.

f) Rural and urban populations were added together resulting in a total estimated population of 1560 within the 10-km radius.

Population Between the 10-km and the 80-km Radii

Current (1980) population found in between a 10-km and an 80-km radius of the site was determined as follows:

a) 1980 U.S. Census of Population estimates for cities and counties in Nebraska, South Dakota and Wyoming were used to arrive at total urban population.

b) City populations and areas (sq mi) were subtracted from their respective county population and area to determine the population density of the non-urban areas within each county.

c) Non-urban densities were multiplied by the number of square miles of area of each county in each of the 112 sectors to estimate 1980 non-urban population.

d) The population of cities within each sector was added to the rural population of that sector to get total 1980 population for each sector.

2.3.2 Local Socioeconomic Characteristics

2.3.2.1 Major Economic Sectors. As of the fourth quarter of 1981, the Dawes/Box Butte County area as well as the larger Scotts Bluff area to the southwest exhibited relatively low unemployment rates, ranging from 1.5 to 2.9 percent compared to 4.3 percent for the state. Total employment has been increasing at a slightly faster rate than the total labor force, keeping unemployment rates down (Nebraska Department of Labor, 1982).

The major economic sectors in the project area have changed little in recent years, although individual sectors have shifted in their relative proportion in the overall economy. The area continues its dependence on trades, government and services with considerable buildup in the transportation and utilities sector as railroad activities increased in the Alliance area. Approximately 25 acres adjacent to the western portion of Crawford has been allocated for an industrial park.

The transportation sector accounts for approximately 36 percent of total nonfarm employment and 24 percent of total personal income in the Dawes/Box Butte County area. The trade and government sectors individually comprise 19 to 22 percent of both total employment and income. In Scottsbluff county the trade and manufacturing sectors predominate.

2.3.2.2 Housing. Between 1970 and 1980, total housing units increased by 17 percent in Dawes County and as much as 44 percent in Box Butte County to the south. Chadron, the largest community in Dawes County (1980 population of 5,933) and within 40 km (25 miles) of the project site, experienced a 25 percent increase in housing stock. Alliance, in Box Butte County, approximately 72 km (45 miles) from the project site with a 1980 population of 9,869 exhibited a 54 percent growth in total housing units during the decade (U.S. Department of Commerce, Bureau of the Census, 1981a).

In 1980, Dawes and Box Butte counties had vacancy rates of 10.9 and 8.4 percent, respectively (U.S. Department of Commerce, 1982). The average value of owner-occupied units for sale ranged from $34,500 in Dawes County (approximately 1,600 units) to $45,200 in Box Butte County (approximately 2,400 units). The average value of available rental units ranged from $142 per month in Dawes County (900 units) to $196 per month in Box Butte County (1,250 units) (U.S. Department of Commerce, Bureau of the Census, 1982).

According to a local Crawford realtor, rental property in Crawford is scarce. However, a May 1982 listing of property revealed nine houses, one lot, one rooming house and two parcels of land were up for sale. Housing prices ranged from $11,000 to $28,000 while the parcels of land averaged less than $500/acre (Lakey, 1982).

High interest rates and high tax rates are the major deterrences for potential home buyers in the project area. Interest rates on most home mortgages run around 18%. However, the Nebraska Mortgage Finance Fund recently offered 13 1/8% interest home loans for those persons making $32,500 or less.

The purchase of homes by Wyoming Fuels employees would provide the City with ad valorem property taxes. The City of Crawford levys the highest mill rate in the entire State of Nebraska, with taxes on a $50,000 home about $1,500/yr (Lakey, 1982).

2.3.2.3 Preliminary Assessment of Social and Economic Effects

The Crow Butte R&D project will require an average of eight employees during the construction phase beginning in July 1983. At the end of the construction activities, in late 1983, it is anticipated that a total of seventeen employees will be on-site as operations employees. These employees could eventually be operators within the commercial plant and well field, providing a stable transition to the commercial operations phase. The commercial plant would require a gradual employment increase through 1990 to approximately 50 employees. Both the gradual nature of employment increase and the estimated local resident hiring of about 90-95 percent of the total work force suggests that existing public facilities and services will not be adversely affected by project-related population growth. Income from salaries paid to Wyoming Fuels employees are expected to result in increased business and governmental incomes within the Crawford area and surrounding region.

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2.4 REGIONAL HISTORIC, ARCHEOLOGICAL, ARCHITECTURAL, SCENIC AND NATURAL LANDMARKS

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2.4.1 INTRODUCTION

The initial Research and Development (R&D)-scale study for the Crow Butte project was carried out by the University of Nebraska (UNL) during March and April, 1982. A review of pertinent literature and records and an intensive (100% coverage) pedestrian survey of select project lands (Section 19, T31N, R51W) were completed to identify resources which may be affected by development of the R&D-scale mining operation.

A summary of the results and recommendations of this study is presented here. The full descriptive account of this work, prepared by UNL in Technical Report No. 82-02 (Bozell and Pepperl 1982), is on file at the Nebraska State Historic Preservation Office and is available for professional review.

2.4.1.1 STUDY METHODS

Methods utilized in this study were developed in accordance with Federal standards (36CFR1210) for data recovery and reporting requirements published as proposed guidelines (36CFR Part 66) in the Federal Register (42[19]:5374-5383, January 1977). Tasks completed in the present work program are identified below.

Literature Review. A thorough review of previous archeological, paleontological, and historical studies relevant to the study area was conducted to identify known resources, particularly those within an 8km (5mi) radius of the projected R&D facility location, and to assess the general cultural and scientific significance of the study region. The status of known resources with respect to National Register eligibilities was determined through consultation of listings published in the Federal Register.

This effort involved examination of select published references as well as other site records and materials on file at the Division of Archeological Research, the University of Nebraska libraries, the Midwest Archeological Center, National Park Service, and the Nebraska State Historical Society. More extensive reviews may be required at a later date pending development of commercial operations.

Archival Research. The reference resources noted above as well as records filed at the National Archives, Washington, and the Dawes County Courthouse, Chadron, were inspected for historic documentation of persons and events associated with project area locations. In addition to published histories and biographies, pertinent records include various land entry files such as the U.S. General Land Office Tract Book, homestead claimant and witness proof documents, and the county Numerical Index, as well as other county records and available historic map sources.

This effort involved gathering of general information concerning the commercial study area (CSA) as well as site-specific data pertinent land tracts and resources located within the R&D plant unit. Beyond interpretive considerations, this work provides a basis for assessing the importance of area resources to local, regional or national history.

Field Investigation. On-site efforts consisted of an intensive (100% coverage) pedestrian survey of the R&D study area (640 acres) and preliminary documentation of observed surface remains. In addition to locating and identifying previously unrecorded resources within the survey unit, the field visit was also utilized to verify architectural locations noted on various map sources, primarily farmsteads, that were visible from roadways throughout the commercial study area. These field data were employed in evaluating the extent of particular tasks that would be required during the commercial-scale study.

Resource Evaluation and Reporting. Analytic and reporting efforts necessary to the resource management objectives of this study included: 1) processing and descriptive analysis of recovered materials; 2) compilation of site-specific descriptive data and field records; 3) preliminary assessment of identified resources with respect to site integrity and National Register criteria regarding cultural and scientific values; and 4) preparation of a report providing suggested stipulations for clearance of the R&D plant unit (Section 19, T31N, R51W) for project development, and recommended design for compliance work required for clearance for commercial-scale operations. Evaluative considerations and recommendations were accomplished through consultation with appropriate State (SHPO) and Federal (NRC) agencies.

2.4.2 BACKGROUND

2.4.2.1 Environmental Setting

The most prominent physiographic feature in the general project area is the Pine Ridge Escarpment, which Fenneman (1931:4, 18) considers a distinct physiographic sub-unit marking the northern limits of the High Plains section of the Great Plains province. This heavily dissected escarpment occupies the northern half of Sioux and Dawes Counties and rises 300 to 900 ft. above a broad area of low relief extending into South Dakota.

Scenic and Natural Landmarks. The Pine Ridge region contains a variety of scenic and natural landmarks, several of which are visible or within close proximity to the proposed CSA. The most prominent are the extensive butte and ridge systems surrounding the general vicinity, particularly Crow Butte and Little Crow Butte directly to the east of the project boundary and Red Cloud Buttes ca. 5km to the northwest. Crow Butte, the site of a notorious conflict between the Crow and Brule Sioux Indians in 1848 (Hanson and Walters 1976:14-15), also served as a prominent landmark for early explorers, fur traders, and settlers. Additional scenic features characterizing this area include the White River valley along the northern edge of the CSA, and the Pine Ridge Division of the Nebraska National Forest bordering the southern and eastern margins of the project, and including the Ponderosa State Wildlife Area.

2.4.2.2 Cultural Setting

The general project vicinity has been inhabited intermittently for the past 10,000 years by a variety of Native American populations and more recently by Euroamerican traders, settlers, and rural communities.

Prehistoric Periods. The project area is situated near the edge of both the Central Plains and Northwestern Plains archeological subareas as defined by Wedel (1961, 1978, Frison (1978), and others.

Recognized cultural units in the general vicinity are: Paleo-Indian (10,000-5,000 B.C.), Archaic (5,000 B.C. - A.D. 1), Plains Woodland (250 B.C. - A.D. 950), and several Plains Village (A.D. 900-1850) taxa including Dismal River, Upper Republican, and Coalescent prehistoric cultural traditions and variants as well as historic Native American populations (e.g., Dakota or Sioux) are also represented.

Paleo-Indian remains (projectiles) are commonly reported for this area, but only one site has been systematically investigated. The Hudson-Meng site, located approximately 40km (25mi) northwest of the Crow Butte project along a tributary of the Cheyenne River in Sioux County, was subjected to testing and excavation by Chadron State College during the late 1960s through the late 1970s (Agenbroad 1978a; 1978b). These investigations have verified the presence of a Paleo-Indian bison kill and adjacent butchering floor, associated with over three hundred bison, and an abundance of artifactual material. The majority of diagnostic projectile points is assigned to the Alberta culture (Agenbroad 1978a:131). Radiocarbon assays place the occupation between 8900-9400 B.P.

Archaic and Woodland period sites in the region have not been intensively studied but surveys near the project area indicate both periods are represented by small temporary camps (Meston 1976:43). It is noteworthy that much of the Archaic materials recorded by Meston and others (site files, NSHS) appear to be associated with the latter portion of the period. Systematic study of these and earlier sites known in this area could potentially have some impact on our understanding of human occupation of the Plains during a period (ca. 6000 B.C. - 1500 B.C.) of changing environmental conditions recognized as the Altithermal climatic episode (see Antevs 1955; Reeves 1973).

Plains Village tradition materials are also present in the region. Ceramic and chipped stone diagnostic artifacts indicate several cultural taxa are represented including Dismal River (Gunnerson 1960:226), Upper Republican (Meston 1976:43-44), and Coalescent components (Ludwickson 1982) The presence of historic Native American nomadic groups, particularly Dakota or Sioux, during Euroamerican settlement and military occupation of the region are more extensively documented (see Grange 1978; Hyde 1937; and Hanson and Walters 1976).

Historic Exploration and Settlement Periods. Historic accounts of Native American presence within the study area, including oral traditions and notes of explorers and military personnel, indicate that during recent times (ca. 1800-1877) this region was contained within various tribal hunting territories as well as territorial boundaries and reservations defined by Federal treaties. However, Native

American occupation of relatively permanent or long-term settlements in the immediate area are not evident. Various nomadic groups as the Sioux, Cheyenne, Arapaho and Crow located largely in the Black Hills area to the north utilized the White River region and other areas extending south to the Platte River (see Hartley 1981).

The principal Native American group occupying or utilizing the study area throughout at least much of the nineteenth century was the Teton Sioux tribe (or Lakota). The Teton represent the western division of the Dakota-speaking subgroup (Sioux) of the Siouan linguistic family and include the Brule and Oglala bands (see e.g., Voeglin 1941). The Teton gradually moved westward from their homelands in Minnesota during the eighteenth century (Hyde 1937) and various sources indicate their territory extended to the headwaters of the White River by the early nineteenth century (see e.g., Lewis and Clark 1814:1, 714; Thwaites 1905:VI, 98-99).

Beginning in 1851, Federal treaties with the various Plains tribes significantly reduced the 'Indian territory' west of the Missouri River but the Sioux retained control of the White River region (Royce 1899:786-787). By 1868 further land cessions confined the Sioux to a permanent Dakota reservation extending along the southern edge of present South Dakota between the Missouri River and the Black Hills with rights only to hunt within their former territories to the south (Royce 1899:848-849). The Oglala and Brule, along with other groups were issued supplies at the Red Cloud Agency (1873-1877) and Spotted Tail (Whetstone) Agency (1872-1877) located respectively west and east of the present project area but outside the reservation proper. The locations of camps or other occupancy of these groups within the immediate project vicinity is unclear.

Removal of the agency populations to reservation lands to the north in 1877 opened the area to Euroamerican settlement and large cattle raising operations entered the vicinity as early as 1878 (Grange 1978:225).

The influx of Euroamerican influence within the project area discussed here concerns various episodes of fur trade, military installations and frontier settlement largely involving an 80 year period between the mid-nineteenth and early twentieth centuries. Earlier entries into the Central and Northern Plains by French, English and American explorers were essentially restricted to the Missouri and Platte River drainages. As part of the Missouri

Company's efforts to open the upper Missouri River to commerce, James MacKay traveled up the Niobrara River in 1796 but turned south near present Valentine without reaching the general project vicinity (see Nasatir 1952:93-108; Diller 1955).

The fur trade extended into Dawes County during the 1830s and two trading posts were established south of Chadron in the 1840s (Hanson and Walters 1976:6). These include Chartran's Post (1841-1845) and Bordeaux's Post (1841-1876). The fur trade in western Nebraska ceased following the termination of the Bordeaux Post.

In 1855, a military exploration under the leadership of General W.S. Harney entered the project vicinity by traveling down the White River through South Dakota and into the Nebraska Panhandle (Warren 1856). The first permanent military installation in the area was Camp Robinson, established in 1874 near the Red Cloud Agency to control Indian opposition. The installation was renamed Fort Robinson in 1878 and remained an important post for the monitoring of Indians and frontier settlement. The fort was utilized for various military purposes through 1948 (Grange 1978).

Settlement of Dawes County began in 1885 under the provisions of the Pre-emption Act of 1841 and the Homestead Act of 1861 and was intensified with arrival of the railroad in 1886. Most of the land was settled during the 1880s, but adverse environmental and economic conditions, such as the drought of the 1890s, forced three out of five people to leave their claim after several years (Ragon et al. 1977:1). The town of Chadron was formed in 1885 and Dawes County and Crawford were established the following year (Anonymous 1961).

2.4.2.3 Summary and Assessment of Previous Investigations

The Pine Ridge region including the White River drainage of northwest Nebraska has been the subject of occasional small scale archeological, paleontological and historical studies for a number of years. Interest in the paleontological remains of the area extends to the late nineteenth century. Archeological sites are known but for the most part intensive survey and excavation efforts have not been initiated within the general area. Attention to historic resources has been directed largely toward the late nineteenth century military and reservation activities associated with sites at the west edge of the study area. In each case, previous work provides a general view of the potential productivity of this region for study but only a limited range of resource types and contexts have been considered. Systematic investigations within the present project unit have not been previously initiated.

Paleontological Studies. Surficial geology and paleontology of northwest Nebraska has been studied by numerous workers beginning with O.C. Marsh in the 1870s (see Schuchert and Levene 1940) and continuing to the present (Schultz and Stout 1955; Martin 1973). Most of these efforts have concentrated on select localities, primarily within the "Little Badlands" area approximately 24km (15mi) northwest of the Crow Butte project (see Darton 1903; Schultz and Stout 1955; Wood 1969; Singler and Picard 1980). Limited stratigraphic work and fossil collecting have been carried out in the Pine Ridge Escarpment (see Wellman 1964; Martin 1973) but have not included systematic inspection of exposures located within the Crow Butte project along the eastern and southern margins of the permit area.

Bedrock exposures in the immediate Crawford vicinity are limited to the late Oligocene-early Miocene Arikaree group (Gering, Monroe Creek and Harrison formations of Lugn, 1939) which have produced important vertebrate fossils in western Nebraska and South Dakota (Macdonald 1970; Martin 1973). This general region is the single source of early Miocene exposures accessible to study east of the Rocky Mountain range.

The upper-most unit of the Arikaree group, the Harrison formation, is exposed at the top of the buttes within the Pine Ridge Escarpment. The medial unit, the Monroe Creek formation, comprises the majority of the bluff exposures and is clearly represented within the project. The Gering formation (known as the Sharps formation in South Dakota), and possibly a portion of the upper Oligocene Brule formation, may be accessible at the base of higher sections.

Type sections of these formations in Nebraska are from near Harrison located west of the study area. Exposures of these strata are known to occur in the Crawford area, but with the exception of work in the Fort Robinson vicinity, published stratigraphic sections are not available for the present survey unit.

Fossil taxa expected within strata exposed in the project area include 131 faunas known from rocks of the same age at localities in the surrounding area (see e.g., Macdonald 1970). Fish bearing strata are rare but occasional thin shale lenses representing lake bed deposits can be expected. Few birds are known but numerous lizards and a broad range of mammals are recorded. The only North American early Miocene primate (Ekgmowechashala philotau) is contained within the Gering formation. Other mammalian faunas of the Arikaree group include marsupials (mini possums); small insectivores and rodents; various carnivores including the last occurrence of archaic canine as well as ancestral dogs and also sabre cats; and finally a variety of ungulates, principally oreodonts but including tapirs, horses, rhinos, a giant hog (Entelodontidae, indet.), camels, and small "deer."

University of Nebraska State Museum (UNSM) collecting localities near the Crow Butte project include four Arikaree sites located largely within escarpment areas beyond the permit boundary.

UNSM Dw-108 (Chadron Roadside Locality) is located approximately 27km (17mi) northeast of the project and contains fossils of the Gering formation. This site was discovered by Larry D. Martin and Hal McGrew in 1970 (see Martin 1973).

UNSM Sx-22 (unnamed) is situated directly northwest of the project, approximately 20km (12mi) beyond the permit boundary, and is also a Gering formation locality but includes Oligocene units (see Martin 1973).

Cochran Wayside Area Locality is located just southwest of the proposed permit area within the escarpment. Three significant collections have been made from which 10 species of fossil vertebrates have been identified.

Coffin Butte Locality is situated in the Fort Robinson area west of the Crow Butte project. More than 20 scattered fossil finds representing early Miocene mammals have been recorded.

Cultural Resources Investigations. Early archeological reconnaissance in the region was largely an unprogrammed effort associated with paleontological research carried out by the University of Nebraska State Museum. Barbour identified weathered-out features (hearths) as early as 1891 in the general vicinity (Barbour and Schultz 1936:444). Various Paleo-Indian projectiles, particularly Yuma and Folsom types, were collected during preliminary paleontological and geological reconnaissance of the area (Barbour and Schultz 1936:432, 444).

More recent reconnaissance of the region has been conducted by the Nebraska State Historical Society (NSHS). The bulk of this work has been limited site inspections and testing largely associated with highway salvage efforts, but resulting in identification of numerous archeological localities in both Sioux and Dawes Counties (see Grange 1964, 1978). These investigations have documented human occupation of the area throughout the recognized period of Native American and Euroamerican use of the Plains area.

Portions of the White River and Hat Creek drainage systems within the Oglala National Grassland Preserve north of the Crow Butte project were systematically surveyed in 1972 by the University of Nebraska, Department of Anthropology. Intensive surface inspection along segments of the creek terraces was limited to the upper reaches of Whitehead Creek and entire lengths of Big Cottonwood and Sand Creeks, all in northern Sioux and Dawes Counties (Meston 1976). These survey units extended to within 8-16km (5-15mi) north of the Crow Butte project permit boundary. More than 30 Native American sites were identified (Meston 1976:2). Diagnostic cultural materials indicate occupation of the region during the Paleo-Indian, Archaic, Woodland, Plains Village, and Historic periods (Meston 1976:42).

In sum, reconnaissance survey and limited testing have been conducted in the immediate vicinity for over 50 years. These efforts were largely oriented toward documentation of select cultural manifestations. The manner in which these recorded resources are representative of the range of cultural variability within the region cannot presently be defined. Sustained, systematic investigations necessary to this evaluation have not been initiated. However, through previous efforts, it is evident that the northwestern Nebraska region has supported human occupation throughout the range of recognized prehistoric and historic periods.

Previously recorded resources relevant to these periods include nine Native American and Euroamerican sites located within an 8km (5mi) radius of the Crow Butte project, two of which are situated within the CSA. These resources (see Bozell and Pepperl 1982:17-18) are summarized in Table 1. Relationship to the present survey unit (Section 19, T31N, R51W) is also indicated.

National Register Properties. A consultation of the most recent listing (Federal Register 47[22], Tuesday, February 2, 1982) of properties on the National Register

Table 1. Summary of previously recorded cultural resources within an 8km (5mi) radius of the projected R&D plant location; Crow Butte Project, Dawes County, Nebraska.

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Relation to Project Area[2]
25DW51 (Ft. Robinson)	U.S. military post guardhouse; ca. 1874 (National Historic Landmark)	1966 excavation (NSHS); Grange (1978)	7.0km northwest
25DW54 (Red Cloud Agency)	Oglala Sioux reservation, agency post (ca. 1873-1878) (National Historic Landmark)	1958 survey and surface collection (NSHS)	5.5km northwest
25DW55	Fort Robinson (general area)		7.0km northwest
25DW59	lithic debris; unassigned	1956 survey (NSHS)	5.5km northwest
25DW60	lithic debris; unassigned	1956 survey (NSHS)	4.5km northwest
25DW73	lithic debris, bone; Historic Sioux	1959 survey (NSHS)	4.5km northwest (within CSA)
25DW74 (Franey)	lithic debris, tools (end scrapers), hearth; preceramic	1959 survey and collection (NSHS); Grange (1964)	2.5km northeast
25DW88	Historic Dakota burial	1969 survey (NSHS)	6.5km north
25DW89	Euroamerican homestead (?)	1972 recorded (NSHS)	1.0km northwest (within CSA)

[1]NSHS = Nebraska State Historical Society; CSC = Chadron State College.
[2]Indicates distance (km) and direction from R&D-scale unit (Section 19, T31N, R51W).

Table 1. Summary of previously recorded cultural resources within an 8km (5mi) radius of the projected R&D plant location; Crow Butte Project, Dawes County, Nebraska (concluded).

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Relation to Project Area[2]
25DW105 (OK Ranch)	lithic debris, tools, ceramics, bone; Upper Republican/Dismal River (Agenbroad 1976); Extended Coalescent (Ludwickson 1982)	1976 survey (CSC)	7.0km north

[1]NSHS = Nebraska State Historical Society; CSC = Chadron State College.
[2]Indicates distance (km) and direction from R&D-scale unit (Section 19, T31N, R51W).

of Historic Places (Federal Register 44[26], Part II, 1979) indicates seven sites in Dawes and Sioux Counties are on the Register but none are located within proposed project boundaries. The nearest registered sites are Fort Robinson and the Red Cloud Agency (see Table 1) which have been designated as National Historic Landmarks (documentation on file, National Park Service, Denver).

The final listing of the National Registry of Natural Landmarks was also consulted (Federal Register 1977, 37 [20]:1496-1499). A single Nebraska resource, Fontanelle Forest in Sarpy County at the eastern margin of Nebraska, is listed.

2.4.2.4 Regional Natural and Historical Significance

Extant information, as discussed above, offers ample evidence that the Nebraska panhandle segment of the High Plains physiographic unit contains a variety of natural and historical resources characteristically limited to this region that could potentially provide unique research opportunities from several perspectives. The Pine Ridge region and the adjacent White River drainage system include a number of widely recognized paleontological localities as well as prominent natural landmarks. In addition, the region contains key historic resources associated with military and Native American reservation periods (i.e., Fort Robinson and the Red Cloud and Spotted Tail Agencies). Recent archeological investigations in the High Plains suggest the prehistory of the region is characterized by a high degree of cultural homogeniety within a broad temporal sequence (Frison 1978:2-3). This portion of the High Plains also provides a number of lithic source localities including the Chadron formation outcroppings, Little Badlands, and the Spanish Diggings quarries (Wyoming) that could influence the range of Native American site types present within the study area.

Although general categories of potentially significant natural and scientific values have been identified, a systematic record of the full range of resource variability has not been compiled. This situation is particularly true of paleontological and prehistoric cultural resources. Implementation of a regional-scale systematic sampling program would be required to fully address issues relevant to prehistoric, historic, and natural significance and to develop an appropriate preservation plan.

2.4.3 ARCHIVAL RESEARCH

A preliminary search of historical documents was completed prior to initiation of the field investigation to generate expectations concerning the potential presence of historic sites within the study area and to develop a basis for evaluating identified resources. Work involving local sources was carried out during the field visit. Following the on-site inspection, additional records were researched for particular locations within the study unit to obtain data concerning individuals, construction dates, periods of occupation and other information relevant to identification of recorded resources.

2.4.3.1 Rural Domestic Settlement

The land tract contained by the R&D study unit (Section 19, T31N, R51W) was initially settled as four equal-sized pre-emption claims filed in the late 1880s and maintained by the claimants for four or less years. Within less than 20 years the entire section was owned by two individuals (Eugene Stetson and Henry Daniels) whose families presently maintain title to the property. With two exceptions--Thorp (SW¼) and Hobson (NE¼)--transactions prior to the Stetson and Daniels purchases were short-term and likely involved non-resident interests.

Information obtained from Federal land entry files (Dawes County Courthouse and National Archives, Washington) and census records (Nebraska State Historical Society) indicate that the four initial claimants occupied homesteads within the survey unit at various times during the period 1885-1893. Further details concerning these individuals--J.J. Harvey (see site 25DW111), Hans Wulf (see site 25DW112), Cyrenius Fiandt (see site 25DW113), and Frank Fleming (see site 25DW117)--and buildings constructed on their claims are documented in the full study report (see Bozell and Pepperl 1982:21-23).

Only one of the four homesteads is plotted on any of the historical map sources (1913-1980) available for review. This site (25DW112), Wulf/Daniels Place) appears on all maps consulted. This evidence may indicate that the three unrecorded locations were abandoned and structures removed prior to 1913.

This difference between map data and locations field recorded within the R&D scale survey unit, as well as general field observations within the CSA suggest that previous rural settlement on project lands was likely of greater density than indicated by historic map information. A total of 34 historic resource locations--largely farmsteads of which 27 contain intact buildings--were noted during a brief field check of the entire permit area. Only 24 of these locations are represented on available maps.

2.4.3.2 Rural Institutions

Evidence of rural community facilities previously located within the study area consists of a public school, a church, and a cemetery. A second public school location, situated just beyond the northern boundary of the survey unit, is also relevant here.

Superintendent of Schools records on file at the county courthouse in Chadron indicate that present survey lands (Section 19) were once within former School District No. 25 and lands directly north (Section 18) were at one time within District No. 9.

District No. 25 was formed 15 February 1886 and a schoolhouse was apparently established in the extreme northeast corner of Section 19 (see 25DW115). District No. 9 was formed 3 October 1885. A former schoolhouse location is in the extreme southwest corner of Section 18 at 1 mi due west of School No. 25. The two districts were consolidated in 1903 and dissolved in 1976.

The presumed original site (25DW115) of the District No. 25 schoolhouse was also the location of the First Presbyterian Church of Crow Butte which was constructed ca. 1896 on an acre of land purchased for $25.00 from A.E. Hobson (numerical index). According to Mr. Harold Gibbons, who presently farms this tract, the church building was later moved several times eventually arriving at its present location at the Wulf/Daniels farmstead (see 25DW112).

The relationships between the school and church usage of this site or the date when the building ceased functioning for either purpose is unclear. The Standard Atlas of Dawes County (1913), the earliest map source for this area showing structural locations, labels both of the two sites in Section 18 and Section 19 (25DW115) as schools. These two structure locations are also plotted on the U.S. D.A. 1915 series soil survey map (Burn et al. 1917) and both appear to be represented by church symbols. However, only the site in Section 18 is shown on the 1937 Department of Roads highway map suggesting that the church (or former school building) located in Section 19 (25DW115) was moved sometime between 1915 and 1937.

In either event, the study area apparently contained a sufficient population to sustain a church and school during the late nineteenth century and maintained a school until 1976. Archival records concerning the Crow Butte Cemetery (1888-1971) located at the western edge of the survey unit were not investigated.

2.4.4 STAGE 1 FIELD INVESTIGATIONS: 1982

An in-field inspection of the R&D study area (Section 19, T31N, R51W) was conducted during the period 29 March - 2 April 1982, by an experienced four-member field crew. Additional procedures carried out during this effort included verification of architectural structures visible from roadways throughout the CSA, coordination with Wyoming Fuel Company (WFC) field personnel and landowners, and historic archival research for Section 19 conducted at the Dawes County Courthouse.

2.4.4.1 Survey Procedures

All lands within Section 19 were subjected to intensive (100%) pedestrian surface survey. The investigation procedure consisted of walking in a zig-zag reconnaissance pattern at closely spaced intervals, normally 20-30m. Intervals were modified as necessary to meet varying terrain and vegetational conditions. Inspection of all exposed areas, such as animal burrows, WFC exploratory drill pads, and eroded surfaces was completed. An intensive effort was made to examine all cutbanks exposed along Squaw Creek and adjacent intermittent tributaries for buried cultural deposits.

All cultural sites identified during the survey were plotted on U.S.G.S. 7.5 minute topographic maps (Crow Butte Quadrangle). A detailed examination of the immediate area of each located cultural resource was performed to identify horizontal limits and composition of surface materials. A preliminary field inventory of observed materials and sketch map of the immediate site vicinity were also made at this time. In addition, photographic documentation of all site locations was completed. More extensive field documentation such as instrument mapping (transit), collection of temporally diagnostic specimens, and in one case cutbank profiling, was carried out during further investigations of select sites.

Surface visibility varied within the section. Much of the northeast quarter section was cultivated (very short winter wheat) providing good to excellent visibility. Most of the remaining surface was covered with short bunch grass offering fair visibility. The surface of the wooded Squaw Creek bottomland was generally obscured but creek bank exposures facilitated subsurface observations throughout this area.

2.4.4.2 Survey Results

A total of 640 acres including a segment of the Squaw Creek channel and associated terraces were inspected resulting in identification of ten previously unrecorded cultural resources. Seven of these are assigned systematic site numbers while the remaining three locations are designated only by their field numbers for reasons discussed below. Descriptive characteristics are summarized in Table 2. A map of recorded resource locations is provided in the full study report (Bozell and Pepperl 1982: Figure 3).

Native American Resources. Two Native American sites, an isolated fragment of chipped stone flaking debris (FN-1), and a subsurface deposit of bone (cf. bison) and charcoal (FN-2) exposed along the Squaw Creek cutbank were identified within the R&D plant unit. Origin of the bone deposit is unclear. Site 25DW114 consists of an extensive scatter of chipped stone tools, flaking debris, and bone, while remains at site 25DW116 are limited to three specimens of chipped stone flaking debris. All of these sites are located within 100m of Squaw Creek in the northeastern portion of the section.

Euroamerican Resources. Five Euroamerican sites and the Crow Butte Cemetery (FN-3) were recorded during the survey. These resources include an abandoned farmstead (25DW112), three historic debris scatters marking the former locations of two possible homestead sites (25DW111 and 25DW113) and a removed church (25DW115), as well as an isolated windmill complex (25DW117).

Table 2. Summary of cultural resources identified during the spring 1982 investigation; Crow Butte Project, Dawes County, Nebraska.

Site Number	Description and Temporal Assignment	Topographical Location	Area (m^2)	Field Investigation
25DW111 (Harvey Homestead ?)	surface; glass, ceramic, metal, bone debris; Euroamerican; late 19th century (?)	top and slope of small knoll	1,024	survey, sketch map, photographs
25DW112 (Wulf/Daniels Place)	surface; abandoned farmstead (house, depression, 11 outbuildings); Euroamerican; late 19th/early 20th century	broad terrace; Squaw Creek	6,000	survey, sketch plan, photographs
25DW113 (Fiandt Homestead ?)	surface/buried; glass, ceramic, metal, wood, leather debris (25-40cm S.D.); 4 depressions; Euroamerican; late 19th century (?)	broad terrace; Squaw Creek	9,000	survey, transit map, soil probe/shovel test, photographs
25DW114 (unnamed)	surface; chipped stone tools, flaking debris, bone; Late Archaic and possibly other pre-Plains Village period components	broad terrace; Squaw Creek	250,000	survey, transit map, controlled surface collection, photograph
25DW115 (School No. 25)	surface; glass, brick debris; former location of First Presbyterian Church and public school; Euroamerican; late 19th century	small rise on upper slope	900	survey, sketch map

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Table 2. Summary of cultural resources identified during the spring 1982 investigation; Crow Butte Project, Dawes County, Nebraska (concluded).

Site Number	Description and Temporal Assignment	Topographical Location	Area (m^2)	Field Investigation
25DW116 (unnamed)	surface; chipped stone flaking debris; unassigned Native American	terrace slope; Squaw Creek	2	survey, sketch map, photographs
25DW117 (Fleming Homestead ?)	surface; windmill, cistern, stocktank complex; Euroamerican (possibly associated with Fleming Homestead); late 19th century (?)	terrace slope; Squaw Creek	250	survey, sketch plan, photographs
FN-1	surface; 1 chipped stone flake; unassigned Native American	terrace slope;	1	survey
FN-2	buried; bone, charcoal; unknown cultural association	eroding cutbank; Squaw Creek	50 (length)	survey, controlled bank profile/collection, sketch map, photographs
FN-3	Crow Butte Cemetery; Euroamerican; 1880-1971	level ridge top	2,700	survey, sketch plan, photographs

2.4.5 SITE DESCRIPTIONS

Brief narrative descriptions summarizing locational information and the results of site-specific investigations are presented here in sequence by site number. Detailed descriptions, site maps, photographs, and field records for each of the ten resource locations are contained in the full study report (Bozell and Pepperl 1982:31-54 and Appendix B).

Field observations lacking spatial integrity (e.g., isolated specimen locations) or identifiable cultural association, as well as sites (e.g., cemeteries) not eligible for National Register consideration are designated by field numbers (FN-1 through FN-3) and are described following the site narratives.

2.4.5.1 25DW111 (Harvey Homestead ?)

This site consists of historic debris thinly scattered on the top and slopes of a small knoll in the extreme southwestern corner of Section 19 at 3885 ft. elevation. Approximately 25-30 specimens including window glass, milk glass, china, white (thin) ironstone, metal, and bone were observed within an area of ca. 32x32m, and left in place.

The site is situated on a land tract for which the initial claim (pre-emption) was filed by Jefferson J. Harvey in 1888, and finalized in 1891 (U.S. General Land Office tract book). Federal census records for 1900 (Crawford Precinct) indicate Harvey was born in Missouri in 1852, married Lillie Phelps in 1876, and together they had six children. Harvey and his family moved to Dawes County in April of 1886 and filed a pre-emption claim for the southwest quarter of Section 19. Harvey initially constructed a dugout on the land, where he and his family lived for several years, while Harvey farmed and worked for the Chicago and Northwestern Railway. The family eventually moved to Crawford where Harvey was appointed City Marshall from 1901-1908 (Anonymous 1909:315).

Claimant's testimony filed by Harvey (17 October 1888) summarizes improvements he made on the claim (National Archives, Washington). The house (16x32 ft.) was a two-story frame structure with shingle roof, board floors, three doors, and six windows. Additional structures included: a log stable (14x16 ft.), cellar (10x12 ft.), hen house/cow shed, and a well (53 ft. deep). Harvey's cost estimate for these improvements was $598.00. At the time of his testimony, Harvey had 30 acres of tilled land on which he raised corn, oats, millet, and vegetables.

Although this site may represent the former location of the farmstead constructed by the Harvey family in homesteading this land tract, no definitive evidence of this possibility was obtained. However, other potential homestead remains were not identified within Harvey's initial claim (southwest quarter).

2.4.5.2 25DW112 (Wulf/Daniels Place)

This site is an abandoned farmstead consisting of an intact house and twelve outbuildings as well as various structural remains and debris situated at 3880 ft. elevation on a broad south and west-facing terrace directly above the east bank of Squaw Creek. An access drive connects the farm to a county road at approximately 0.3km (0.2mi) to the east.

Each of the 18 features identified are presented in Table 3. The present condition of each of the nine intact buildings ranges from poor to good, but in general all appear to remain structurally sound. A map of the site and photographs of various structures is provided in Bozell and Pepperl (1982: Figures 4, 5, and 6).

Feature 1, the dwelling, is comprised of four major structural components which may represent as many construction episodes. A veranda or open porch extends along the eastern facade, or formal front, of the house and connects the gabled upright at the southeastern corner, the central wing, and a smaller gabled unit at the northern end of the building. In addition to the present door in the wing extension, a former doorway, later converted to a window, is located in the east facade or gable end of the upright unit.

On the basis of Wulf's proof testimony (see below) the gabled upright at the southeastern corner of the building likely represents the core component or initial dwelling unit. The exterior of this structure is sheathed with vertical planking (1x12 in) over which horizontal clapboard (¼x4 in) has been added suggesting the possible use of timber frame construction.

The site is situated on the land tract initially claimed (pre-emption) in 1889 and patented in 1891 by Hans Wulf who held the property for four years until 1893. Wulf's

Table 3. Summary of structures and surface features recorded at the Wulf/Daniels farmstead (25DW112) during the 1982 investigation; Crow Butte Project, Dawes County, Nebraska.

Feature Number	Description and Structural Details	Exterior Dimensions(m)
1	house; single story balloon (?) frame; hipped and gable roofs, stone and concrete foundation; wire and cut nails	13.8x13.0
2	chicken coop; balloon frame, gambrel roof, concrete foundation; wire nails	2.5x3.75
3	chicken coop; balloon frame, hipped roof, concrete foundation; eight sided; wire nails (see Figure 6A)	5.0x10.9
4	shed; log, stone foundation; wire nails	3.3x3.0
5	depression; large, [illegible]near; possibly barn location	13.0x19.5
6	latrine; frame, gable roof; wire nails	1.4x1.4
7	shed (poultry ?); balloon frame, shed roof, stone and concrete foundation; wire nails	3.7x2.6
8	former church; balloon frame, gable roof, stone and concrete foundation; wire nails (see Figure 6B)	11.2x7.4
9	storage shed; balloon frame, gable roof, stone foundation; wire and cut nails	7.5x5.0
10	grain storage/barn; balloon frame, gable roof, stone and concrete foundation; wire nails	9.5x6.2
11	garage/work shop; balloon frame, gable roof, concrete foundation; wire nails	8.8x6.1
12	windmill/stocktank; metal, concrete block foundation	-
13	stone foundation	3.6x1.8
14	stone concentration	-
15	lumber debris (structure location ?)	-
16	cistern; metal cover	2.0x1.3
17	propane tank	-
18	lumber debris (structure location ?)	-

NOTE: The location of each feature is shown on the site map (see Bozell and Pepperl 1982: Figure 4).

homestead testimony (8 April 1889) summarizes improvements he made on the claim. The house (14x16 ft.) is a frame structure with a shingle roof, board floor, one door, and two windows. Additional structures include a frame barn (16x24 ft.), cave (8x12 ft.), corral, and fence (40 acres). Wulf's cost estimate for these improvements was $310.00. At the time of his testimony, Wulf was farming 10 acres (corn and vegetables).

The dimensions (4.4x5.0m or 14.4x16.4 ft.) of the gabled upright at the southeastern corner of the present dwelling are consistent with the house dimensions (14x16 ft.) recorded by Wulf. The barn dimensions provided by Wulf (16x24 ft.) are similar to those recorded for Feature 9 (16.4x24.6 ft.). The vertical siding of this feature could indicate a relationship to construction utilized in Wulf's house and that a late nineteenth century episode is reasonable. Similar construction was recorded for Features 10 and 11, possibly indicating that these buildings were part of the original Wulf farmstead constructed prior to 1893 and suggesting that the original farmyard likely ocupied the southeastern third of the site. The location of the cave or cellar constructed by Wulf is presently unclear.

The site appears to have been occupied since 1888, however particular details concerning occupational history remain unclear; these can likely be established through interviews with local residents.

2.4.5.3 25DW113 (Fiandt Homestead ?)

This site consists of one large and three small depressions (see Table 4) located on a broad terrace surface. A sparse scatter of historic debris (10-15 specimens) is situated on the eroded terrace slope adjacent to the depressions. The site is located at 3890-3900 ft. elevation approximately 60-100m south of the west bank of Squaw Creek.

The surface scatter contains bottle and window glass fragments, thick brown ironstone, and metal. Subsurface materials identified in probe tests of one depression (Feature 3) include burned wood, glass, metal, and leather. A contour map of the site is presented in Bozell and Pepperl (1982:40).

The site is situated on a land tract for which the initial claim was filed by Cyrenius Fiandt in 1888 and finalized in 1891 (U.S. General Land Office tract book). Claimant's proof testimony filed by Fiandt (10 December

Table 4. Summary of surface features identified at site 25DW113 during the spring 1982 field investigation; Crow Butte Project, Dawes County, Nebraska.

Feature Number	Description	Dimensions (m) LengthxWidth	Dimensions (m) Depth	Comments
1	depression with remains of stone foundation (7 rocks) at perimeter	7.5x7.0	ca. 0.85	probe test: sterile
2	depression	7.2x6.2	ca. 0.35	shovel test (0-40cm S.D.): burned wood, glass, metal, leather noted at 25-40cm S.D.
3	depression with remains of stone foundation (ca. 25 rocks) on east edge	9.4x7.5	ca. 0.50	shovel test (0-25cm S.D.): rocks noted at 10-15cm S.D.
4	depression	27.0x23.0	ca. 1.00	shovel test (0-25cm S.D.): sterile

1888) summarizes the improvements he made on the claim (National Archives, Washington). The house (12x15 ft.) was a frame structure with board and tarpaper roof, board floor, three doors and five windows. An 8x12 ft. addition was also added. Additional structures included a frame barn (12x28 ft.), board barn (12x16 ft.), cave (8x12 ft.), log chicken coop (8x12 ft.), fence (105x36 ft.), hog yard, and a well (41 ft. deep). Fiandt's cost estimate for the improvements was $400.00. At the time of his testimony, Fiandt was farming 10 acres planted in corn, wheat, potatoes, and millet.

Site 25DW113 is likely the former location of the Fiandt homestead. No alternative locations were identified within Fiandt's initial claim. Interviews with local residents could serve to clarify the origin and use of this site.

2.4.5.4 25DW114 (Unnamed)

This site consists of an extensive scatter (100x200m) of chipped stone tools, flaking debris and bone fragments exposed on the surface of a cultivated field (winter wheat). The site is situated at 3880 ft. elevation on the broad south-facing terrace above the east bank of Squaw Creek and extends across the entire cultivated area limited by roads on the east and north, by the terrace edge on the south, and by an abandoned farmstead (25DW112) on the west.

A total of 37 specimens was recorded at 28 surface locations and included chipped stone tools (n=10), flaking debris (n=18), and unmodified bone (n=9) as described in Table 5. A contour map showing the distribution of these materials is presented in the full report (Bozell and Pepperl 1982: Figure 8). Only eight stone tools and a single identifiable bone fragment were collected. These specimens are discussed and illustrated in Bozell and Pepperl (1982:43-47).

The presence of an Archaic period component at this site is indicated by a nearly complete projectile (Bozell and Pepperl 1982: Figure 9-C) which compares with a Duncan type specimen originally illustrated by Wheeler (1954: Figure 1-a, c). This point type has been recovered from sites in Montana, Wyoming, and central South Dakota, as well as western Nebraska and is affiliated with prehistoric occupations during a span ranging from 2550-850 B.C. In general, the type is attributed to mid-to-late (ca. 1500 B.C.) Archaic period origins (see e.g., Wedel 1961:250-251; Frison 1978:40-56).

Table 5. Inventory of cultural materials recovered at Native American site 25DW114 during the spring 1982 investigation; Crow Butte Project, Dawes County, Nebraska.

Cat. No.	Specimen Category and (Frequency)	Description
1	lithic tool (1)	triangular biface (?), edge fragment; quartz
2	lithic tool (1)	endscraper, distal fragment; quartz
3	lithic tool (1)	straight/ovate biface, solid quartzite
4	lithic tool (1)	triangular biface, proximal fragment; chert
5	lithic tool (1)	endscraper, distal fragment; chert
6	lithic tool (1)	double-notched biface; chert
7	lithic tool (1)	double-notched biface; chert
8	lithic tool (1)	retouched flake; solid quartzite
9	unmodified bone (1)	Bovidae; right proximal radius
10	lithic tool (1)	retouched flake; solid quartzite
11	unmodified bone (1)	unidentifiable fragment
12	unmodified bone (1)	unidentifiable fragment
13	lithic debris (1)	chipped stone flake; quartzite
14	lithic debris (1)	chipped stone flake; chert
15	lithic debris (1)	chipped stone flake; chert
16	lithic debris (1)	chipped stone flake; quartzite
17	lithic debris (1)	chipped stone flake; clear chalcedony
18	unmodified bone (1)	unidentifiable fragment
19	unmodified bone (1)	unidentifiable fragment
20	lithic debris (2)	chipped stone flake; chert chipped stone flake; solid quartzite
21	unmodified bone (1)	unidentifiable fragment
22	unmodified bone (1)	unidentifiable fragment
23	lithic debris (1)	chipped stone flake; chert
24	lithic debris (1)	chipped stone flake; solid quartzite
25	unmodified bone (1)	unidentifiable fragment
26	unmodified bone (1)	unidentifiable fragment
27	lithic tool (1)	retouched flake; chert
	lithic debris (1)	chipped stone flake; chert
28	lithic debris (6)	chipped stone flake; chert
	lithic debris (1)	chipped stone flake; solid quartzite
	lithic debris (2)	chipped stone flake; chalcedony

NOTE: The provenience of all specimens is indicated per catalog number on site map (Bozell and Pepperl 1982: Figure 8). Catalog numbers 1-9 were collected; all other materials were left in place.

2.4.5.5 25DW115 (School No. 25)

This site is the former location of a rural schoolhouse and the First Presbyterian Church of Crow Butte, which has since been moved to another location (see site 25DW112, Feature 8). The site presently consists of a limited scatter of brick fragments and window glass located on a small rise in the extreme northeastern corner of Section 19 at 3900 ft. elevation. The surface of the area is currently under cultivation (winter wheat).

The initial claim for this land tract (NE¼, Section 19) was filed by Hans Wulf in 1889 and finalized in 1891 (U.S. General Land Office tract book). A.E. Hobson acquired the property in 1893. The First Presbyterian Church of Crow Butte purchased from Hobson one acre of land in the northeast corner of the quarter section for $25.00 in 1896 (Dawes County numerical index). Construction of the church began in the same year. It is unclear when the structure was moved to the Daniels farmstead, however, the Standard Atlas of Dawes County (1913) and the 1917 soil survey map show the structure (as a school) at its original location. The 1937 Department of Roads map and current topographic map (1980 Crow Butte Quadrangle) have no structures plotted for this location, indicating the building was probably moved sometime between 1917 and 1937. Harold Gibbons, who currently farms this tract, indicated that the structure had been used as both a church and school at its original location, and for hay storage at the present location at site 25DW112.

The site appears to have been originally developed as a school (ca. 1886) and later as a church (ca. 1896; see Archival Research, 2.4.3). The building was moved several times prior to arriving at its present location. The precise date of the original movement is uncertain but probably occurred between 1915 and 1937. Interviews with local residents could clarify the function and use periods of this site.

2.4.5.6 25DW116 (Unnamed)

A single chipped stone tool and flaking debris (n=2) were observed along the west-facing terrace slope above and ca. 30m east of Squaw Creek. The site is situated at 3850 ft. elevation. A retouched flake (silicified wood) and two specimens of chipped stone flaking debris (chert and red/white chalcedony) were recorded within a 1x2m surface area. These specimens were left in place.

The observed lithic specimens are not temporally diagnostic and the site has not been assigned to a particular cultural period. Verification of subsurface deposits and possible relationship to an isolated find (FN-1) located approximately 200m northwest would require limited subsurface testing of the west-facing Squaw Creek terrace slope within and between these two locations.

2.4.5.7 25DW117 (Fleming Homestead ?)

The site consists of a wooden framed windmill, concrete cistern, and metal stock tank situated within a barbed wire fence near the edge of the southwest-facing terrace approximately 40m northeast of Squaw Creek at 3840 ft. elevation. The windmill, manufactured by the Aeromotor Company, is in good and operable condition, but presently is not utilized.

The site is located in the northwest quarter of Section 19. The initial claim for this land was filed by Frank Fleming in 1886 and finalized in 1890 (U.S. General Land Office tract book). The 1900 series Federal census records for Dawes County indicate Frank Fleming was born in Ohio in December of 1852 and homesteaded in Dawes County during the 1880s. By 1900 Fleming was a blacksmith residing in Crawford. Fleming's homestead proof testimony (26 October 1886) summarizes improvements he made on the claim (National Archives, Washington). The house (18x24 ft.) was a log structure with three doors and five windows. Outbuildings included a frame blacksmith shop (14x22 ft.), frame stable (12x14 ft.), corn crib/wagon shed (16x16 ft.), and a well. Fleming's cost estimate for these improvements was $525.00. At the time of his testimony, Fleming was farming 12 acres as well as operating the blacksmith shop.

This site may be the former location of the Fleming homestead but positive evidence for this possibility was not obtained. No other potential location for this farmstead was identified within Fleming's initial claim (northwest quarter).

2.4.5.8 Field Number-1

This locality consists of an isolated fragment of chipped stone flaking debris located on a west-facing terrace slope approximately 20m east of Squaw Creek at 3840 ft. elevation. The observed specimen is a small brown chert percussion flake. No additional cultural materials were located, however, a small lithic scatter (25DW116) was identified approximately 200m southeast of FN-1.

The surface specimen is not temporally diagnostic and the locality is not assignable to a particular cultural period. Verification of potential subsurface materials and possible relationship to site 25DW116 would require limited subsurface testing of the west-facing Squaw Creek terrace slope within and between these site areas.

2.4.5.9 Field Number-2

This locality consists of a buried horizon of bone (Bovidae) and charcoal exposed in an approximately 50m extent of the west bank of Squaw Creek at 3830 ft. elevation. The majority of these materials occur in two soil levels of light brown/grey mottled silty sand. Surface depth of these levels ranges from ca. 1.00-1.50m. A very limited quantity of bone and charcoal was observed in an upper level of medium grey/brown mottled fine silty sand (0.20-0.40m S.D.).

A controlled profile of the bank was excavated and matrix was dry screened through 1/4-in hardware cloth. Materials recovered through these procedures included approximately 20 large mammal bones (see Table 6). No cultural materials were observed in the creek bank or recovered through the screening process.

All recovered vertebrate materials appear to be Bovidae (cow/bison). Two elements (fibular tarsal and metacarpal) compare well with bison materials. Most of the remaining elements also appear to be bison but positive identifications could not be made due to the incomplete and eroded condition of the specimens.

No information gathered during investigation of FN-2 suggests this deposit of bone and charcoal is the result of human activity. However, given the limited nature of testing during the spring 1982 investigation as well as the association of bison bone and charcoal, future cutbank profiling and subsurface testing on the overlying creek bottom surface may be warranted to clarify the origin of these materials.

2.4.5.10 Field Number-3 (Crow Butte Cemetery)

This locality is the site of the Crow Butte Cemetery, which is situated on a nearly level bluff top on the western margin of Section 19 at 3910 ft. elevation. The cemetery contains at least 16 headstones with dates of death ranging from 1888-1971. Dimensions of the site are ca.

Table 6. Summary of vertebrate remains recovered from controlled bank profile #1 at site FN-2, Crow Butte Project, Dawes County, Nebraska.

Cat. No.	Depth (S.D.)	Taxa	Element	Side/Portion	Comment
1	0.25m	Bovidae	unidentified long bone	unsided diaphysis fragment	
2	1.35m	*Bison bison*	fibular tarsal	right complete	
3	1.40m	*Bison bison*	metacarpal	left proximal	rodent gnawing
4	1.30m	Bovidae	1st phalange	left complete	carnivore gnawing
5	bank slump	Bovidae	mandible	right posterior (M/2)	
5	bank slump	Bovidae	patella	right complete	carnivore gnawing
6	bank slump	Bovidae	rib fragments (7)	unsided	
7	1.05m	Bovidae	cranial fragments (6)	unidentified	
8	0.80m	Bovidae	rib fragment	unsided	rodent gnawing

NOTE: see Bozell and Pepperl 1982: Appendix B for drawing of bank profile.

90x30m and it is surrounded by a barbed wire fence with wooden posts. A gate is located in the fenceline along the western margin.

None of the individuals interred in the Crow Butte Cemetery were involved in settlement of the R&D-scale study area (Section 19, T31N, R51W). In that cemeteries are ordinarily not considered eligible for National Register consideration (36CFR60.6), this location was not further documented or evaluated.

2.4.6 DISCUSSION AND RECOMMENDATIONS

2.4.6.1 Preliminary Resource Evaluation

In that subsurface testing and other intensive site-specific investigations were not programmed for the initial effort, information concerning the limits and integrity of potential cultural deposits, as required for National Register assessment of these locations, has not been defined, and where warranted, will need to be developed during future stages of the study. Initial evaluations of each of the ten recorded resource locations are summarized in Table 7.

Native American Resources. The three locations containing surface evidence of Native American remains are all located along the north side of Squaw Creek within 100m of the stream channel. A fourth location, consisting of buried bone (cf. bison) and charcoal exposed in the south bank of the creek, is of uncertain cultural association.

Two of these sites (25DW116 and FN-1) are represented by limited surface materials. Although present evidence is not indicative of productive data recovery potentials, the presence of buried cultural deposits cannot be entirely discounted. Should subsurface remains be encountered in this area as a result of project development, a professional evaluation of the deposit would be required.

The third site, 25DW114, is more clearly of potential research interest in that it contains materials relevant to taxonomic, functional, and subsistence considerations, along with a greater likelihood for intact subsurface remains, suggesting that a broader range of research questions could be productively addressed at this location.

Table 7. Preliminary resource evaluations and Stage 1 recommendations for prehistoric and historic sites identified during the 1982 field investigation; Crow Butte Project, Dawes County, Nebraska.

Site Number and Name	Site Type and Period of Use	Preliminary Evaluation and National Register Potentials[1]	Recommendation[2]
25DW111 (Harvey ?)	surface debris (former homestead ?); ca. 1888	moderate historic (local) value; limited data recovery potential (archeological)	no further work
25DW112 (Wulf/Daniels)	abandoned farm buildings; ca. 1889-1960s (?)	moderate historic (local) and probable architectural (regional) interest; productive data recovery potential (architecture)	avoid physical and visual effects; assessment to clarify potential effects
25DW113 (Fiandt ?)	surface; depressions, debris; (former homestead); ca. 1888	limited historic value; moderate data recovery potential (archeological)	no further work
25DW114 (unnamed)	surface; lithic, bone; mid-to-late Archaic (ca. 1500 B.C.) and other pre-village component (?)	probable scientific value; productive data recovery potential (archeological)	avoid physical effects; limited testing to establish site limits and clarify potential effects

[1]Historic values noted here refer to estimated availability of written or verbal documentation. The importance of these values remains to be determined.

[2]Further work required to identify specific limits for avoidance and to determine need for further National Register assessment is indicated.

Table 7. Preliminary resource evaluations and Stage 1 recommendations for prehistoric and historic sites identified during the 1982 field investigation; Crow Butte Project, Dawes County, Nebraska (concluded).

Site Number and Name	Site Type and Period of Use	Preliminary Evaluation and National Register Potentials[1]	Recommendation[2]
25DW115 (School No. 25)	surface debris (former school and/or church moved to 25DW112); ca. 1886-1930s (?)	moderate historic (local) value; limited data recovery potential (archeological)	no further work
25DW116 (unnamed)	surface; lithic; unassigned Native American	unknown scientific value; limited data recovery potential	no further work
25DW117 (Fleming ?)	unused livestock watering facilities; contemporary	limited historic value; limited data recovery potential	no further work
FN-1 (unnamed)	isolated; lithic; unassigned Native American	limited data recovery potential	no further work
FN-2 (unnamed)	buried; bone, charcoal; unknown cultural association	unknown scientific value	no further work
FN-3 (Cemetery)	Crow Butte Cemetery (1888-1971)	not eligible for National Register consideration	avoidance; contact local managers if affected

[1]Historic values noted here refer to estimated availability of written or verbal documentation. The importance of these values remains to be determined.

[2]Further work required to identify specific limits for avoidance and to determine need for further National Register assessment is indicated.

A general temporal and cultural assignment of the remains, or of a component of the site, is provided by a nearly complete projectile (cat. no. 7) recovered from the surface that is assignable to a variant of the general McKean complex which is a Middle to Late Plains Archaic period archeological unit principally associated with the High Plains including the Northwestern and Northern Plains subareas (see e.g., Mulloy 1954; Wedel 1961:250-251; Frison 1978:40-56).

Previous systematic investigations of Plains Archaic components have not been initiated within the northwestern Nebraska area. McKean complex variants are largely known from surrounding areas in Wyoming, Montana, and the Dakotas (see e.g., Tratebas 1981) but are not well defined. In this respect, site 25DW112 could provide important site-specific data concerning this general High Plains complex and will be a key component in future considerations of project-wide significance relevant to regional prehistory.

Although remains recorded at this site have been exposed by surface disturbance through cultivation, and additionally may have been affected by the farm drive on the north, the diversity and horizontal extent of the observed assemblage indicate that further productive data recovery is possible but will require testing below the plow zone to establish the presence of intact deposits. Likewise, testing would be required to determine site limits, particularly along the northern site margin, as needed to define a strategy for avoidance of project impacts on this potentially significant archeological resource.

Euroamerican Resources. Five of the six Euroamerican sites recorded within the R&D-scale study unit apparently originated during the initial ten-year phase (ca. 1886-1896) of homestead settlement in the immediate area. The other site (25DW117) consists of livestock facilities which appear to be of more recent origin but may occupy the location of a potential homestead site (Fleming) that was not otherwise identified. Only four of these early settlement period sites warrant evaluation; the fifth (FN-3), the Crow Butte Cemetery (ca. 1888-1971), is not eligible for National Register consideration (see 36CFR Part 60.6).

Of these four resources, three locations (25DW111, 25DW112 and 25DW113) likely represent initial homestead sites while the fourth (25DW115) is the former location of the First Presbyterian Church of Crow Butte (ca. 1896-1930s ?) and possibly the original site of School No. 25 (ca. 1886-1903 ?).

Three sites contain only surface debris (25DW111) or foundation remains (25DW113 and 25DW115). Although these sites could offer productive archeological opportunities, the presence of intact subsurface deposits is unknown. The availability of historic documentation that would add to the value of these resources with respect to understanding of local and regional history appears, at present, to be limited.

The remaining site, 25DW112 (Wulf/Daniels Place) contains intact architectural features that are of probable stylistic importance and possible structural interest but will require further field assessment to facilitate these determinations. In particular, the dwelling (Feature 1) at this site may provide an example of architectural developments that are represented by a limited number of houses in Nebraska and are not normally associated with the period during which the structure was likely constructed.

The original component of this house apparently consisted of the single upright unit at the south end of the building. The upright and wing which extends to the north at the front central portion of the house may represent the initial stage of modification in developing the present structural form. Alone, the small, nearly square (4.4x 5m) upright component represents a minimal housing unit (Glassie 1975:118) such as that utilized for early colonial dwellings as derived from the English "Hall" or one-bay cottage house generally of about 16 ft. (ca. 5m) in length (Foley 1980:14). The vertical planking beneath the horizontal clapboard siding of this unit may also indicate an English traditional influence and suggests the possibility that this portion of the structure may be constructed of timber framing rather than balloon framing more commonly used during the late nineteenth century.

In considering the upright and northern wing as a composite house unit, this component is referrable to Greek Revival forms which are typified by a door in the gable end with one or two wings extending from the sides of the house (Glassie 1968:129). This formal architectural style was largely associated with the period 1820-1860 (Whiffen 1969:37-47) but apparently continued in folk construction beyond the mid-nineteenth century (Glassie 1968:133).

Although the building would be of interest in either case noted above, further consideration of these possibilities will require inspection of the house interior to develop floor plans, structural details, and clarification of the sequence of construction of the various components.

2.4.6.2 Potential Project Impacts

Criteria of effect are as defined in 36CFR800.3 and involve direct or indirect changes resulting from project development that alter the integrity of location, setting, materials, or other characteristics relevant to potential National Register qualifications of the subject resources. Direct environmental alterations considered here are short range, immediate effects including surface modifications and constructed features associated with the R&D building site, access roads, and R&D production locations that could potentially result in: 1) physical disturbance of resources locations; or 2) introduction of visual elements that are out of character and disrupt or alter the setting of applicable resources.

Considerations relevant to the R&D operation are as follows:

1. No properties previously listed in the National Register of Historic Places or registered as natural or historic landmarks occur within the R&D-scale survey unit and no pending plans in this regard were identified.

2. Ten newly identified resource locations were recorded as a result of the Stage 1 survey, but data recovery sufficient to fully assess National Register eligibilities was not programmed as part of this work.

3. On the basis of present information, two of the ten newly recorded resource locations warrant further field investigation and assessment with respect to National Register criteria. These locations are of potential site-specific importance on the basis of scientific data recovery opportunities (25DW114) and architectural merit (25DW112) and will be key elements in assessing resource significance on a project-wide level during the CSA investigation.

4. Avoidance of effect is the principal option in each case, pending full assessment. Avoidance of physical disturbance is relevant to both resources while maintenance of the integrity of setting is applicable to architectural features at site 25DW112.

5. The planned site layout for the R&D facility involves a plant building (ca. 70x100 ft.) of approximately two stories in height, two evaporation ponds, and a well field. These and other minor features will be contained within an

area approximately 8 ha (20 ac.). This location occupies a resource-free area directly south of Squaw Creek. The planned building is west (ca. 350m or 1150 ft.) of site 25DW113 and is southwest (ca. 330m or 1100 ft.) across the creek from the southern margin of sites 25DW112 and 25DW114.

6. The R&D facility will not physically disturb any of the identified resources. Further considerations relevant to the three nearest resources concern only the visual relationships of the plant to architectural site 25DW112.

7. Based on plans developed by WFC, the R&D facility will not adversely affect the visual integrity of site 25DW112. Architectural features at site 25DW112 and those planned for the R&D facility are situated at comparable elevations (ca. 3886 ft.) on opposing sides of Squaw Creek. The top of the R&D structure would be at approximately 3910 ft. elevation, about 10 ft. above the uppermost ground-level elevation of site 25DW112. In this respect, the buildings at each site, given the intervening distance, would be of comparable visual scale. Additionally, the wooded valley of Squaw Creek effectively separates the two locations both in terms of distance and with respect to the partial screening of the R&D facility provided by the trees along the creek bottom. The unimposing size and orientation of the planned structure should not significantly disturb the rural character of this area.

2.4.6.3 Stage 1 Recommendations

Cultural remains recorded at eight of the ten newly identified resources located within the Stage 1 survey unit appear to represent limited site-specific historical values and data recovery potentials and in themselves do not presently warrant National Register consideration. Further field work at these sites is not recommended on the basis of extant information. Although it is unlikely that these eight sites will be important in consideration of resource significance at a project-wide level, it remains possible that further professional evaluation could be required should subsurface remains be encountered as a result of project development.

The two resources (25DW112 and 25DW114) which do warrant further consideration of potential National Register eligibilities will not be directly affected by development of the R&D site and continued assessment of these resources will not be necessary prior to construction of the planned facility.

In sum, general and site-specific recommendations regarding the R&D survey unit are as follows.

1. No further investigations will be required in advance of planned construction. Clearance of this area for R&D operations is recommended.

2. Pending adequate assessment of sites 25DW112 and 25DW114 (see Bozell and Pepperl 1982:61-62), stipulations relevant to possible future development within this unit (Section 19) concern only avoidance of effect on these two resources. The recommended limits for avoidance of physical disturbance consists of an area (ca. 8 ha or 20 ac.) bounded on the south by the north bank of Squaw Creek and on the north by a line 50m north and parallel to the present access drive to site 25DW112. The eastern boundary is the county road and the western limit is defined by the creek channel. This area encompasses the recorded surface extent of both sites and provides a boundary beyond which the possible limits of site 25DW114 would not be expected to exceed.

3. In the event subsurface cultural deposits are encountered during construction, professional evaluation should be permitted to determine the need for data recovery.

2.4.7 SUMMARY AND CONCLUSIONS

The initial stage of cultural resources investigations within the proposed Crow Butte Uranium Prospect near Crawford, Dawes County, Nebraska was carried out during March and April 1982 under a contractual agreement between Wyoming Fuel Company and the University of Nebraska. Preliminary background and archival research were initiated in conjunction with an intensive field survey to obtain data required for preparation of a Research and Development Application. This work established a basis for addressing potential effects of the planned R&D facility on identified cultural resources. Pertinent results and conclusions are outlined below.

1. Preliminary literature and records research indicated that systematic investigations had not been previously conducted within the proposed R&D plant area and that no National Register eligible properties had been recorded within or adjacent to the survey unit.

2. Limited previous studies in surrounding areas provided evidence that a wide range of paleontological, prehistoric and historic resources of potential significance to regional studies are present in the near vicinity and could likely be encountered on project lands. Registered National Historic Landmarks representing military and Native American reservation period use of the study area are located near the proposed Crow Butte project.

3. Intensive (100% coverage) pedestrian inspection of the R&D-scale survey unit (640 ac.) resulted in identification of ten newly recorded resource locations. Included are three sites representing Native American components, six Euroamerican locations, and a buried deposit of undetermined cultural association.

4. Eight of these newly identified resources contained limited observed evidence of cultural remains and were not determined to be of significant historic value on the basis of the archival research. These sites do not warrant further National Register consideration.

5. The remaining two sites are of potential archeological data recovery importance (25DW114) and possible architectural interest (25DW112). Further information would be required to determine potential National Register eligibilities.

6. The planned R&D facility will not directly affect any of the resources identified within the survey unit and clearance of this area for R&D operations is recommended.

7. Although no further investigations are needed prior to construct on of the R&D facility, project planning should allow for professional evaluation if needed during major earth-moving operations and should provide for avoidance or assessment of sites 25DW112 and 25DW114 during future phases of the Crow Butte project.

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SECTION 2.5

METEOROLOGY

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2.5 METEOROLOGY

2.5.1 Introduction

This section describes the meteorological conditions in the region surrounding the Crow Butte project. This information is required in Section 2.5 of the U. S. Nuclear Regulatory Guide 3.46. The data presented in this section will be used to determine the effect of the local climate on the proposed operations. The joint frequency data will be used to assess the atmospheric dispersion characteristics present in the region.

The primary source of data is from the Climatological Summary for Chadron, Nebraska. This summary covers 30 years of observation, from 1941 through 1970. Data are also included from the National Weather Stations at Scottsbluff, NE and Rapid City SD.

The Crow Butte Project is located in Dawes County. This county is located in the north central portion of the Nebraska panhandle and its northern border is shared with South Dakota. The weather patterns are typical of a semi-arid continental climate. This climate is characterized by warm summers, cold winters, light precipitation and frequent changes in the weather.

The Rocky Mountains to the west and the Black Hills to the north effectively block moisture from these directions, while moisture from the south is directed eastward by a plateau south of the region. As a result of this topography the area is generally drier than the rest of the panhandle.

Precipitation during the winter months averages about 1.0 cm (0.39 in) per month generally occurring as light snow. Cold spells persist for only a few days ending with the advance of warmer air from the west or southwest. Occasionally there are winters with persistently cold temperatures and heavy snow.

Precipitation increases in the spring, with March usually posting the greatest monthly snowfall. The snow and gentle rains gradually change to showers and thundershowers as June approaches. The high temperatures increase to near 27°C (81°F) in April and temperatures above 32°C (90°F) have been recorded as early as May.

Thunderstorms produce most of the precipitation during the summer months. In severe storms hail and damaging winds can be problems but tornadoes are rare. The warmest month of the year is July with an average high temperature of 32°C (90°F) and a average low temperature of 15°C (59°F). Several times during the summer months temperatures can be expected to climb above 38°C (100°F).

Precipitation becomes light again during the fall months. High temperatures drop to around 29°C (84°F) in September and by the beginning of October they only reach to near 21°C (70°F). Increasing cloudiness and falling temperatures best characterize November. Early snows have been reported in September and by the end of November most of the precipitation is in the form of snow.

The following data were taken from the Climatological Summary for Chadron, Nebraska prepared by U.S. Department of Commerce (USDC, 1971). The data were collected at the Chadron

Airport, latitude 42° 50' north, longitude 103° 05' west with a ground elevation of 1006 m (3300 ft) above mean sea level. The airport is located 7.2 km (4.5 miles) west of Chadron, 29 km (18.0 miles) east of Crawford, and 31 km (19.3 miles) east-northeast of the license area. The period of record for the data is 30 years, from 1941 through 1970. Data were collected at the State Normal School, now Chadron State College, from 1915 through 1936 after which time observations began at the airport.

2.5.2 Temperature

Table 2.5-1 shows the mean daily maximum and minimum temperatures as well as the mean monthly temperatures. The months November through March all have mean daily minimum temperatures below freezing with January the coldest month with a mean daily minimum temperature of -12.4°C (9.7°F). December, January and February, all have monthly mean temperatures below freezing. The warmest months are July and August with mean daily maximum temperatures above 31°C (87°F). The mean yearly temperature is 8.7°C (47.7°F).

The temperature extremes for the period of record are given in Table 2.5-2 along with the year of occurrance. Four months, June through September, recorded temperatures in excess of 37.8°C (100°F). Only July and August did not have recorded low temperatures below freezing. Five months, November through March, had recorded low temperatures below -17.8°C (0°F). The lowest temperature for the period of record was -33.9°C (-29.0°F) in January 1949 but the lowest temperature on record was -35°C (-31.0°F) occurring on February 8, 1936. The high temperature during the period of record was 43.3°C (109.9°F)

TABLE 2.5-1

MEAN TEMPERATURES

	MEAN DAILY MAXIMUM		MEAN DAILY MINIMUM		MEAN MONTHLY	
	°C	°F	°C	°F	°C	°F
Jan.	2.4	36.3	-12.4	9.7	-5.0	23.0
Feb.	5.0	41.0	-9.8	14.4	-2.4	27.7
Mar.	8.1	46.6	-6.7	19.9	0.7	33.3
Apr.	15.4	59.7	0.1	32.2	7.8	46.0
May	20.7	69.3	5.8	42.4	13.3	55.9
June	26.2	79.2	10.9	51.6	18.6	65.5
July	31.9	89.4	14.7	58.5	23.3	73.9
Aug.	31.6	88.9	13.8	56.8	22.7	72.9
Sept.	25.3	77.5	7.3	45.1	16.3	61.3
Oct.	18.8	65.8	0.9	33.6	9.9	49.8
Nov.	9.7	49.5	- 5.8	21.6	1.9	35.4
Dec.	4.1	39.4	-10.3	13.5	-3.1	26.4
Year	16.6	61.9	0.7	33.3	8.7	47.7

TABLE 2.5-2

TEMPERATURE EXTREMES

	Record High			Record Low		
	°C	°F	Year	°C	°F	Year
Jan.	18.3	64.9	1965	-33.9	-29.0	1949
Feb.	23.3	73.9	1962	-31.7	-25.1	1962
Mar.	29.4	84.9	1946	-28.9	-20.0	1948
Apr.	32.2	90.0	1962	-17.2	1.0	1968
May	36.7	98.1	1969	- 8.9	16.0	1954
June	40.0	104.0	1961	- 3.3	26.1	1969
July	43.3	109.9	1954	3.3	37.9	1945
Aug.	40.6	105.1	1959	1.7	35.1	1942
Sept.	39.4	102.9	1959	- 7.2	19.0	1942
Oct.	35.0	95.0	1947	-14.4	6.1	1952
Nov.	25.0	77.0	1965	-27.8	-18.0	1959
Dec.	21.7	71.1	1941	-33.3	-27.9	1968
Year	43.3	109.9	July 1954	-33.9	-29.0	Jan 1949

in July 1954 while the record high temperature was 43.9°C (111°F) on August 25, 1926.

Table 2.5-3 lists the mean number of days per month with temperatures above or below selected values. There are an average of 44 days per year with maximum temperatures exceeding 32.2°C (90°F) and 37 days per year when the maximum temperature will not exceed 0°C (32°F). On almost fifty percent of the days in a given year the temperature will fall to 0° (32°F) or below and on an average 19 of those days the temperature will go below -17.8°C (0°F).

The average date of the last 0°C (32°F) temperature is May 18 while the first fall freeze is expected on September 18. The average growing season is 120 to 130 days in length (USDA, 1981). These are average values and the exact occurrence of freezing temperatures is dependent on exposure.

2.5.3 Precipitation

Precipitation in the region is generally light with the greatest occurrences in the spring and summer. Table 2.5-4 lists the monthly precipitation totals for the period of record. June has the greatest precipitation with a mean of 8.43 cm (3.31 in). The driest months are November through February, when average monthly precipitation is about 1.0 cm (0.39 in). The mean yearly precipitation is 39.52 cm (15.55 in).

Also listed in Table 2.5-4 are the maximum 24-hour precipitation events. The maximum 24-hour rainfall of 8.08 cm (3.18 in) was recorded on June 21-22, 1947. The greatest monthly accumulation was 26.37 cm (10.38 in) recorded during June 1947. The greatest annual precipitation was 80.54 cm (31.71 in) in 1915

TABLE 2.5-3

TEMPERATURE OCCURRENCES

	Mean Number of Days With Maximum Temperatures		Mean Number of Days With Minimum Temperatures	
	>32.2°C >90°F	<0°C <32°F	<0°C <32°F	<-17.8°C <0°F
Jan.	0	11	31	8
Feb.	0	7	28	4
Mar.	0	6	28	2
Apr.	<0.5	1	15	0
May	1	<0.5	4	0
June	5	0	<0.5	0
July	16	0	0	0
Aug.	16	0	0	0
Sept.	5	0	2	0
Oct.	<0.5	<0.5	15	0
Nov.	0	3	27	1
Dec.	0	9	30	4
Year	44	37	180	19

TABLE 2.5-4

PRECIPITATION TOTALS
WATER EQUIVALENT

	Mean		Maximum 24-hour		
	cm	in	cm	in	Year
Jan.	1.04	0.41	2.72	1.07	1949
Feb.	0.94	0.37	1.24	0.49	1953
Mar.	1.78	0.70	2.21	0.87	1945
Apr.	4.24	1.67	5.51	2.17	1942
May	7.57	2.98	5.46	2.15	1942
June	8.43	3.32	8.08	3.18	1947
July	5.49	2.16	4.95	1.95	1965
Aug.	2.46	0.97	3.63	1.43	1951
Sept.	3.38	1.33	5.89	2.32	1959
Oct.	2.11	0.83	3.94	1.55	1942
Nov.	1.09	0.43	2.84	1.12	1944
Dec.	.99	0.39	1.27	0.50	1965
Year	39.52	15.56	8.08	3.18	June 1947

while the driest year on record was 1956 when only 26.82 cm (10.56 in) of precipitation fell.

The mean and extreme snowfalls for the period of record are listed in Table 2.5-5. The mean annual snowfall is 105.16 cm (41.40 in). July and August are the only two months without a reported snowfall. The maximum mean monthly snowfall is in March and is reported to be 20.57 cm (8.10 in). The maximum monthly snowfall is 151.38 cm (59.60 in) recorded in January 1949, while the greatest June snowfall is 3.05 cm (1.20 in). The largest 24-hour total snowfall is 67.82 cm (26.70 in) recorded in January 1949.

Precipitation data from Scottsbluff, Nebraska, located 98 km (60.9 mi) south of the license area and from Rapid City, South Dakota 158 km (98.2 mi) north of the license area indicate that precipitation in excess of 0.03 cm (.01 in) can be expected on an average of 85 and 96 days per year, respectively (NOAA, 1980a,1980b). These data are listed in Table 2.5-6. Also given in this table are the mean number of days on which thunderstorms may occur. The annual occurrences range from 44 in Scottsbluff to 15 in Rapid City. In the more severe thunderstorms high winds and possibly hail can be expected to occur. Tornadoes are a rare occurrance. In the USNRC, Draft Generic Environmental Impact Statement on Uranium Milling,(USNRC, 1979) the authors calculated a mean annual frequency of 0.6 for tornadoes in intensity Category I at Rapid City. The annual probability of occurrence at this location is 4.8×10^{-4}. A tornado in intensity Category I has a rotational speed of 134 m/s and a translational speed of 26 m/s.

TABLE 2.5-5

MEAN AND EXTREME SNOW FALLS

	Mean		Maximum Monthly			Maximum 24-hour		
	cm	in	cm	in	Year	cm	in	Year
Jan.	18.80	7.40	151.38	56.60	1949	67.82	26.70	1949
Feb.	15.75	6.20	59.69	23.50	1958	26.16	10.30	1958
Mar.	20.57	8.10	53.85	21.20	1954	22.86	9.00	1954
Apr.	13.97	5.50	49.28	19.40	1970	25.40	9.00	1968
May	2.79	1.10	23.62	9.30	1950	17.78	7.00	1942
June	<1.27	<0.50	3.05	1.20	1969	3.05	1.20	1969
July	0.	0.	0.	0.	----	0.	0.	----
Aug.	0.	0.	0.	0.	----	0.	0.	----
Sept.	1.27	0.50	25.40	10.00	1965	25.40	10.0	1965
Oct.	3.81	1.50	24.64	9.70	1969	18.29	7.20	1969
Nov.	12.70	5.00	65.79	25.90	1947	20.57	8.10	1956
Dec.	15.49	6.10	46.99	18.50	1967	15.24	6.00	1967
Year	105.16	41.40	151.38	59.60	Jan 1949	67.82	26.70	Jan 1947

TABLE 2.5-6

PRECIPITATION EVENTS

	Mean Number of Days with Precipitation >0.03 cm >0.01 in		Mean Number of Days with Thunderstorms	
	Scottsbluff, NE	Rapid City, SD	Scottsbluff, NE	Rapid City, SD
Jan.	6	7	0	0
Feb.	5	8	0	0
Mar.	8	9	<0.5	<0.5
Apr.	8	10	2	1
May	12	12	7	6
June	11	12	11	11
July	8	9	17	12
Aug.	6	8	8	9
Sept.	6	6	4	3
Oct.	4	5	1	<0.5
Nov.	4	6	<0.5	<0.5
Dec.	5	6	<0.5	<0.5
Year	85	96	44	15
Period of Record	37	38	37	38

2.5.4 Humidity

Relative percent humidities at the Scottsbluff and Rapid City weather stations are given in Table 2.5-7. The humidities at 0500, 1100, 1700, and 2300 hours are listed. Both locations have about the same humidity during the night but in the early morning Scottsbluff is slightly more humid. By noon and throughout the afternoon Scottsbluff becomes less humid than Rapid City. From Table 2.5-7 it can be seen that these humidity differences are slight and the humidity at the license area is expected to be similar to these locations.

2.5.5 Winds

Wind data are not available from Chadron Airport. Figures 2.5-1 and 2.5-2 are the wind roses for Scottsbluff, Nebraska and Rapid City, South Dakota respectively. These figures do show predominant wind patterns that are similar, however, the finer details are greatly influenced by the local topography. Rapid City has a predominant wind from the north-northwest while Scottsbluff has a slightly bimodal distribution with the predominant winds from the west-northwest and the east-southeast. The least prevalent wind direction at both locations is from the southwest.

The annual relative joint frequency distribution as a function of six Pasquill stability classes is presented in Appendix 2.5(A). These data were collected at Scottsbluff, Nebraska and compiled by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration. The period of record for these data is from January 1967 through December 1971. The Scottsbluff data were chosen as being most representative of the

TABLE 2.5-7

PERCENT RELATIVE HUMIDITY

Month	0500 hours NE[a]	0500 hours SD[b]	1100 hours NE	1100 hours SD	1700 hours NE	1700 hours SD	2300 hours NE	2300 hours SD
Jan.	74	68	59	60	60	64	72	68
Feb.	74	72	53	61	50	63	70	72
Mar.	75	74	49	56	44	55	68	72
Apr.	76	73	46	49	40	46	66	68
May	77	75	45	49	41	46	67	70
June	78	76	43	51	39	48	67	73
July	79	72	42	45	37	40	66	65
Aug.	80	69	44	41	38	36	67	60
Sept.	78	66	42	40	36	38	66	59
Oct.	74	64	42	40	39	44	64	60
Nov.	75	67	52	51	51	58	68	66
Dec.	74	68	55	59	57	65	70	68
Year	76	70	48	50	44	50	68	67
Period of Record	16	30	16	30	16	30	16	30

[a] Scottsbluff, NE

[b] Rapid City, SD

license area and the placement of the air monitoring stations was based on the wind rose obtained from Scottsbluff. The annual morning mixing height is 300 m while the average afternoon mixing height is 2000 m. The annual average mixing height is 522 m. This information was obtained from the data compiled by Holzworth (1979).

2.5.6 Local Meteorological Station

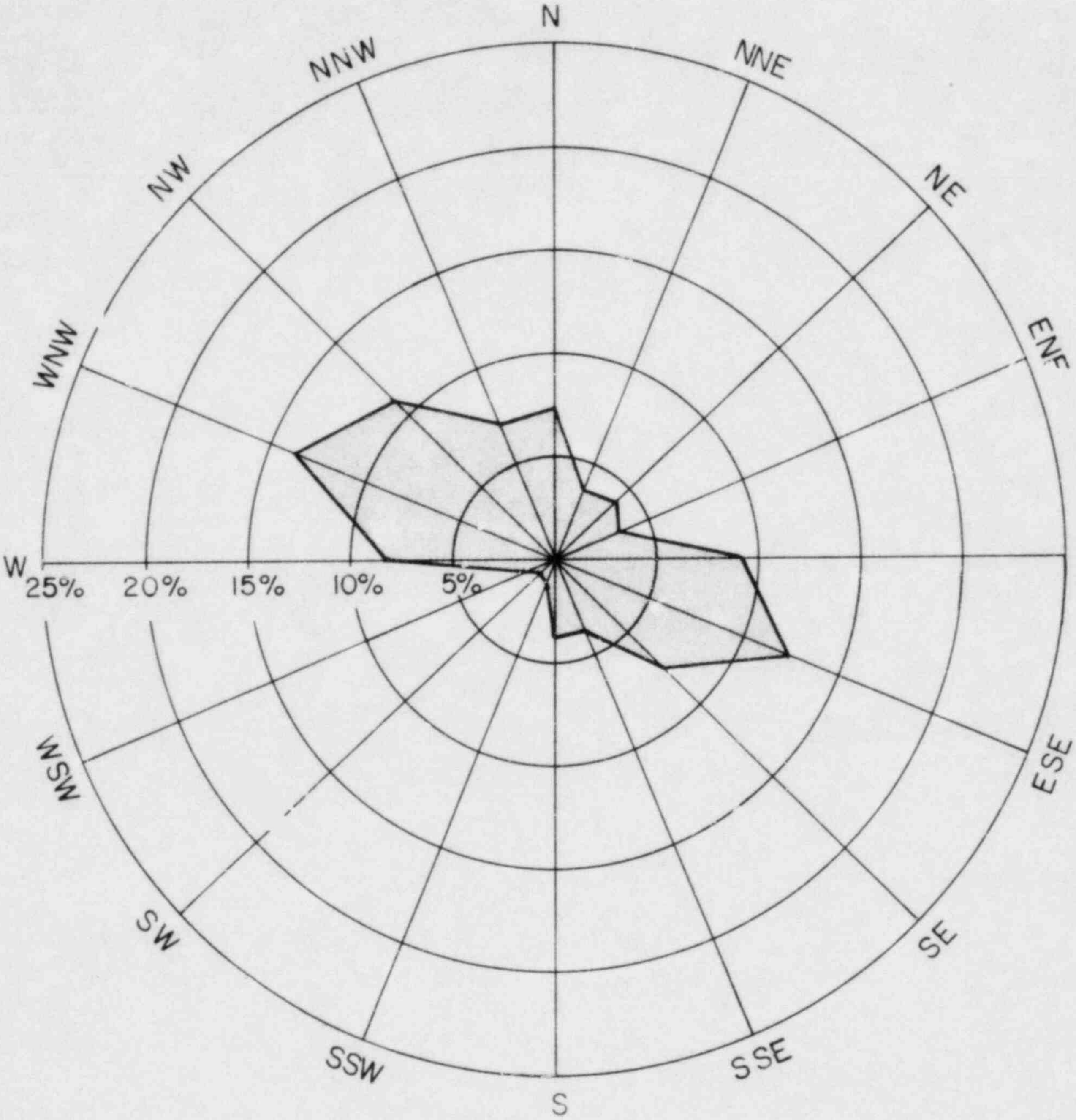
Local terrain will have a significant influence on the wind patterns in a given area. Because of this, Wyoming Fuel Company has installed a meteorological station in the vicinity of the Crow Butte Project. This station is capable of measuring wind speed, direction, and the standard deviation of the wind direction. From this information joint frequency data will be compiled. This locally obtained information will then be used to assess the impact of a commercial in-situ facility should the pilot plant prove to be successful.

Precipitation is also recorded at the station with a heated tipping bucket rain gauge. Evaporation is measured using a 48" evaporation pan and an evaporation gauge with analog output. The air temperature is also recorded using a precision linear thermistor and fan aspirated radiation shield. All the information is recorded on strip chart recorders. In addition the information is run through a microprocessor and recorded on magnetic tape. The information from the tape is transferred to a computer and then verified by comparison from the strip charts and from visual observation records.

SCOTTSBLUFF — SURFACE WINDS

PERCENTAGE FREQUENCIES OF WIND DIRECTION

14,600 OBSERVATIONS



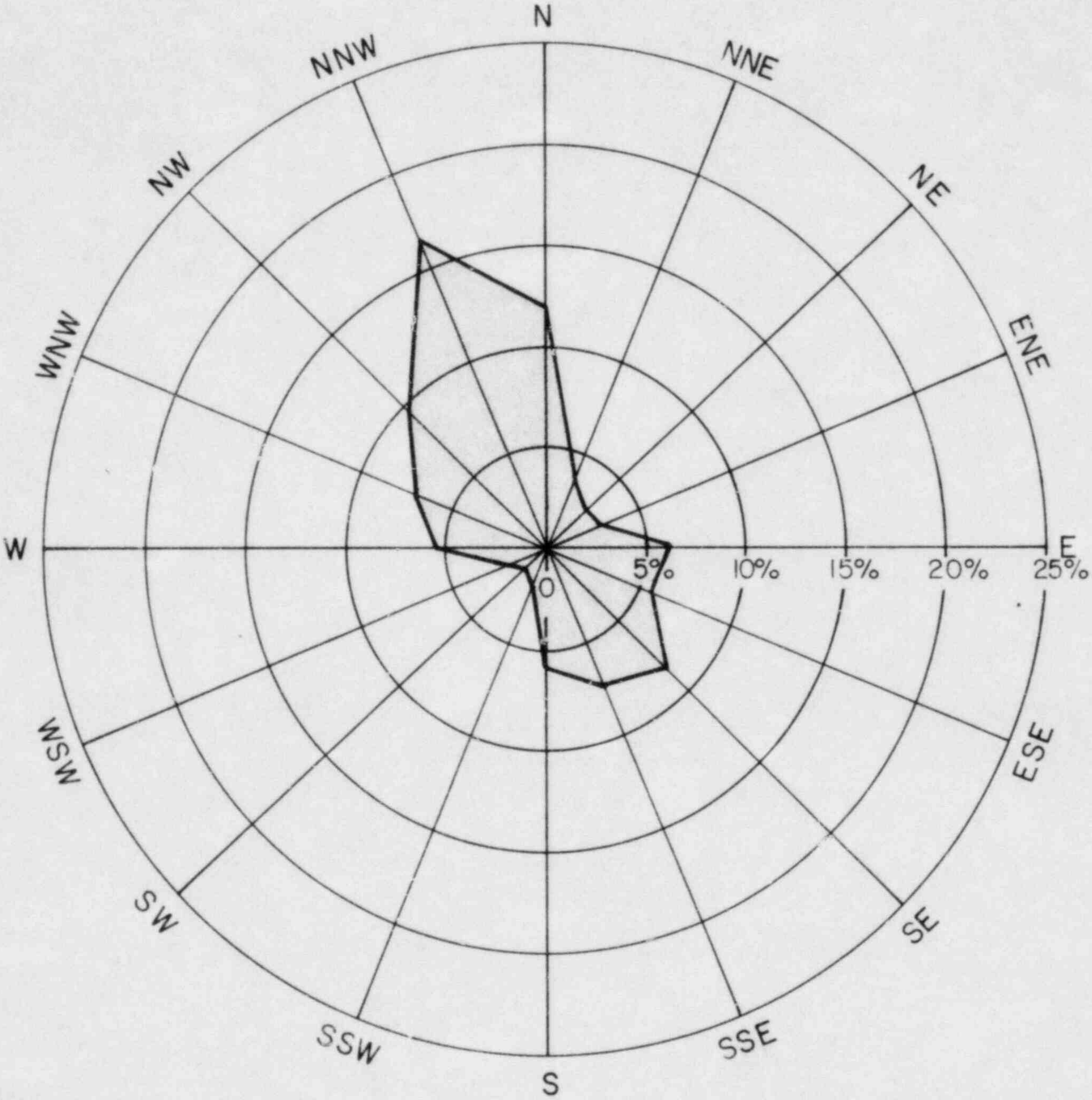
% CALMS = 3.4%

REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			SCOTTSBLUFF-SURFACE WINDS
			PREPARED BY:
			DWN BY: R.E. Larson · DATE: 9-16-82 · FIGURE 2.5-1

RAPID CITY- SURFACE WINDS

PERCENTAGE FREQUENCIES OF WIND DIRECTION

14,600 OBSERVATIONS



% CALMS = 5.0 %

REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			RAPID CITY- SURFACE WINDS
			PREPARED BY:
			DWN BY: R.E. LARSON / DATE: 9-16-82 / FIGURE 2.5-2

The meteorological station became operational in May 1982. Initially, the evaporation gauge did not operate properly and reliable evaporation data are available beginning in September 1982. Table 2.5-8 is a listing of the mean daily maximum and minimum temperatures recorded at the Crow Butte Meteorological Station for the period of May through October 1982. Table 2.5-9 shows the precipitation for the same period and Table 2.5-10 lists the predominant wind direction, average speed and maximum wind gust during each month.

As a result of the extremely short period that the station has been in operation these data are not considered representative of the average meteorological conditions in the project area. At the time of submission of an application for a commercial scale operation there will be sufficient data available to characterize the regional meteorology.

TABLE 2.5-8

DAILY MAXIMUM AND MINIMUM TEMPERATURES
RECORDED AT THE CROW BUTTE
METEOROLOGICAL STATION

[1] Month	Mean Daily Maximum		Mean Daily Minimum		Mean Monthly	
	°C	°F	°C	°F	°C	°F
May	18.6	65.5	4.7	40.5	11.6	52.9
June	22.1	71.8	8.9	48.0	15.5	59.9
July	30.5	86.9	13.5	56.3	22.0	71.6
Aug.	31.3	88.3	14.4	57.9	22.9	73.2
Sept.	23.0	73.4	7.9	46.2	15.5	59.9
Oct.	15.1	59.2	0.5	32.9	7.8	46.0

[1] Data collected during 1982.

TABLE 2.5-9

PRECIPITATION RECORDED AT THE
CROW BUTTE METEOROLOGICAL STATION

[1]Month	Precipitation cm	Precipitation in
May	13.87	5.46
June	5.89	2.32
July	4.55	1.79
Aug.	3.30	1.30
Sept.	4.78	1.88
Oct.	3.38	1.33

[1] Data collected during 1982.

TABLE 2.5-10

WIND DATA RECORDED AT THE
CROW BUTTE METEOROLOGICAL STATION

[1] Month	Predominant Direction	Average Speed mph	Maximum Speed mph
May	Northeast	10.8	54.8
June	South-Southeast	13.0	59.7
July	South	11.3	58.6
Aug.	South	13.7	44.2
Sept.	South	11.4	42.8
Oct.	Northwest	18.7	57.2

[1] Data collected during 1982.

REFERENCE

Holzworth, George C., Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, United State Environmental Protection Agency, PB-207-103, 1972.

National Oceanic and Atmospheric Administration, Local Climatological Data, Annual Summary with Comparative Data - Scottsbluff, Nebraska, United States Department of Commerce, Asheville NC, 1980.

National Oceanic and Atmospheric Administration, Local Climatological Data, Annual Summary with Comparative Data - Rapid City, South Dakota, United States Department of Commerce, Asheville NC, 1980.

United States Department of Agriculture, "Draft Environmental Impact Statement, Nebraska National Forest, Land, and Resource Management Plan", USDA 02-07-81-07, USDA Forest Service, Chadron NE 1981.

United States Department of Commerce, "Climatological Summary For Chadron Nebraska", Climatography of the United States No. 20-25, 1941-1970.

United States Nuclear Regulatory Commission, Draft Generic Environmental Impact Statement on Uranium Milling, NUREG - 0511, Washington D.C., 1979.

APPENDIX 2.5(A)

TABLE

ANNUAL FREQUENCY DISTRIBUTION

Stability Class: A

Number of Occurrences: 126

Station: Scottsbluff NE

Period of Record: 1967-1971

	Speed(KTS)						
Direction	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	>21	Total
N	0.000201	0.000068	0.000000	0.000000	0.000000	0.000000	0.000270
NNE	0.000066	0.000068	0.000000	0.000000	0.000000	0.000000	0.000135
NE	0.000334	0.000205	0.000000	0.000000	0.000000	0.000000	0.000539
ENE	0.000133	0.000137	0.000000	0.000000	0.000000	0.000000	0.000270
E	0.000268	0.000137	0.000000	0.000000	0.000000	0.000000	0.000405
ESE	0.000268	0.000137	0.000000	0.000000	0.000000	0.000000	0.000405
SE	0.000334	0.000205	0.000000	0.000000	0.000000	0.000000	0.000539
SSE	0.000265	0.000274	0.000000	0.000000	0.000000	0.000000	0.000539
S	0.000464	0.000479	0.000000	0.000000	0.000000	0.000000	0.000944
SSW	0.000201	0.000068	0.000000	0.000000	0.000000	0.000000	0.000270
SW	0.000201	0.000068	0.000000	0.000000	0.000000	0.000000	0.000270
WSW	0.000464	0.000479	0.000000	0.000000	0.000000	0.000000	0.000944
W	0.000531	0.000548	0.000000	0.000000	0.000000	0.000000	0.001079
WNW	0.000803	0.000411	0.000000	0.000000	0.000000	0.000000	0.001214
NW	0.000334	0.000205	0.000000	0.000000	0.000000	0.000000	0.000539
NNW	0.000201	0.000068	0.000000	0.000000	0.000000	0.000000	0.000270
TOTAL	0.005068	0.003562	0.000000	0.000000	0.000000	0.000000	

Stability Class: B

Number of Occurrences: 668

Station: Scottsbluff NE

Period of Record: 1967-1971

	Speed(KTS)						
Direction	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	>21	Total
N	0.000347	0.001096	0.000616	0.000000	0.000000	0.000000	0.002060
NNE	0.000140	0.000822	0.000274	0.000000	0.000000	0.000000	0.001236
NE	0.000553	0.000890	0.000205	0.000000	0.000000	0.000000	0.001649
ENE	0.000301	0.000822	0.000479	0.000000	0.000000	0.000000	0.001602
E	0.000531	0.001233	0.001164	0.000000	0.000000	0.000000	0.002928
ESE	0.000795	0.001370	0.001096	0.000000	0.000000	0.000000	0.003261
SE	0.000771	0.001233	0.001507	0.000000	0.000000	0.000000	0.003511
SSE	0.000588	0.001096	0.001301	0.000000	0.000000	0.000000	0.002985
S	0.000808	0.001918	0.000822	0.000000	0.000000	0.000000	0.003548
SSW	0.000438	0.000685	0.000685	0.000000	0.000000	0.000000	0.001807
SW	0.000404	0.000959	0.000342	0.000000	0.000000	0.000000	0.001705
WSW	0.000404	0.000959	0.000616	0.000000	0.000000	0.000000	0.001979
W	0.001052	0.002877	0.001781	0.000000	0.000000	0.000000	0.005709
WNW	0.001107	0.002260	0.001918	0.000000	0.000000	0.000000	0.005285
NW	0.000853	0.001712	0.001370	0.000000	0.000000	0.000000	0.003935
NNW	0.000634	0.001370	0.000548	0.000000	0.000000	0.000000	0.002552
TOTAL	0.009726	0.021301	0.014726	0.000000	0.000000	0.000000	

Stability Class: C

Number of Occurrences: 1403

Station: Scottsbluff NE

Period of Record: 1967-1971

Direction	Speed(KTS) 0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	>21	Total
N	0.000238	0.000822	0.001370	0.000274	0.000000	0.000000	0.002703
NNE	0.000112	0.000342	0.000822	0.000137	0.000000	0.000000	0.001413
NE	0.000162	0.000822	0.001575	0.000000	0.000068	0.000000	0.002628
ENE	0.000169	0.000890	0.001164	0.000205	0.000000	0.000000	0.002429
E	0.000187	0.001781	0.004110	0.000616	0.000000	0.000000	0.006694
ESE	0.000280	0.002671	0.007260	0.000685	0.000000	0.000000	0.010897
SE	0.000346	0.001849	0.005548	0.001096	0.000000	0.000000	0.008839
SSE	0.000137	0.001301	0.003493	0.001096	0.000068	0.000000	0.006096
S	0.000317	0.001575	0.003904	0.000890	0.000000	0.000000	0.006687
SSW	0.000043	0.000411	0.001096	0.000137	0.000000	0.000000	0.001687
SW	0.000162	0.000822	0.000685	0.000137	0.000000	0.000000	0.001806
WSW	0.000093	0.000890	0.001233	0.000137	0.000000	0.000000	0.002354
W	0.000425	0.002603	0.006027	0.001096	0.000274	0.000137	0.010562
WNW	0.000500	0.004041	0.008425	0.001438	0.000137	0.000068	0.01461[illegible]
NW	0.000525	0.003562	0.005616	0.001370	0.000274	0.000000	0.011347
NNW	0.000483	0.001712	0.002260	0.000616	0.000205	0.000068	0.005346
TOTAL	0.004178	0.026096	0.054589	0.009931	0.001027	0.000274	

Stability Class: D

Number of Occurrences: 3863

Station: Scottsbluff NE

Period of Record: 1967-1971

Direction	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	>21	Total
	Speed(KTS)						
N	0.000202	0.002260	0.003562	0.008562	0.003699	0.000959	0.019243
NNE	0.000104	0.000548	0.002123	0.002877	0.000411	0.000342	0.006405
NE	0.000110	0.001918	0.001438	0.002945	0.000685	0.000137	0.007233
ENE	0.000127	0.000959	0.001438	0.002877	0.000685	0.000274	0.006360
E	0.000312	0.001644	0.003836	0.005753	0.000479	0.000000	0.012024
ESE	0.000214	0.002466	0.007945	0.013014	0.002329	0.000000	0.025967
SE	…10	0.002397	0.005274	0.012877	0.003425	0.000274	0.024457
SSE	…5	0.000890	0.001918	0.007603	0.001918	0.000205	0.012730
S	…36	0.001507	0.002671	0.005068	0.001507	0.000137	0.010977
SSW	0.000108	0.000616	0.000616	0.001438	0.000274	0.000000	0.003053
SW	0.000016	0.000274	0.000548	0.000822	0.000137	0.000000	0.001797
WSW	0.000067	0.001164	0.000890	0.001301	0.000548	0.000137	0.004108
W	0.000071	0.001233	0.004521	0.010205	0.007397	0.003425	0.026852
WNW	0.000234	0.002808	0.008014	0.020616	0.010000	0.005000	0.046672
NW	0.000259	0.001986	0.006644	0.011986	0.008562	0.004726	0.034163
NNW	0.000151	0.001370	0.003014	0.008219	0.006575	0.003219	0.022548
TOTAL	0.002466	0.024041	0.054452	0.116164	0.048630	0.018836	

Stability Class: E

Number of Occurrences: 4127

Station: Scottsbluff NE

Period of Record: 1967-1971

Direction	Speed(KTS) 0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	>21	Total
N	0.001105	0.002055	0.007397	0.007123	0.001918	0.000479	0.020078
NNE	0.000354	0.001301	0.004247	0.004315	0.000822	0.000411	0.011450
NE	0.000333	0.001849	0.004452	0.003630	0.001301	0.000137	0.011703
ENE	0.000149	0.000753	0.004795	0.004315	0.000890	0.000205	0.011108
E	0.000497	0.001986	0.014521	0.007671	0.000205	0.000000	0.024880
ESE	0.000346	0.001986	0.017945	0.020479	0.002[illegible]34	0.000000	0.043291
SE	0.000299	0.001507	0.009795	0.011438	0.001986	0.000068	0.025093
SSE	0.000170	0.000959	0.002329	0.002466	0.000548	0.000000	0.006471
S	0.000088	0.000890	0.002329	0.001712	0.000411	0.000068	0.005499
SSW	0.000102	0.000274	0.001233	0.000342	0.000274	0.000137	0.002363
SW	0.000116	0.000411	0.000753	0.000479	0.000000	0.000000	0.001760
WSW	0.000157	0.000068	0.001027	0.001164	0.000342	0.000068	0.002828
W	0.000374	0.001507	0.006233	0.0[illegible]90	0.004521	0.001507	0.025032
WNW	0.000661	0.002123	0.012055	0.016712	0.005205	0.002260	0.039017
NW	0.000456	0.001575	0.009452	0.014247	0.005205	0.001575	0.032511
NNW	0.000340	0.001164	0.005548	0.007808	0.003288	0.001438	0.019587
TOTAL	0.005548	0.020411	0.1040109	0.114794	0.029452	0.008356	

Stability Class: F

Number of Occurrences: 4413

Station: Scottsbluff NE

Period of Record: 1967-1971

Direction	Speed (KTS) 0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	>21	Total
N	0.004483	0.015958	0.007945	0.000000	0.000000	0.000000	0.028387
NNE	0.002725	0.008973	0.003493	0.000000	0.000000	0.000000	0.015191
NE	0.003660	0.009246	0.003562	0.000000	0.000000	0.000000	0.016468
ENE	0.001541	0.007740	0.002945	0.000000	0.000000	0.000000	0.012226
E	0.005654	0.022055	0.016986	0.000000	0.000000	0.000000	0.044695
ESE	0.003083	0.017260	0.019795	0.000000	0.000000	0.000000	0.040137
SE	0.001670	0.007672	0.004384	0.000000	0.000000	0.000000	0.013724
SSE	0.000930	0.004178	0.002260	0.000000	0.000000	0.000000	0.007368
S	0.002037	0.005822	0.001644	0.000000	0.000000	0.000000	0.009503
SSW	0.000735	0.001369	0.001164	0.000000	0.000000	0.000000	0.003269
SW	0.000754	0.002055	0.000274	0.000000	0.000000	0.000000	0.003083
WSW	0.000694	0.003219	0.000616	0.000000	0.000000	0.000000	0.004529
W	0.002530	0.007192	0.005000	0.000000	0.000000	0.000000	0.014722
WNW	0.003003	0.014315	0.014795	0.000000	0.000000	0.000000	0.032113
NW	0.003137	0.014658	0.013356	0.000000	0.000000	0.000000	0.031151
NNW	0.004187	0.013493	0.008014	0.000000	0.000000	0.000000	0.025694
TOTAL	0.040822	0.155205	0.106233	0.000000	0.000000	0.000000	

SECTION 2.6

HYDROLOGY

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LIST OF FIGURES

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2.6 HYDROLOGY

2.6.1 Ground Water

Two aquifers are of interest in the Crawford and Crow Butte area with regards to the Crow Butte Project. These are the shallow Brule aquifer and the deeper Chadron aquifer. The latter contains the uranium mineralization of interest to this project. This section describes the regional and local hydrology of these aquifers, including physical and chemical characteristics. Information is supplied in accordance with U.S. NRC Regulatory Guide 3.46 (Task FP818-4) and Staff Technical Position Paper #WM-8102 (1981).

A hydrologic test was performed in the proposed R&D wellfield to determine the hydrologic characteristics of the Chadron aquifer. The following discussion includes the results of that test and the conclusions which can be drawn concerning directional permeabilities, transmissitivies, vertical avenues of flow, confining layers and boundary conditions. Tabulated data are included in the appendix.

Finally, as required in Regulatory Guide 3.46 a soils study was made of the proposed R&D project area. Sources of soils information included a Dawes County soil survey published in 1977 by the U.S. Dept. of Agriculture Soil Conservation Service, walk-around field examinations, soil sampling for radionuclides and soils borings performed for the evaporation pond site investigation. From the latter, soils types of the surface and near surface materials are identified, together with hydrologic and other physical properties. The pertinent segments of these data are presented in this section.

Regional Hydrology. The Crawford-Crow Butte area is located in northwestern Nebraska in Dawes and Sioux counties. Outcropping geologic formations in this area include the Upper Cretaceous Pierre Shale, the Tertiary Oligocene Chadron and Brule Formations, and the Miocene Gering Formation. These strata are described in detail in Section 2.7, Geology.

Surface expression of the Pierre Shale occurs north of the White River fault and northeast of Crawford. The Pierre Shale is not considered to contain aquifers of any importance in this region. Because of its nonpermeable nature it also serves as an aquiclude preventing vertical migration of waters. Where fault zones occur, this shale should seal the fractures as appears to be the case at the White River fault.

The Chadron Formation outcrops in a narrow band at Crawford and continuing east. Some recharge may occur in this area. The basal sandstone of the Chadron Formation is considered the only aquifer in that unit. Overlying material within that unit consists of clay and siltstone with low to very low permeabilities. This formation contains areas of uranium mineralization which are of economic interest. These are found in association with presence of hydrogen sulfide which has been found in water samples from this formation (Struempler, 1979). Further descriptions of this and the Brule aquifers are included in this section within the hydrologic test description.

The Brule formation consists of interbedded sandstone, siltstone and ashey clay areas. Regionally and locally this is an important aquifer, producing sufficient quantities of low dissolved solids water, to be used for domestic and agricultural purposes. Surface exposure of the Brule occurs between the town of Crawford and the Pine Ridge foothills southeast of the proposed project. Recharge to the several sandstones results from infiltration of precipitation and exchange with surface water.

Above an elevation of approximately 4100 ft (1250 m) is the Gering Arikaree Formation (Witzel, 1974). Gering Formation sandstones provide water in areas south and further west of the project area. Springs are also common in this formation, and in several cases these springs comprise the major water supply to local streams. Water quality of the Gering (Arikaree) is of similar quality to that from Brule sands.

Geologic formations dip generally to the south-southeast in this area to the Cochran Arch. A map prepared by Sounders and Freethey (1975) indicates that the water table configuration in the region trends north northeast. No regional water level maps are available for the Chadron or Brule aquifers.

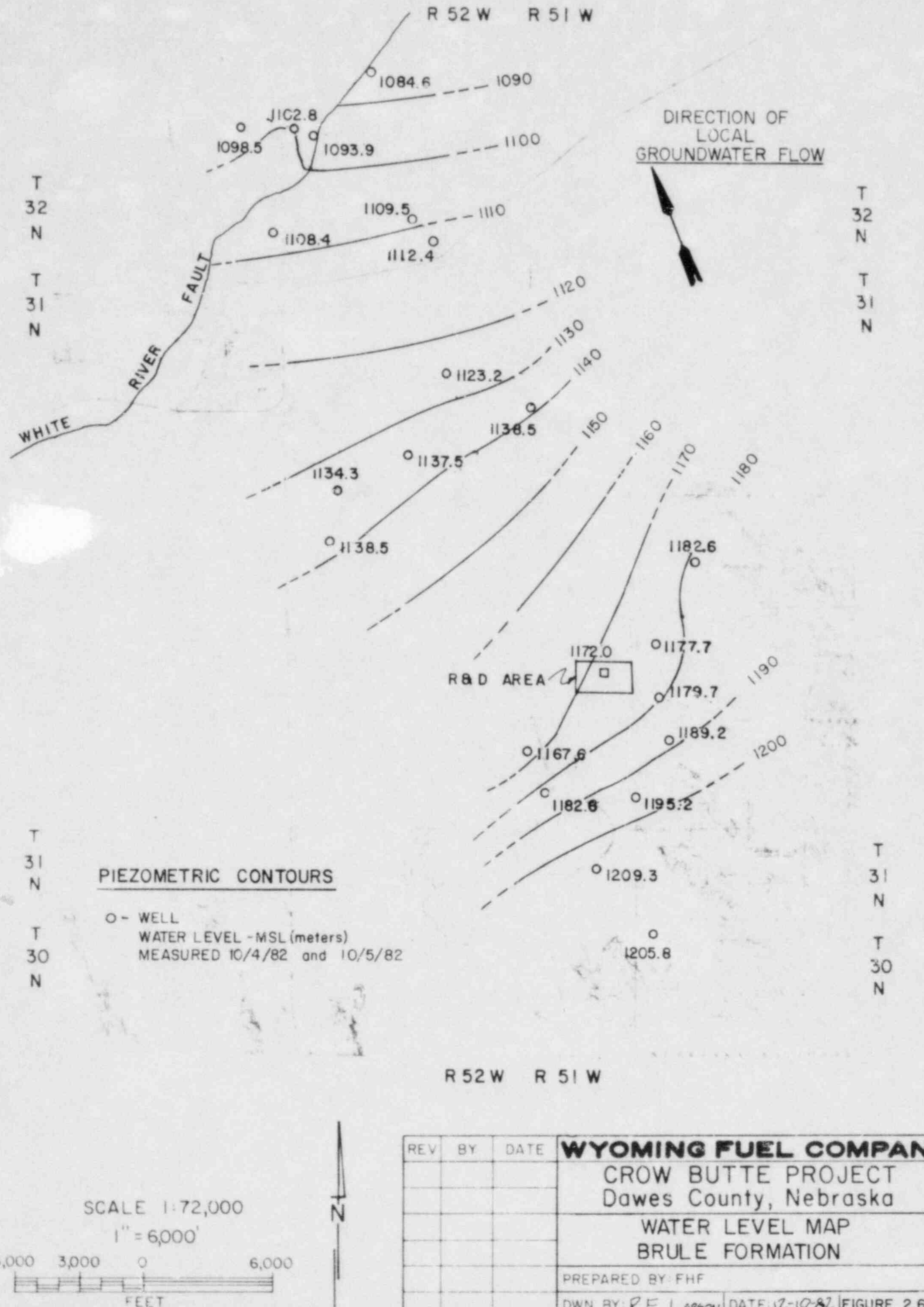
An artesian basin is present in the Chadron in the vicinity of the White River fault. The eastern extent of the artesian system is approximately 8 mi (12.9 km) east of Crawford. Recharge to the system is apparently from streams such as Sand Creek which cross the outcropping basal Chadron sands.

Water level data has been gathered from available and specially drilled wells througout the Crawford-Crow Butte area for the Chadron and Brule aquifers. Maps of the piezometric surfaces for these two aquifers are included as Figures 2.6-1 and 2.6-2. Locally the direction of flow in the Brule aquifer is to the north-northwest. Correlation of these data points is more difficult because wells completed in the various minor sands of the Brule indicate that they have slightly different piezometric surfaces.

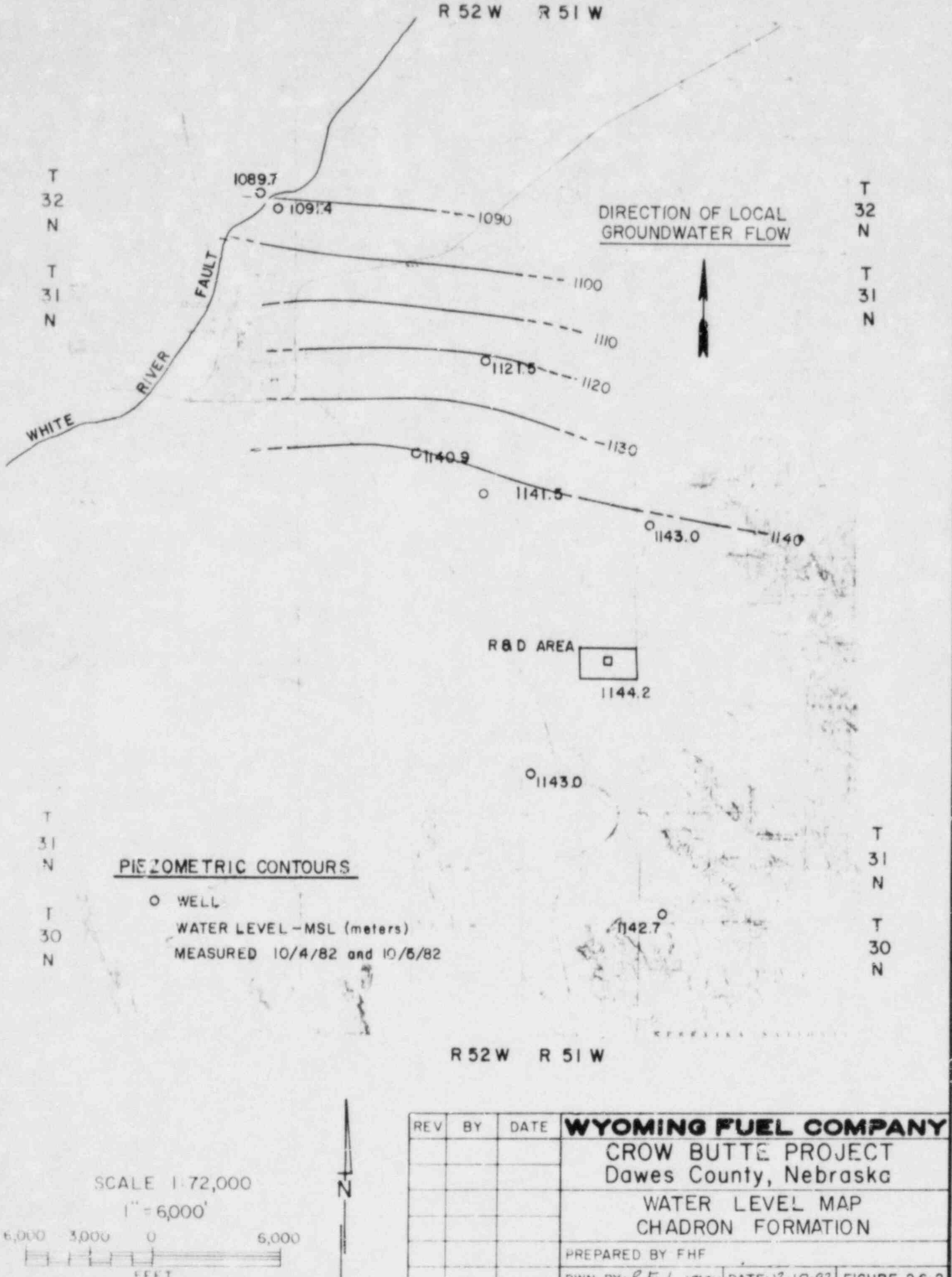
The Chadron aquifer is artesian and wells from the fault to about 3000 m (9850 ft) south are free flowing at the surface. The direction of ground water migration in that area is north towards the fault. Further to the south the piezometric surface becomes almost flat and appear to be starting a gradual dip to the south.

Local Hydrology. The hydrogeologic system within and surrounding the Crow Butte project area is essentially the same as found regionally. The outcropping Brule Formation is underlain sequentially by the Chadron Formation and Pierre Shale. Figure 2.6-3 is a cross-sectional representation of these strata indicating their hydrologic properties. This section is based on lithologic descriptions and electric well logs from exploration drilling, core samples and baseline wells. Figure 2.6-4 shows the location of this section.

The production aquifer, which is the basal Chadron sand, is shown bounded above and below by units which serve as aquicludes. The term "aquiclude" is used to mean a strata capable of transmitting only minor amounts of fluid either vertically or horizontally. Typical values are in the range of 10^{-4} to 10^{-5} darcys for vertical and horizontal permeabilities (Todd, 1980). This is also expressed as approximately $1x10^{-7}$ to $1x10^{-8}$ cm/sec. In many cases values are



REV	BY	DATE	
			WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			WATER LEVEL MAP BRULE FORMATION
			PREPARED BY: FHF
			DWN BY: R.E. Larson DATE: 12-10-82 FIGURE 2.6-1



REV	BY	DATE

WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Dawes County, Nebraska

WATER LEVEL MAP
CHADRON FORMATION

PREPARED BY FHF

DWN BY R.E. Larson | DATE 12-10-82 | FIGURE 2.6-2

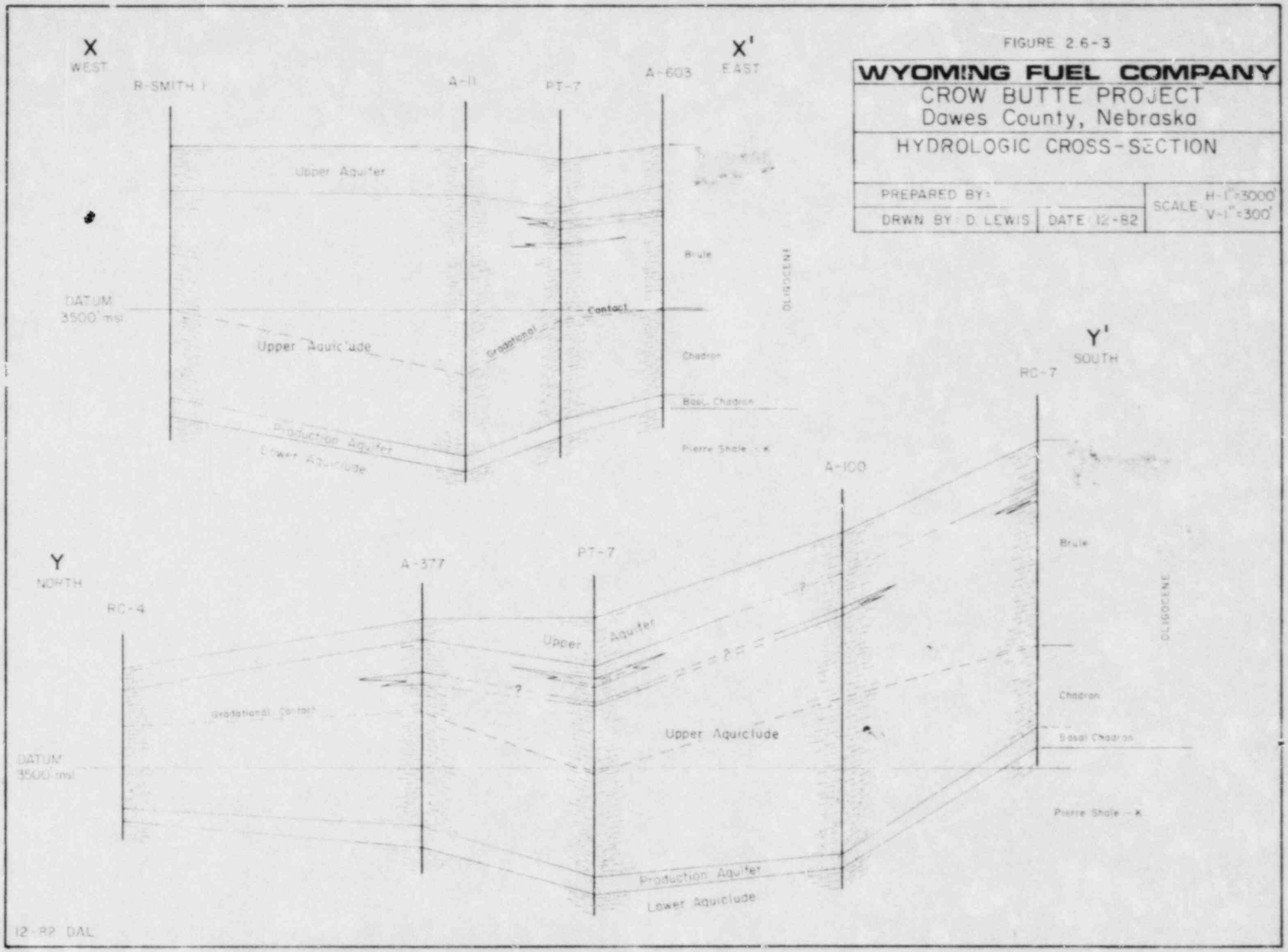
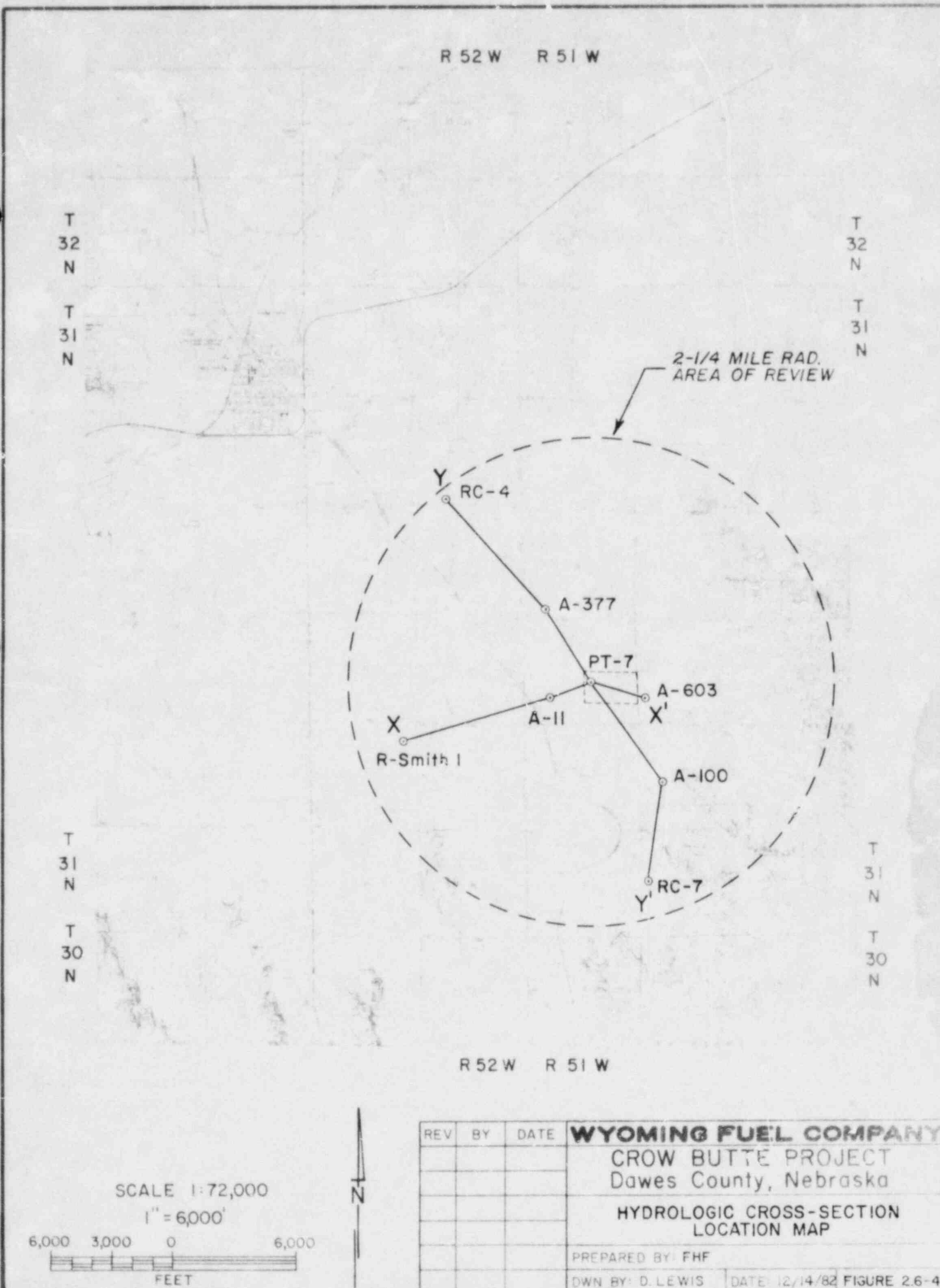


FIGURE 2.6-3
WYOMING FUEL COMPANY
CROW BUTTE PROJECT
Dawes County, Nebraska
HYDROLOGIC CROSS-SECTION
PREPARED BY:
DRWN BY: D. LEWIS
DATE: 12-82
SCALE: H-1"=3000' V-1"=300'
X
WEST
X'
EAST
R-SMITH 1
A-11
PT-7
A-603
Upper Aquifer
Brule
OLIGOCENE
DATUM 3500' msl
Contact
Gradational
Upper Aquiclude
Chadron
Basal Chadron
Production Aquifer
Lower Aquiclude
Pierre Shale - K
Y'
SOUTH
RC-7
A-100
Y
NORTH
RC-4
A-377
PT-7
Upper Aquifer
Gradational Contact
Upper Aquiclude
Brule
Chadron
Basal Chadron
OLIGOCENE
DATUM 3500' msl
Pierre Shale - K
Production Aquifer
Lower Aquiclude
12-82 DAL



REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			HYDROLOGIC CROSS-SECTION LOCATION MAP
			PREPARED BY: FHF
			DWN BY: D. LEWIS — DATE: 12/14/82 — FIGURE 2.6-4

five or more orders of magnitude less than the adjacent sandstone.

The upper aquifer is indicated on the cross-section as a solid unit. In reality this aquifer consists of a series of sandstone, siltstone and clay stringers many of which are difficult to correlate over any large distance. As stated previously, these sand lenses may exhibit differing water levels. Brule wells PM-6 and PM-7 in the R&D wellfield (Figure 2.6-5) have water levels which differ by 0.74 m (2.43 ft). In addition, recharge capacity may be low in these lenses as indicated by clean-up data for the above two wells.

Should a flow channel develop between the production zone and overlaying aquifer, the tendency would be for water to flow downward from the Brule to the Chadron aquifer under normal conditions. The mean sea level water elevation of PM-6 is 1172.50 m (3846.78 ft) and production well PT-7 is 1144.27 m (3754.17 ft). A hydrostatic head of 28.23 m (92.61 ft) would prevent upward migration of leach fluids or Chadron aquifer water under normal conditions. All exploration drill holes are plugged with a nontransmissive mud to prevent any communication between aquifers. Furthermore all wells are required to be cemented from the top of the screened aquifer to ground surface, followed by pressure testing for well integrity.

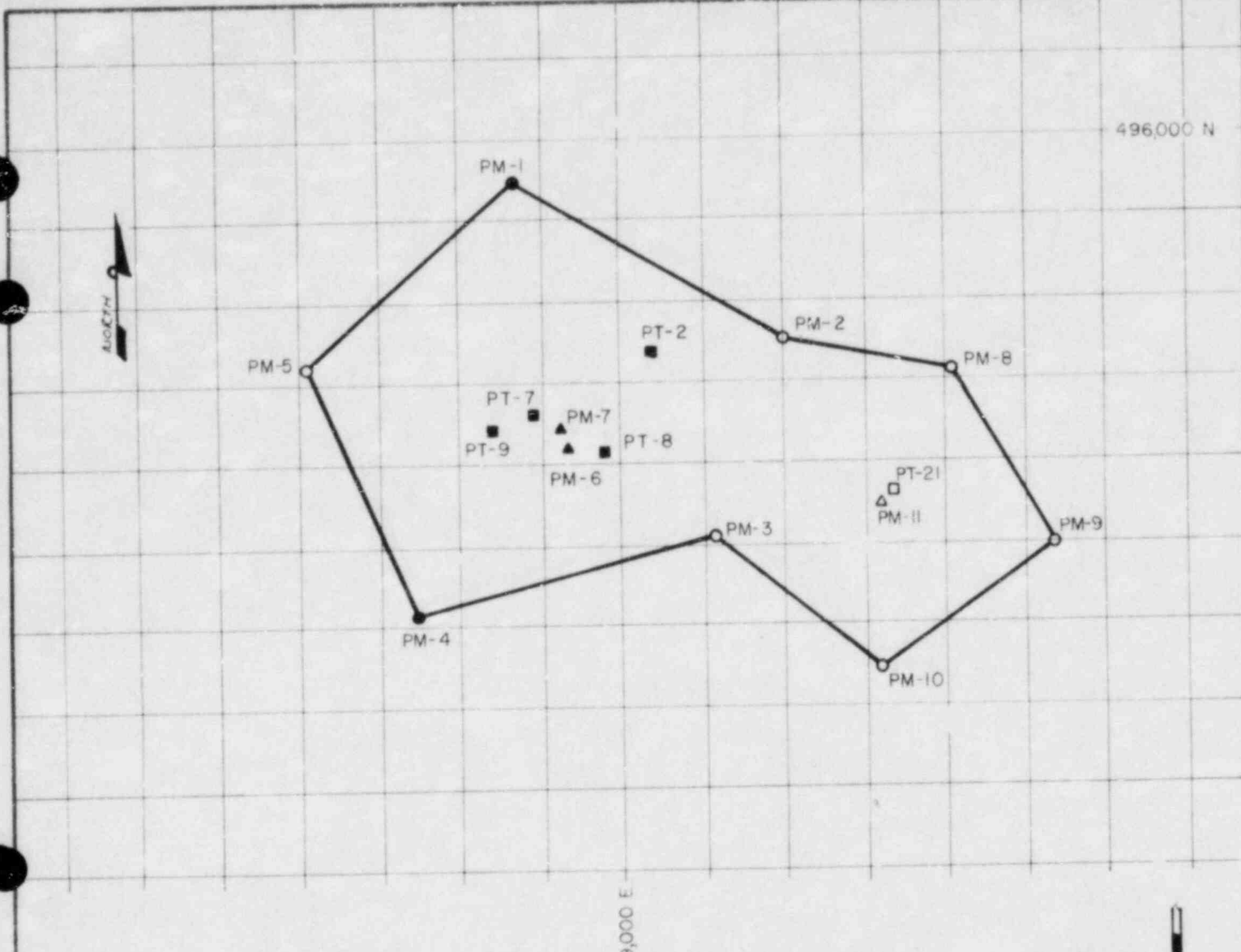
Water User Survey. To fulfill requirements of the NRC and Nebraska DEC UIC program, a survey of existing and abandoned water wells was made. Since Nebraska does not require state registration of private water wells, land owners having wells within 2½ miles from the R&D site were contacted. All obtainable information was collected and is presented here in Table 2.6-1. Figure 2.6-6 illustrates the location of in-use wells, abandoned wells and springs. The nearest abandoned well is located in the Brule aquifer. This well is greater than 730 m (2400 ft) from the proposed wellfield, and should not be affected by the R&D operations.

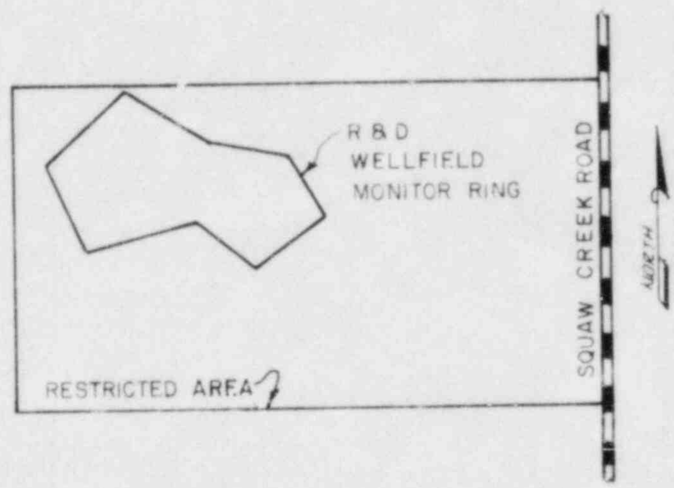
Of the thirty six (36) wells in the 2½ mile radius area thirty one (31) are completed in the Brule Formation. Three of the remaining five wells are located in the Ponderosa State Wildlife Area and the Nebraska National Forest and are recharged from the Arikaree unit of the Gering Formation. The Gering stratigraphically overlies the Brule, and is found at higher elevations in this area. Only two of the area wells are completed in the Chadron, one of which is owned by Wyoming Fuel Company.

The Brule aquifer is used primarily as a domestic and livestock water source. Brule water is desirable because of its high quality, low total dissolved solids and shallow depth. A majority of the wells are less than 30 m (100 ft) deep. The Chadron aquifer has little use because of its objectionable hydrogen sulfide odor, high total dissolved solids concentration and high drilling costs for well completion.

Water Quality. During 1982 selected wells throughout the Crow Butte area of review have been sampled to determine baseline water quality. Six of these wells were existing private wells and six were completed by Wyoming Fuel Company. Further description of the wells and sample results are included in Section 2.11 Background Nonradiological Characteristics and Appendix 2.11(A).

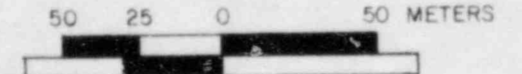
Brule and Chadron water can be classified on the basis of total dissolved solids (TDS) and a trilinear or piper diagram





LEGEND

- ● – PRODUCTION ZONE MONITOR WELL – BASELINE WELL
- ○ – PRODUCTION ZONE MONITOR WELL – PROPOSED WELL
- ▲ – UPPER AQUIFIER MONITOR WELL – BASELINE WELL
- ■ – PRODUCTION ZONE PUMP TEST WELL – BASELINE WELL
- △ – UPPER AQUIFIER MONITOR WELL – PROPOSED WELL
- □ – PRODUCTION ZONE WELL – PROPOSED BASELINE WELL



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			WYOMING FUEL COMPANY CROW BUTTE PROJECT Dawes County, Nebraska
			BASELINE WELL LOCATIONS
			PREPARED BY:
			DWN BY: R.E. LARSON — DATE: 12-10-82 — FIGURE 2.6-5

TABLE 2.6-1
WATER USER SURVEY WELLS
(WITHIN A 2 1/4 MILE RADIUS OF R & D WELLFIELD)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
5	Fern Bass	1913	80	Steel	60-80	----	Brule Fm	D L
6	Mike Dyer	1950	75	Steel	50-75	20.8	Brule Fm	D
7	Mike Dyer	1954	75	Steel	50-75	70	Brule Fm	L
8	Mike Dyer	1954	75	Steel	50-75	70	Brule Fm	L
9	Mike Dyer	1920	70	Steel	60-70	59.2	Brule Fm	L
10	Mike Dyer	----	----	----	----	----	Brule Fm	L
11	Mike Dyer	----	110	----	----	64.7	Brule Fm	N
12	Mike Dyer	----	135	----	----	75.6	Brule Fm	L
13	Mike Dyer	----	----	----	----	52.0	Brule Fm	L

* D=Domestic, L=Livestock, I=Irrigation, C=Commercial, N=Seldom Used

WATER USER SURVEY WELLS
(WITHIN A 2 1/4 MILE RADIUS OF R & D WELLFIELD)
(Continued)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
14	John Paris	1960	80	Galvanized	30-80	43.2	Brule Fm	L
15	John Paris	1960	75	Galvanized	30-75	34.3	Brule Fm	L
16	John Paris	1960	80	Galvanized	30-80	50	Brule Fm	D L
17	H. Gibbons	1960	80	Steel	40-80	46.5	Brule Fm	D L
18	H. Gibbons	1946	120	Steel	80-120	40	Brule Fm	L
19	H. Gibbons	----	80	Steel	40-80	40	Brule Fm	L
24	F. Ehlers	----	80	Steel	60-80	59.2	Brule Fm	L
25	F. Ehlers	----	75	Steel	55-75	36.1	Brule Fm	D L
26	[illegible] Stetson	1890	80	Steel	19-80	19	Brule Fm	D L

* D=Domestic, L=Livestock, I=Irrigation, C=Commercial, N=Seldom Used

WATER USER SURVEY WELLS
(WITHIN A 2 1/4 MILE RADIUS OF R & D WELLFIELD)
(Continued)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
27	O. Stetson	1930	80	Galvanized	35-80	35	Brule Fm	L
28	O. Stetson	1981	80	Plastic	60-30	30	Brule Fm	L
31	H. Bunch	1955	135	Galvanized	30-135	93.2	Brule Fm	L
32	H. Bunch	1947	400	Steel	?-400	39.8	Chadron Fm	D L
35	State of NE	----	300	Galvanized	280-300	----	Gering Fm	L
37	State of NE	----	----	----	----	----	Gering Fm	D
38	State of NE	----	80	Galvanized	60-80	40	Gering Fm	L
41	M. Franey	1900	100	----	----	60	Brule Fm	L
49	Gerald Lux	1920	80	Galvanized	25-80	72.4	Brule Fm	L

* D=Domestic, L=Livestock, I=Irrigation, C=Commercial, N=Seldom Used

WATER USER SURVEY WELLS
(WITHIN A 2 1/4 MILE RADIUS OF R & D WELLFIELD)
(Continued)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
50	Gerald Lux	1973	180	Steel	20-180	80.0	Brule Fm	L
57	Tom Brott	1920	25	Galvanized	?-25	12	Brule Fm	D L
58	Tom Brott	1980	35	Plastic	16-35	15	Brule Fm	L
59	Tom Brott	1970	35	Plastic	?-35	15	Brule Fm	L
62	Wyoming Fuel	1981	470	Plastic	430-470	35.2	Chadron Fm	C
63	Wyoming Fuel	----	----	----	----	----	Brule Fm	D
64	Orville Davis	1946	30	Galvanized	10-30	19.7	Brule Fm	D
71	Sam Pedrick	----	100	----	----	50.0	Brule Fm	L
72	Sam Pedrick	----	450	----	----	82.2	Brule Fm	L

* D=Domestic, L=Livestock, I=Irrigation, C=Commercial, N=Seldom Used

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analysis. The Brule aquifer is termed fresh water, as it has less than 1000 mg/l TDS. The Brule is classified as drinking water based on the TDS criteria. Drinking water standards are based on 1) the presence of objectionable tastes, odors or colors, and 2) the presence of substances with adverse physiological effects such as lead, mercury, sulfate and radium-226 (Davis and De Wiest,1966).

Chadron Formation water is classed as brackish, as it contains greater than 1,000 and less than 10,000 mg/l TDS. The use category is "poor" for general household use and "poor" for irrigation (Davis and De Wiest,1966). The term "poor" is given because several parameters such as sodium, bicarbonate and sulfate exceed the maximum recommended concentrations for "good". Irrigation criterial are also based on tolerance of various plant species to "salt" content of the water and build-up of minerals in the soils.

The trilinear or piper diagram which is based on the percentage concentration of dominant cation and anion equivalents in solution shows the Brule as a calcium bicarbonate water. The Chadron is a sodium sulfate/sodium chloride water. These distinct groupings (Figure 2.6-7) correspond to Spalding, (1982). Spalding concluded the Arikaree, Brule and stream waters all exhibit calcium bicarbonate characteristics while the Chadron, an older deeper formation, contains more mineralized water.

Hydrologic Testing. An aquifer testing program is an integral part of the evaluation of a uranium bearing sand's amenability to in-situ mining and confinement of the leaching solutions vertically and horizontally. The ability of the host sand to transmit fluid is measured in units of hydraulic conductivity (k) or transmissivity (kb; where b=formation thickness). An average value for k can be obtained from the analysis of drawdown data from a pumping test.

Implicit to the application of this type of analysis is a series of assumptions that must be borne in mind during the analysis of the data and the application of the results. The assumptions underlying the methods used herein are listed below.

- The aquifer has seemingly infinite areal extent,
- The aquifer is homogeneous, isotropic and of uniform thickness over the area influenced by the pumping test,
- Prior to pumping, the piezometric surface is nearly horizontal over the area influenced by the pump test,
- The aquifer is pumped at a constant discharge rate,
- The pumped well penetrates the entire aquifer and thus receives water from the entire thickness of the aquifer by horizontal flow.

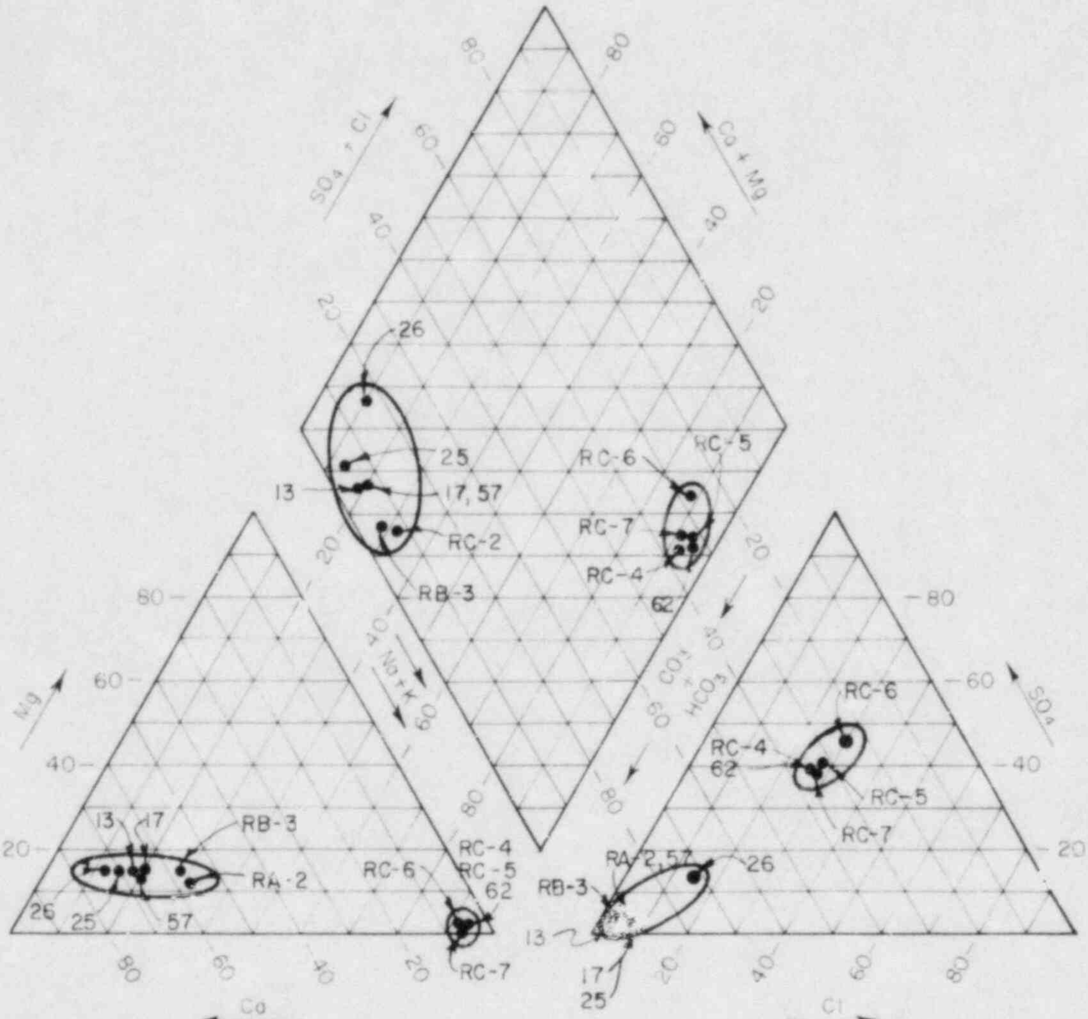
The first three assumptions are seldom entirely satisfied in nature although small deviations are not prohibitive. The fourth assumption is more easily satisfied by careful control of the pump discharge rate. The last qualification, of full aquifer penetration by the pumping well is not practical within an in-situ mining wellfield. But by using observation wells at sufficient distances (>2b) the effects of spherical flow are eliminated.

With an understanding of these limitations the results of the aquifer test can be used to predict the response of the aquifer to hydraulic stresses of varving magnitude and duration. The effects of sustained pumping on water levels in area wells can be estimated. Also leakage into the aquifer from

FIGURE 2.6-7

TRILINEAR DIAGRAM

Ground Water Within the Area of Review
Crow Butte R&D Project



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ANIONS

PERCENTAGE OF TOTAL EQUIVALENTS

BRULE WATERS

CHADRON WATERS

1-10-83

adjacent aquifers through the confining strata or via other drill holes can be assessed by analyzing the shape of the curves of the plotted drawdown data. In the same way, changes in aquifer thickness and flow retarding boundaries such as faults can be located. Changes in transmissibility and horizontal anisotropy can also be investigated.

The pump test in the proposed R&D wellfield was conducted during November 1982 for a period of 50.75 hr and the recovery was monitored subsequently for 27.6 hrs. Water levels in four production zone observation wells were monitored as well as two shallow aquifer monitor wells. The following sections describe the results of that test. Figure 2.6-8 shows the relative locations of the wells used in the aquifer test.

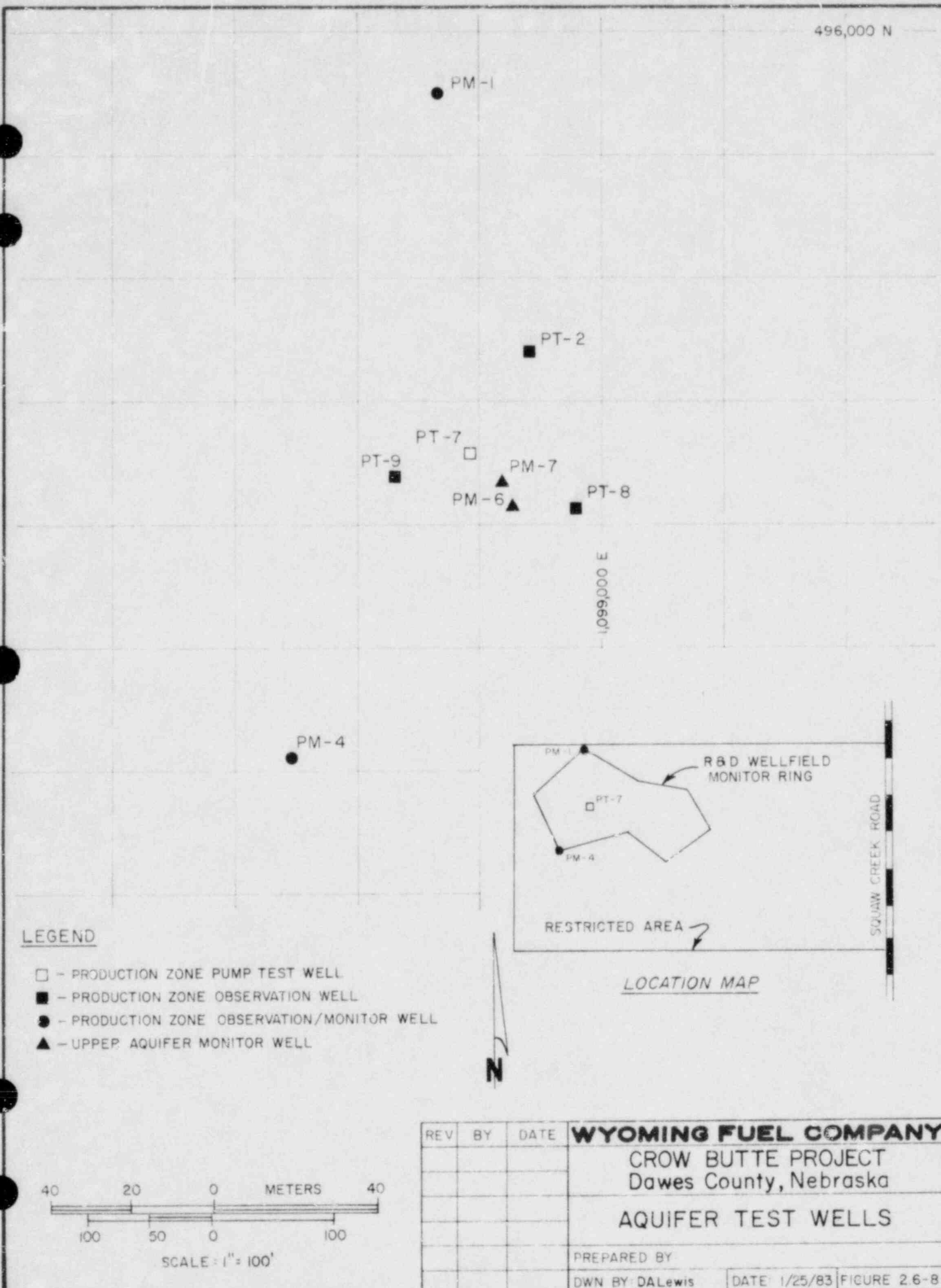
Geological Setting. The basal sands of the Oligocene Chadron Formation in the proposed R&D area comprise a 12-18m (40-60 ft) thickness of locally heterogeneous sands, silts and clays of fluvial origin. The sands range from coarse conglomerates with cobbles up to 15 cm (6 in) to fine sand, silt and clay lenses which vary in thickness from a few centimeters to over a meter. The uranium mineralization is generally found in the lower 9-12 m (30-40 ft) of sand. This horizon is fairly distinct hydrologically being confined on the top by a 12-30 m (40-100 ft) thickness of dense clay and silt and lying unconformably on 350 m (1200 ft) of Pierre Shale. The uranium mineralization in the pilot area occurs in the lowermost 4.5-6.0 m (15-20 ft) of the Chadron Formation. This material varies in character from fine to medium grained uniform sand encountered in wells PT-2 and PT-3 to thin lenses of coarse to medium sand interbedded with lenses of clay and silty sand as found in PT-7 and PT-9. The variability of the material can be seen in resistance logs from those holes that have been included in Appendix 2.6(A). The lowermost 4.5-6.0 m (15-20 ft) of sand was screened in the pump test pattern holes.

The middle member of the Chadron Formation as described in the geological section of this document consists of bentonitic clays with very fine sand. The uppermost member is made up of greenish gray siltstone and massive clay with occasional limestone and gypsum. There is no good sand development in the upper members that would constitute an aquifer.

Lying conformably on top of the Chadron is the Brule Formation. The Orella Member which is the lower member, consists of massive brown siltstone with spotty green clay nodules. The Orella Member has a thickness of 60-75 m (200-250 ft).

The upper 90-120 m (300-400 ft) of Brule has been designated the Whitney Member which outcrops in the proposed pilot area. Within the Whitney Member are thin lenses of sand which are saturated. The best sand in the Whitney occurs at a depth of at approximately 60 m (200 ft). This unit is a rather coarse grained clean sand. Well PM-6 was completed in this unit and was monitored during the aquifer test. Above that sand is a sequence of fine grained sands interbedded with silt that continues to the surface. Well PM-7 is screened in those shallow sands from 27-30 m (90-125 ft). PM-7 was also monitored during the pump test.

A major regional fault zone exists approximately 8 km (5 mi) northwest of the R&D area, along the White River striking northeast-southwest. Displacement across the fault has been estimated at 90-120 m (300-400 ft) vertically with the upthrown side to the south. The basal Chadron sands to the


496,000 N
PM-1
PT-2
PT-7
PT-9
PM-7
PM-6
PT-8
1,099,000 E
PM-4
PM-1
R&D WELLFIELD
MONITOR RING
PT-7
PM-4
SQUAW CREEK ROAD
RESTRICTED AREA
LOCATION MAP
LEGEND
□ – PRODUCTION ZONE PUMP TEST WELL
■ – PRODUCTION ZONE OBSERVATION WELL
● – PRODUCTION ZONE OBSERVATION/MONITOR WELL
▲ – UPPER AQUIFER MONITOR WELL
N
40 20 0 METERS 40
100 50 0 100
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REV
BY
DATE
WYOMING FUEL COMPANY
CROW BUTTE PROJECT
Dawes County, Nebraska
AQUIFER TEST WELLS
PREPARED BY
DWN BY: DALewis
DATE: 1/25/83
FIGURE 2.6-8

south of the fault are truncated against upper Chadron or lower Brule beds to the north.

Aquifer Test Well Pattern. The wells used for the aquifer test were located so that they can be incorporated into the proposed pilot wellfield which is shown in Figure 2.6-5. Four of the proposed pattern wells were drilled and completed in the lower 4.5-6.0 m (15-20 ft) of the basal Chadron sands. They are numbered PT-2, PT-7, PT-8 and PT-9. Two of the proposed production zone monitor wells were also drilled and completed in the same horizon. The two production zone monitor wells are designated PM-1 and PM-4. In addition to the production zone wells two shallow aquifer monitor wells were installed into saturated upper sands of the outcropping Brule Formation. The deeper of the two is PM-6 and the other is assigned the number PM-7.

The original completion method used for the wells was the integral screen and cement basket completion. Some difficulties with the original 10 cm (4 in.) screen made it necessary to install 5 cm (2 in.) telescoping liners inside the 10 cm (4 in.) to control sand production.

Table 2.6-2 lists the completion details for the pump test wells along with their distances from the pumping well, PT-7. Logs of these wells are provided in Appendix 2.6(A).

The Chadron wells are completed only in the lower 4.5-6.0 m (15-20 ft) of the basal sand which has a total thickness of 10-12 m (35-40 ft). The effects of spherical flow as a result of partial penetration of the aquifer by the well screen are most apparent in the vicinity of the pumping well. As a general rule horizontal flow conditions are assumed to exist at dis-

TABLE 2.6-2
R&D PROJECT AREA
PUMP TEST WELL COMPLETION DATA

Well No.	Total Depth(ft)	Centralizer Depths(ft)	Basket Depth(ft)	Screen Interval(ft)	Distance To Pumpin Well(ft)
PM-1	674.5	640,540,440, 340,240,160, 120,60,Top	645	649.5-669.5	293
PM-4	674.5	10,40,80,115, 215,315,415, 515,615	637	641.5-646.5 654.5-669.5	293
PM-6	217.5	0,60,140,180	193	196-211	55
PM-7	129.5	0,40,80	85	89.5-94.5 99.5-104.5 109-114 119.5-124.5	35
PT-2	665.5	10,60,80,119, 219,319,419, 519,619	641	641-656	93
PT-7	672.5	20,80,120,230, 330,430,530,630	648	649-664	0
PT-8	674.5	630,530,430,330, 230,130,70,30,8	650	653-668	93
PT-9	680.5	10,50,90,140,240. 340,440,540,640	656	659-674	66

tances from the pumping well greater than 2 times the total aquifer thickness. For this situation the drawdown data from wells at a distance of more than 20-25 m (70-80 ft) should be free from the influence of partial penetration. Well number PT-9 is the only production zone well closer than 28 m (93 ft) and PT-9 was not monitored during the aquifer test because of screen plugging.

The static water levels for the test area are given in Table 2.6-3. As can be seen, the piezometric surface is essentially flat across the test pattern.

Pump Test. The center well of the pattern PT-7, was equipped with a 7½ HP submersible pump which was set at a depth of 189 m (620 ft). The pump discharge line was 1¼ in. iron pipe. Power was supplied by a 20 KVa diesel driven generator which ran continuously for the 50 hr duration of the test. A 2.5 cm (1 in.) diaphragm valve was used as a flow control valve and two Badger flow totalizers were installed in the discharge line to meter the flow. Only one flow meter was used at any one time, keeping the second in reserve. The discharge line from the flow meters was run 152 m (500 ft) from the well head to insure that leakage down into the shallow aquifers did not occur.

A recording barometer was set up near the test area to monitor fluctuations in atmospheric pressure during the test. Measurements of the water levels in the pilot area wells were also made for a period of 8 days after the pump test pattern had returned to static conditions. These data were compared with the variations in atmospheric pressure to determine the degree of correlation between atmospheric pressure and

TABLE 2.6-3

STATIC WATER LEVEL

IN THE CROW BUTTE R&D PROJECT AREA

Well No.	Aquifer	Water Level Elevation* (meters-msl)
PM-1	Chadron	1144.30
PM-4	Chadron	1143.35
PM-6	Brule	1171.50
PM-7	Brule	1172.24
PT-2	Chadron	1144.39
PT-7	Chadron	1144.27
PT-8	Chadron	1144.02
PT-9	Chadron	1144.40

* Measured January 10, 1983

hydrostatic head in the aquifer. The barometric efficiency of the aquifer can be estimated by dividing the changes in water level by the concurrent changes in barometric pressure.

Each of the observation wells was equipped with an electric water level indicator and all measurements in each well were made with the same instrument. During the early stages of the test a person was stationed at each well to take the measurements in rapid succession. Pumping began at 7:15 am on 11/16/82 and was discontinued at 10:00 am on 11/18/82; a period of 50.75 hrs. The recovery of the water levels was then monitored for 27.60 hr. A discharge rate of 91 l/min (24 gpm) was chosen for the test. The overall average flow rate was 90 l/min (23.8 gpm) and the fluctuations were generally less than 1.1 l/min (0.3 gpm) or 1.3 percent. Water level measurements were taken at 1, 2, and 5 minutes then at 5 min intervals for the first 30 min of the test with regularly increasing intervals to 4 hrs after 24 hrs of elapsed time. Drawdowns were generally smooth and symmetrical and there were no equipment failures or interruptions in the test.

Methods of Data Analysis. Thies' Nonequilibrium Method. Water levels in the observation wells continued to decline for the duration of the test indicating a continuously expanding cone of depression. Under those circumstances the unsteady state methods of analysis are generally employed. The most common of these methods is the Thies nonequilibrium curve matching technique. The assumptions listed previously apply to this method.

Additional limiting conditions must also be satisfied:

- The aquifer is confined.

- The flow to the well is in unsteady state.
- The water removed from storage is discharged instantaneously with decline of head.
- The storage in the well can be neglected.

The drawdown data "s" for each well are plotted on log-log coordinate paper versus r^2/t: where r is the distance from pumping well to the observation well and t is time in minutes since pumping started. The curves are then compared to a standard nonleaky artesian type curve which is a log-log plot of the "well function" W(u) and its argument u. The quantity u is defined as, (Ferris, et al, 1962):

$$u = \frac{r^2 S}{Tt} \qquad (1)$$

Where:

T = Transmissibility, in m^2/s or gal/day-ft.

S = Storage coefficient, expressed as a decimal fraction.

t = Time since pumping started, in minutes.

r = Distance from the pumping well.

W(u) is the exponential integral of u which cannot be integrated directly but is approximated by the series:

$$W(u) = -0.577216 - \ln u + u - \frac{u^2}{2(2!)} + \frac{u^2}{3(3!)} - \frac{u^2}{4(4!)} \ldots\ldots \qquad (2)$$

An arbitrary match point is chosen and the corresponding values of u, W(u), r^2/t and s are then used to determine values of T and S via equation (1) and (3).

$$T = \frac{Q}{4 \pi s} W(u) \qquad (3)$$

Where:

s = Drawdown

Q = Pump Discharge Rate

Modified Jacob Nonequilibrium Method. As an alternative Jacob's modified nonequilibrium method can be applied with the additional limitation that u is sufficiently small, generally less than 0.01. This implies that r is small and t is large. The early drawdown data usually do not satisfy this condition. In some instances considerable time must elapse before the data can be used.

The Jacob method utilizes a semi-log plot of drawdown versus time. The slope of a straight line fitted through the data s per log cycle, is determined as well as the value of t_0 where s = 0. These two values are used to determine T and S using equations (4 and 5), (Kruseman and De Ridder, 1970).

$$T = \frac{0.18\ Q}{\Delta s} \qquad (4)$$

$$S = \frac{2.25\ T\ t_0}{r^2} \qquad (5)$$

Thies' Recovery Method. The rate of recovery of the water level in the observation wells after pumping has stopped can be used to arrive at a value for transmissibility. No value for the storage coefficient can be obtained with this method, however, it serves as check on the results of the analysis of the drawdown data. It is of particular usefulness if the pumping rate was not held constant during the drawdown portion of the test. For the analysis the mean rate of discharge over the entire pumping period is used.

A semi-log plot is made of s" the residual drawdown versus the quantity t/t": where t is the time since pumping started and t" is the time since pumping stopped. Similar to the modified Jacob method the slope of the line $\Delta s''$/log cycle is used to determine the value of T. Once again this method assumes a sufficiently small value of the quantity u as defined previously. The equation used to determine T is:

$$T = \frac{2.30\ Q}{4\pi \Delta s''} \qquad (6)$$

<u>Results and Discussion</u>. The drawdown data for wells PT-2, PT-8, PM-1 and PM-4 have been analyzed using Thies' and Jacob's nonequilibrium methods for nonleaky artesian aquifers. Well PT-9 did not respond during the test as a result of screen plugging with fines. The Thies recovery method was also used to estimate the magnitude of T.

The results of the Thies curve matching method produced an average value for T of $5.36 \times 10^{-4} m^2/sec$ (3724 gal/day-ft) and an average storage coefficient S, of 9.66×10^{-5}. The variation in the four estimated values of T was less than 4 per cent. The results of the Thies analysis are given in Table 2.6-4. The log-log time drawdown plots are included in Appendix 2.6(B). The first few data points seldom fall on the type curve because during the early minutes of the test the water is being derived chiefly from storage in the well bore.

TABLE 2.6-4

ESTIMATED AQUIFER PARAMETERS

	Thies' Method		Jacob's Method		Thies' Recovery Method	
	T	S	T	S	T	S
Well #	(m^2/sec)		(m^2/sec)		(m^2/sec)	
PT-2	$5.42x10^{-4}$	$1.24x10^{-4}$	$5.36x10^{-4}$	$1.34x10^{-4}$	$5.27x10^{-4}$	----
PT-8	$5.45x10^{-4}$	$1.20x10^{-4}$	$5.52x10^{-4}$	$1.23x10^{-4}$	$5.77x10^{-4}$	----
PM-1	$5.17x10^{-4}$	$6.51x10^{-5}$	$5.61x10^{-4}$	$5.85x10^{-5}$	$5.73x10^{-4}$	----
PM-4	$5.38x10^{-4}$	$7.72x10^{-5}$	$5.73x10^{-4}$	$7.28x10^{-5}$	$5.88x10^{4}$	----

The rate of extraction of water from the aquifer is considerably less than the pump discharge rate initially. As time goes on less water is being derived from well bore storage and the majority is coming from aquifer storage. The inside diameter of the well casing is 11.10 cm (4.368 in.) with a volume of 9.66 l/linear m (0.778 gal/ft). At a pumping rate of 91 l/min (24 gpm) the majority of the water during the first 10 minutes was derived from well bore storage.

It can be seen from the curves that the data very closely approximate the nonleaky artesian type curve. There is no apparent flattening of the curves which would indicate leakage or recharge from another aquifer nor are there any increases in slope that would indicate thinning or boundary conditions within the radius of influence of the test. Also the rather close agreement of the four estimates of T indicates a condition of horizontal isotropy. The values of S are also quite similar although the more distant wells PM-1 and PM-4 give values slightly less than the two closer wells.

The results of the Jacob method shown in Table 2.6-4 are in close agreement with those of the Thies method. The individual values of T vary less than 10 percent and the average value of 5.51×10^{-4} m^2/sec (3832 gal/day-ft) is within 3 percent of the Thies value. The calculated values of S are very close to those arrived at by the Thies method, the average being 9.71×10^{-5}. The times at which $u<0.01$ for the two well spacings of 28.3 m (93 ft) and 89.3 m (293 ft) are 63 and 620 min respectively. The 3,000 min duration of the pumping period provides adequate data for purposes of this method. The graphical presentation of those data appear in Appendix 2.6(B).

The semi-log plots of the time-drawdown data once again indicate rather ideal conditions. There are no changes in slope which would indicate either leakage or the presence of flow retarding boundaries within the radius of influence of the test.

The results of the analysis of the recovery data are also presented in Table 2.6-4. The average value of T is $5.66 \times 10^{-4} m^2/sec$ (3936 gal/day-ft) for this method which is slightly higher than the values from the previous analyses. Here again conditions appear to be horizontally isotropic. The fact that the recovery curves do not go precisely through s" = 0 and intersect the drawdown axis at a value <0 suggests a slight variation in the value of S for the drawdown and S" for the recovery. This can be expected as no aquifer is perfectly elastic and the rate of rebound often shows some hysteresis.

The results of the three methods of data treatment all support the contention that the lower Chadron aquifer within the area of influence of the test is homogeneous, isotropic, fully confined and of constant transmissibility. No measurable amounts of leakage or boundaries were detected. The presence of the White River Fault was not apparent in the test data. At a distance of 5,700 m and a flow rate of 91 l/min the presence of the fault would have been detectable at an elapsed time of between 6 and 14 days. Future drawdown tests are planned closer to the fault to study its effects prior to commercialization.

The wat levels in the two shallow aquifer monitor wells showed no drawdown during the period of the pump test. A figure is included in Appendix 2.6(B) which shows the water level fluctuations in the shallow wells during t..e period of the test. It is therefore concluded that the confining layers between the production zone and upper aquifers do not permit leakage.

The fluctuations in water levels in the wellfield were measured after the test from 12/6/82 - 12/13/82. Those data were compared with the barometric pressure changes for the same period.

An estimate of the barometric efficiency of the aquifer can be obtained from that comparison. Barometric efficiency is simply the ratio of the water level changes in a well and the concurrent fluctuations in atmospheric pressure. Both values are usually expressed in meters of water. The data for the eight day period of measurement give an average value of 0.40 for the barometric efficiency of the Basal Chadron Sands. A graphical comparison of those data and is included in Appendix 2.6(B). The effects of barometric pressure changes are not noticeable during the early part of a pump test but are often responsible for the minor fluctuations in drawdown during the latter portion of the test when the rate of change in drawdown is very small.

Drawdown Predictions. During the operation of the pilot plant there will be a continuous withdrawal of water (bleed) resulting from waste water generation in the process. The average rate of withdrawal during leaching has been estimated at approximately 6.1 l/min. (1.6 gpm) for a maximum period of 1 year. The effect of this withdrawal on the piezometric surface in the vicinity of the wellfield can be estimated using the Thies equation and the calculated values of T and S at any arbitrary value of r. Additionally a 2 pore volume net withdrawal is anticipated during restoration at a rate of 38.9 l/min (10 gpm). A pore volume estimated to be 5.19×10^6 l (1.37×10^6 gal), has been used to arrive at a pumping period of 190 days. The effects of the pumping rates and times at different distances from the wellfield are given in Table 2.6-5. The effects on the closest Chadron Formation private well, number 32 in the water user's survey, and at the town site of Crawford are also listed in Table 2.6-5. The respective distances to well #32 and Crawford from the pilot wellfield are 3,500 m (11,500 ft) and 5,700 m (18,700 ft).

The production withdrawal will not be measurable at distances greater than 300 m as the natural fluctuations in water level are on the order of 0.15 m (0.5 ft). The restoration withdrawal will produce a broad but very shallow cone of depression which will result in a drawdown of 0.18 m (0.58 ft) in the Chadron wells in the vicinity of Crawford. The upper sands in the Brule Formation should experience no effects from the pumping in the Chadron Formation.

Soils. The Crow Butte R & D Project Area is located in the semiarid western portion of Dawes County. To the south lies the Pine Ridge, an area of rough steep terrain dissected by steep drainageways. Vegetative cover there is typically mixed grass and ponderosa pine trees. Width the of Pine Ridge ranges from 3.2 kilometers to 8 kilometers and from 150 to 305 meters in height from base to crest. South of the Pine Ridge is the Niobrara River drainage basin. The Crow Butte site is situated in the White River watershed along the Squaw Creek tributary. The terrain is gently rolling to hilly.

For the proposed R & D project an investigation was made of the local soils. Existing Soil Conservation Service literature was consulted, and field sampling for radionuclide, phys-

TABLE 2.6-5
DRAWDOWN PREDICTIONS

Distances from pumping well meters (ft)		Production * Drawdown meters (ft)		Restoration ** Drawdown meters (ft)	
28	(93)	0.195	(0.64)	1.16	(3.82)
89	(293)	0.16	(0.53)	0.95	(3.11)
305	(1000)	0.12	(0.41)	0.72	(2.36)
1610	(5280)	0.08	(0.25)	0.41	(1.34)
Well #32		0.05	(0.170)	0.26	(0.86)
Crawford		0.04	(0.123)	0.18	(0.58)

* Q = 6.1 l/min, t = 365 days

** Q = 37.9 l/min, t = 190 days

ical and chemical properties was conducted. The latter were performed in conjunction with the evaporation ponds site investigation. Pertinent information from these sources on the soils within the R & D Restricted Area is presented below.

The Soil Conservation Service was contacted regarding available soils data for the Crow Butte site. In response, they provided a document containing a comprehensive soils survey which had recently been performed. The following soils descriptions and classifications were extracted from a publication entitled "Soil Survey of Dawes County, Nebraska" published in 1977 by the U.S. Dept. of Agriculture, Soil Conservation Service and the University of Nebraska, Conservation and Survey Division.

Dawes County soils formed by weathering of materials of the underlying geologic formations or of materials deposited by wind and water. The Brule Formation outcrops in the Crow Butte project area and at lower elevations. As this material weathered it produced the Epping, Kadoka, Deota, Schamber, and Mitchell soils. Overlying Tertiary age bedrock at higher elevations is the Arikaree Group. This massive sandstone contains layers of compacted silt and clay. Soils formed from this fine grained material are Alliance, Busher, Canyon, Oglala, Tassel and Rosebud. Sandstone mixed with loess formed soils such as Bayard, Bridget and Vetal in colluvial and alluvial materials.

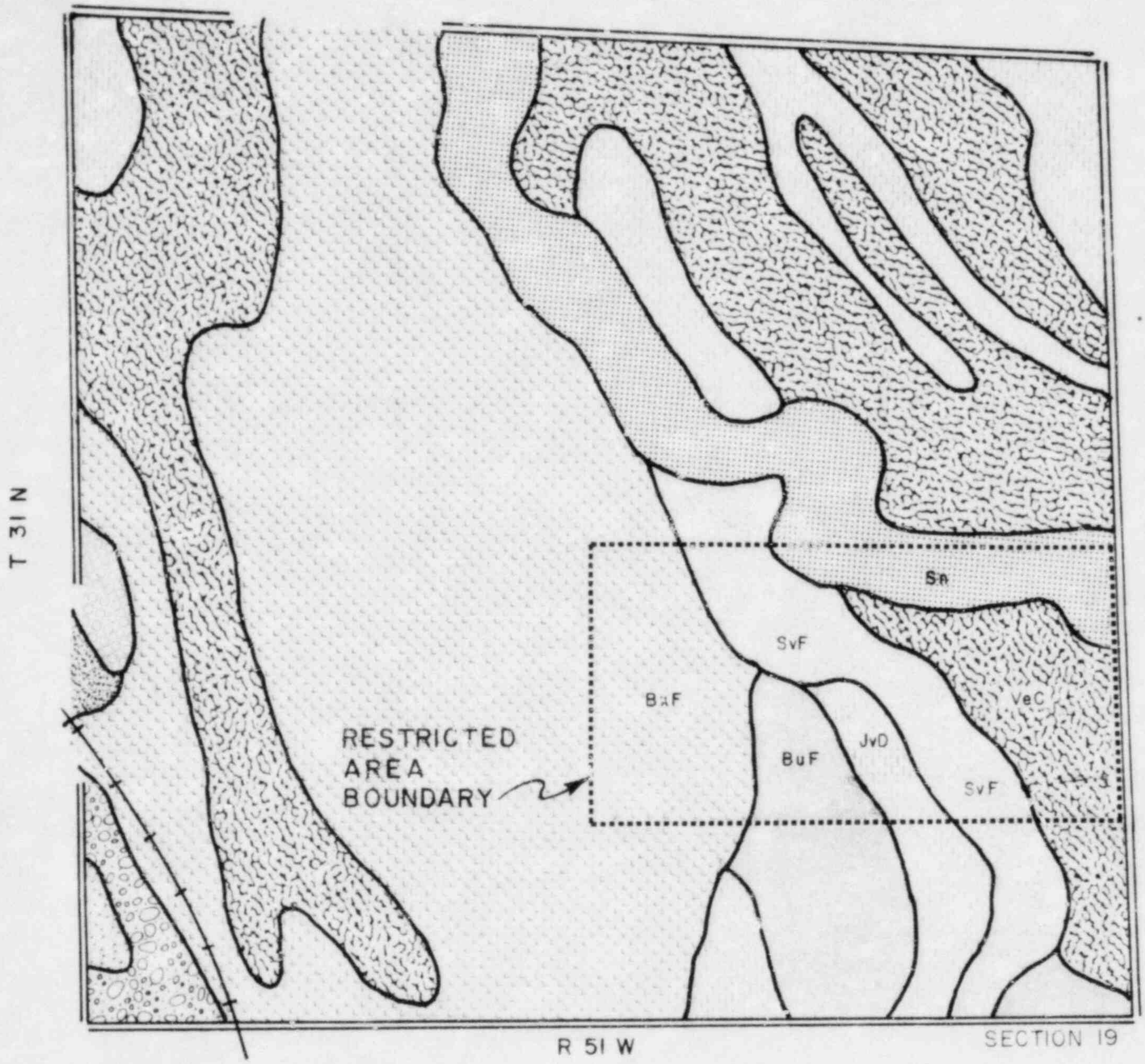
The regional area between the Pine Ridge to the south, the White River to the north and town of Crawford to the northwest is comprised of two major soil associations. The Kadoka-Keith-Mitchell association contains "deep, nearly level to steep, well drained silty soils that formed in loess and in material weathered from siltstone, on uplands and foot slopes." Typically this association consists of undulating to rolling uplands that are dissected by many spring-fed creeks. Areas of this association are mostly west of the restricted area.

The Busher-Tassel-Vetal association is described as "deep and shallow, very gently sloping to steep, well drained to somewhat excessively drained sandy soils that formed in colluvium and in material weathered from sandstone." These sandy soils are found on undulating to hilly uplands which are crossed by numerous creeks and intermittent drainageways. Approximate percentages of soils in this association are Busher 35 percent, Tassel 32 percent and Vetal 15 percent. Minor soils and land types make up the remaining 18 percent. These include the Bayard, Jayem and Sarben soil types and sandy alluvial land.

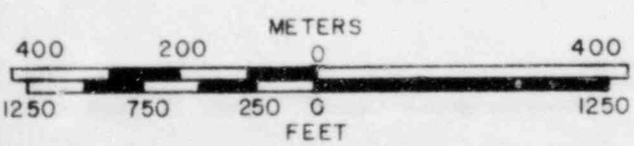
In certain areas the soil material is so rocky, so shallow, so severely eroded or so variable that it has not been classified by soil series. These areas are called land types and are given descriptive names. An example of this is "sandy alluvial land" found within the Busher-Tassel-Vetal association.

The soils shown in Figure 2.6-9 for the restricted area were initially identified and boundaries drawn on aerial photographs by the Soil Conservation Service. The mapping units on aerial photographs are closely equivalent to the soil phases.

Certain of the mapping units are composed of soil complexes or undifferentiated soil groups. A soil complex consists of areas of two or more soils so intricately mixed or so small



AcD2	Alliance silt loam, 3 to9% slopes, eroded
BuD2	Busher loamy very fine sand, 5 to 9% slopes, eroded
BuF	Busher loamy very fine sand, 9 to 20% slopes
BxF	Busher and Tassel loamy very fine sands, 5 to 20% slopes
JvD	Jayem and Vetal loamy very fine sands, 5 to 9% slopes
Sn	Sandy alluvial land
SvF	Sarben and Vetal loamy very fine sands, 9 to 30% slopes
SyF	Schamber soils, 3 to 30%
TaF	Tassel soils, 3 to 30% slopes
VeC	Vetal and Bayard soils, 1 to 5% slopes



REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			SOILS MAP
			PREPARED BY:
			DWN BY: R.E. LARSON | DATE: 9-30-82 | FIGURE 2.6-9

in size that they cannot be shown separately on the soil map. Undifferentiated soil groups are made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The name gives the two dominant soil series represented in the group. Four of the mapping units within the restricted area belong to this category, where the names of dominant soils are joined by "and."

Soils Mapping Unit Descriptions. The following section discusses those soils which occur within the proposed Crow Butte R&D Project area (Figure 2.6-9).

BuF-Busher loamy very fine sand, 9 to 20 percent slopes. This soil is on uplands, occurring in areas up to 81 ha (200 ac) in size. The Busher soil series consists of deep, well drained to somewhat excessively drained soils that formed in material weathered from sandstone. The soil profile is typical of that for the series. The 8 to 18 m (3 to 7 in) thick surface layer is described as grayish brown or dark grayish brown when wet; weak, fine granular structure; soft, very friable; neutral; with a gradual smooth boundary. Lime occurs at a depth of less than 46 m (18 in) in some areas. The A horizon ranges from 18 to 51 m (7 to 20 in) in thickness and is neutral to mildly alkaline. The AC horizon is from 20 to 53 m (8 to 21 in) thick. It is fine sandy loam or loamy very fine sand. Lower horizons become progressively more coarse with sandstone fragments typical in the C horizon.

Permeability of Busher series soils is moderately rapid and water capacity is moderate. Conservation of soil moisture is a major concern in management for control of blowing soil. Runoff is medium.

Natural fertility is medium to low, and organic matter content is moderate. This supports a growth of native grasses, which are used for grazing or hay. The hazard of erosion and steepness of slope make this soil unsuited to cultivation. Classification is sandy range site.

<u>BxF-Busher and Tassel loamy very fine sands, 5 to 20 percent slopes</u>. The majority of occurrences of this uplands soil are 9 to 20 percent slope, but range from 5 to 20 percent. The soil covers areas up to 40.5 ha (100 ac) in size. The group is comprised of about 60 percent Busher loamy very fine sand and 40 percent Tassel loamy very fine sand, however, any mapped area may contain either or both soils. Busher soils are found on middle and lower slope areas and Tassel soils are on ridgetops, knolls and sides of small drainageways.

The brown to light gray surface layer may be less than 18 m (7 in) thick in places. Bedrock occurs at depths of 51 to 91 m (20 to 36 in) in certain areas. Small areas of outcropping sandstone are also included.

This mapping area may be vegetated in native grass, used for grazing or cut for hay. Cultivation is not suitable as serious soil blowing and water erosion may occur if cover is removed. Runoff is medium. Classification of Busher soil is sandy range site and Tassel soil is shallow limy range site.

JvD-Jayem and Vetal loamy very fine sands, 5 to 9 percent slopes. This unit is on uplands and foot slopes in areas up to 121 ha (300 ac) in size. Jayem soils are found on upper parts of side slopes and on ridgetops. Each soil may comprise 50 percent of the unit. Soils of the Jayem series are deep, well-drained to somewhat excessively drained that formed in eolian sands. The representative surface layer is very friable, loamy very fine sand about 33 m (13 in) thick. The subsoil is similar and about 31 m (12 in) thick. In some areas lime may occur at a depth of 25 to 91 m (10 to 36 in).

Vetal soils are also deep and well-drained, but formed in sandy alluvium and colluvium on foot slopes in upland swales. In profile the surface layer is very friable loamy very fine sand about 79 m (31 in) thick underlain by a transitional layer 18 m (7 in) thick. The A horizon ranges from 36 to 102 m (14 to 20 in), and the AC horizon from 20 to 51 m (8 to 20 in) in thickness.

Permeability of both soils is moderately rapid and available water capacity is moderate. Natural fertility is medium and organic-matter content is moderate. Water erosion and soil blowing may be hazards in cultivated or unprotected areas. Runoff is slow to medium. Most areas are in native grasses, however, small acreages may be cultivated by dry land or irrigated methods. Classification is sandy range site.

Sn-Sandy alluvial land, 0 to 3 percent slopes. Calcareous alluvial material make up this land type on bottom lands and the short, steep sides of intermittent drainageways. The surface material is fine sandy loam to very fine sandy loam with small rounded fragments of sandstone interspersed. Gravel is common below a depth of 102 m (40 in). Material on the steep sides of drainages ranges from fine sand to fine sandy loam.

Bottomlands are subject to periodic, short duration flooding, especially in the spring. Permeability is moderately rapid and available water capacity is low to moderate. Runoff is slow on low slope bottomlands and rapid on steep drainageway sides. The water table is below a depth of 3 m (10 ft) in most places.

Most areas are vegetated in native grass, as they are generally unsuited to cultivation due to flooding hazards. Classification is sandy lowland range site.

<u>SvF-Sarben and Vetal loamy very fine sands, 9 to 30 percent slopes</u>. This mapping unit consists of deep, well-drained soils that formed in wind-deposited sands. This soil is found on uplands and foot slopes in areas up to 121 ha (300 ac) in size. Sarben soils are 60 to 80 percent and Vetal soils are 20 to 40 percent of the unit.

Upper portions of side slopes and ridgetops are generally Sarben. The surface layer on A horizon is loamy very fine sand about approximately 15 m (6 in) thick, but ranges from 8 to 25 m (3 to 10 in) in thickness. Underlying material, C horizon, is fine sandy loam, with no AC horizon development present. Lime may occur at a depth of 61 m (24 in). Vetal soils occur swales and on lower portions of foot slopes. The Vetal soils are typical being deep and well-drained. The A horizon may be up to 79 m (31 in) thick with lime occasionally at less than 61 m (24 in) depth.

Permeability is moderately rapid and available water capacity is moderate. Runoff is medium. Natural fertility is medium to low and organic matter content is low. Moisture conservation is by a cover of native grass. This prevents water erosion and soil blowing. Slopes are too steep for cultivation, thus the classification as sandy range site.

VeC-Vetal and Bayard soils, 1 to 5 percent slopes. The soils of this mapping unit are deep, well-drained and formed in sandy alluvium and colluvium. They occur on foot slopes and stream terraces in areas up to 121 ha (300 ac) in size. Vetal soils make up 55 to 75 percent of the total acreage and Bayard soils 25 to 45 percent.

Both soils are loamy very fine sand, neutral to mildly alkaline and very friable. The surface layer includes very fine sandy loam, fine sandy loam, and loamy very fine sand. In some areas the A horizon is less than 18 m (7 in) thick and in other areas silty material is below a depth of 0.6 m (2 ft). Buried soils are common.

Permeability is moderately rapid and available water capacity is moderate. Runoff is slow. Natural fertility is medium and organic matter content is moderate. Approximately half the acreage is cultivated in crops such as wheat, alfalfa, oats and seeded grasses. The other half is range. Conservation of soil moisture and prevention of wind and water erosion are important in farmed areas. Classification is sandy range site.

Plant cover depends upon the site condition. A climax population for sandy alluvial land (Sn) consists of 40 percent sand bluestem, little bluestem, switchgrass and Canada wild rye. About 60 percent is other grasses and forbs such as prairie sandreed, needleandthread, blue grama, Scribner panicum, sand dropseed, western wheatgrass and members of the sedge family. Plants communities common in poor condition sites are blue grama, sand dropseed, Scribner panicum and western ragweed.

The shallow limy range site classification in which Tassel soils of BxF fall contains more alkaline soils as the name implies. Approximately 75 percent of climax plant cover is a mixture of decreaser grasses such as little bluestem, sand bluestem, side-oats grama, needleandthread, prairie sandreed, plains muhly and western wheatgrass. Perennial grasses, forbs and shrubs make up the remaining 25 percent. These increasers include blue grama, hairy grama, threadleaf sedge, fringed sagewort, common prickly pear, broom snakeweed, skunkbush sumac, and western snowberry. These sites are less commonly in poor condition due to their terrain.

The BuF, part of BxF, Jvd, SvF and VeC mapping units are classified as sandy range site. The vegetation which occurs on these soils is influenced by the moderately rapid to rapid permeability of the soils. A typical climax plant community is about 50 percent a mixture of decreaser plants such as sand bluestem, little bluestem, and prairie junegrass. The remaining 50 percent is perennial grass, forbs and shrubs. The principal increasers are blue grama, threadleaf sedge, prairie sandreed, needleandthread, sand dropseed, western wheatgrass, fringed sagewort and small soapweed. A site in poor condition will commonly have blue grama, threadleaf sage, sand dropseed and western ragweed.

2.6.2 Surface Water

The Crow Butte R&D Project lies within the watershed of Squaw Creek which is a small tributary to the major regional water course, the White River. As a part of the preoperational environmental study flow measurements and water quality samples were taken from Squaw Creek in the vicinity of the restricted area.

No surface impoundments occur within or adjacent to the restricted area boundaries. However, for the Nebraska Underground Injection Control permit application the impoundment survey was extended to a 2½ mile radius. This additional information is included.

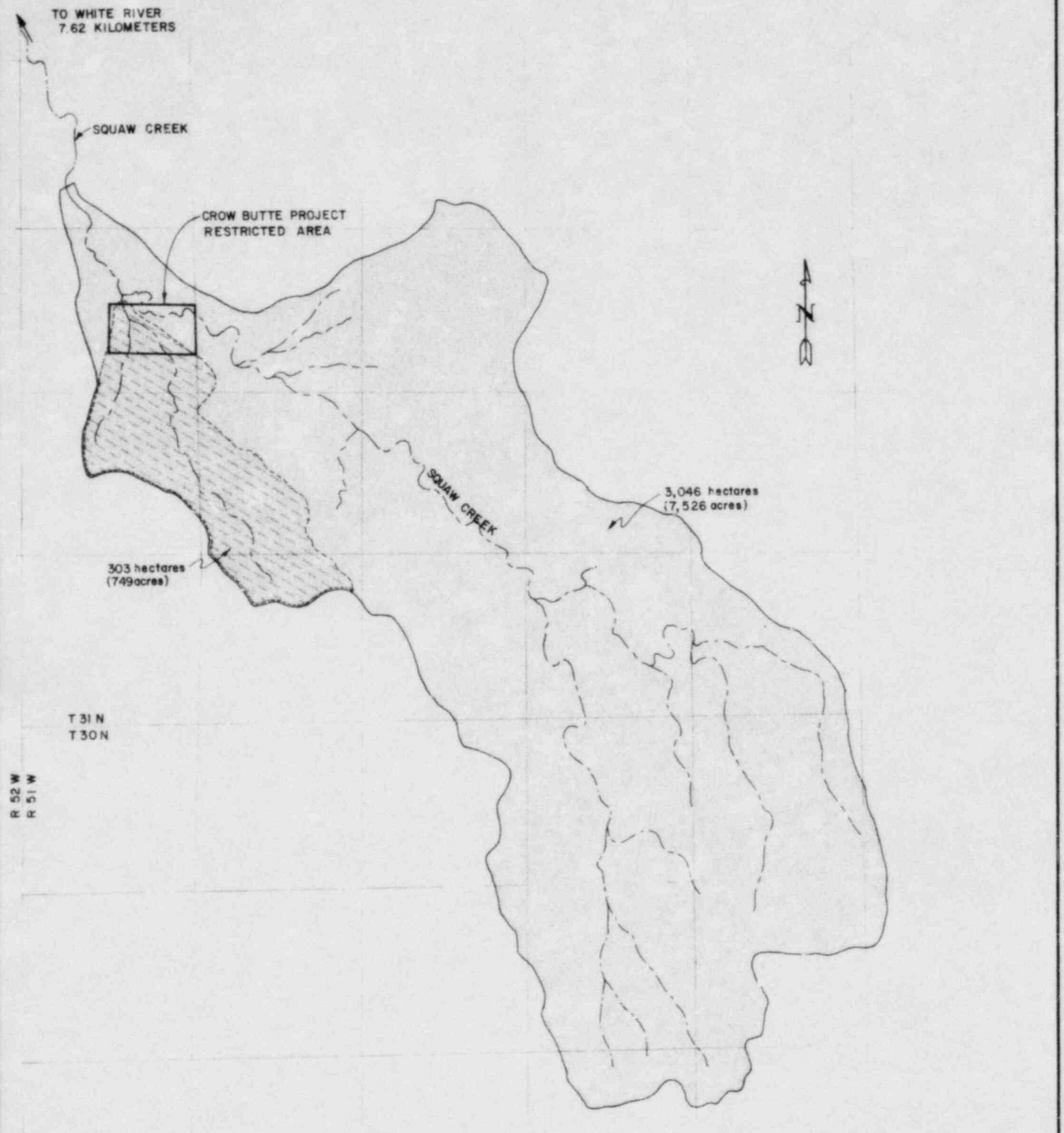
Summaries and data described in this section are in accordance with U.S. NRC Regulatory Guide 3.46 (Task FP818-4).

Location. The Crow Butte restricted area lies in Section 19 of T31N,R51W within the drainage basin of the White River. The White River heads in Sioux County and flows diagonally northward across Dawes County into South Dakota. Northern tributaries in the Crawford area cross upland portions of the Pierre Shale, an impermeable formation. These streams are dry except for runoff flow. The southern tributaries originate in the Pine Ridge escarpment, and flow primarily over National Forest land or grassland. Surface strata is of low permeability and exhibits rapid runoff. These streams are mainly ephemeral except where spring-fed (Agenbroad and Christensen, 1981).

Squaw Creek is one of the southern tributaries. This creek heads in the Nebraska National Forest and Ponderosa State Wildlife Area. From headwaters it flows northwest over range and agricultural land to the White River. Contributions to flow come from springs in the Arikaree Formation, snowmelt, runoff and the shallow Brule aquifer. The latter may receive inflow from the creek during periods of high flow. Due to the time variable nature of these water sources, discharge rates at various points along the creek may experience wide fluctuations on a month to month and yearly basis.

Squaw Creek enters the restricted area in the northeast corner, travels along the northern boundary approximately two-thirds the length and exits to the north. Two branches of an unnamed tributary enter along the southern boundary, join just north of the wellfield and exit the northern boundary before converging with Squaw Creek. This tributary is ephemeral, only flowing when precipitation exceeds infiltration, storage and evaporation. This usually occurs in the spring and early summer when thunderstorms frequently occur.

Figure 2.6-10 illustrates the location of the Crow Butte Project with respect to the upper Squaw Creek watershed and the unnamed tributary. The Squaw Creek watershed above the project covers approximate 3046 ha (7526 ac). The drainage area above and including the ponds, plant and wellfields is only one-tenth the size, totaling 303 ha (749 ac). The watercourse is referred to as the "unnamed tributary" in this report.



UPPER SQUAW CREEK WATERSHED

UNNAMED TRIBUTARY TO SQUAW CREEK WATERSHED

WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Dawes County, Nebraska

UPPER SQUAW CREEK WATERSHED

REV	DESCRIPTION	BY	DATE	REV	DESCRIPTION	BY	DATE

2000 1000 0 2000 4000 8000
FEET

WO NO:

FIGURE NO.
2.6-10

DRAWN BY: R. LARNAU | PREPARED BY: | DATE: 1/24/83

Stream Flow. Flow rates were measured on Squaw Creek for the preoperational survey. Measurement locations and methods are described in Section 2.11 and illustrated on Figure 2.11-1. Stations S-2 and S-3 are upstream and downstream respectively of the restricted area. Stations S-1, upstream just inside the Ponderosa State Wildlife Area and W-2, on the White River are included here for comparison. Figure 2.6-11 shows the fluctuation in discharge rates at these locations over the period of February to November, 1982.

The relative fluctuations in flow rates of the upstream Squaw Creek stations and the White River exhibit very similar patterns. An early summer high is followed by a late summer low and early fall high. Station S-3 exhibits a similar trend but with more exaggerated fluctuations. This may in part be due to stream morphology and difficulty in making measurements. Also the area is severely overgrazed which has resulted in increased sediment loads. The stream channel itself is severely degraded and cannot withstand heavy flows without further degradation. Since these flows are from one year only, far-reaching generalizations cannot be made.

Table 2.6-6 shows the mean monthly discharge of the White River as compared to the mean monthly precipitation over several years (NOAA,1981). This extended data shows that a loose correlation can be made between the direct precipitation and discharge. Higher flows are recorded in spring and early summer, with lowest flow rates in late summer to early fall. For the period of 1931 to 1980 the average normal annual mean discharge (cubic meters per second) at the White River Station at Crawford was 0.57 (20.1 cfs) with a standard deviation of 0.08 (2.8). The maximum was 0.84 (29.7 cfs) and minimum 0.47 cms

TABLE 2.6-6

COMPARISON OF MEAN MONTHLY PRECIPITATION WITH NORMAL MEAN MONTHLY DISCHARGE OF THE WHITE RIVER AT CRAWFORD, NEBRASKA

	Mean Precipitation (1)		Mean Discharge (2)	
	cm	(in)	cms	(cfs)
January	1.04	(0.41)	0.59	(21.0)
February	0.94	(0.37	0.66	(23.4)
March	1.78	(0.70)	0.77	(27.2)
April	4.24	(1.67)	0.72	(25.3)
May	7.57	(2.98)	0.72	(25.6)
June	8.43	(3.32)	0.63	(22.2)
July	5.49	(2.16)	0.44	(15.4)
August	2.46	(0.97)	0.36	(12.6)
September	3.38	(1.33)	0.38	(13.3)
October	2.11	(0.83)	0.47	(16.6)
November	1.09	(0.43)	0.55	(19.4)
December	0.99	(0.39)	0.57	(20.2)

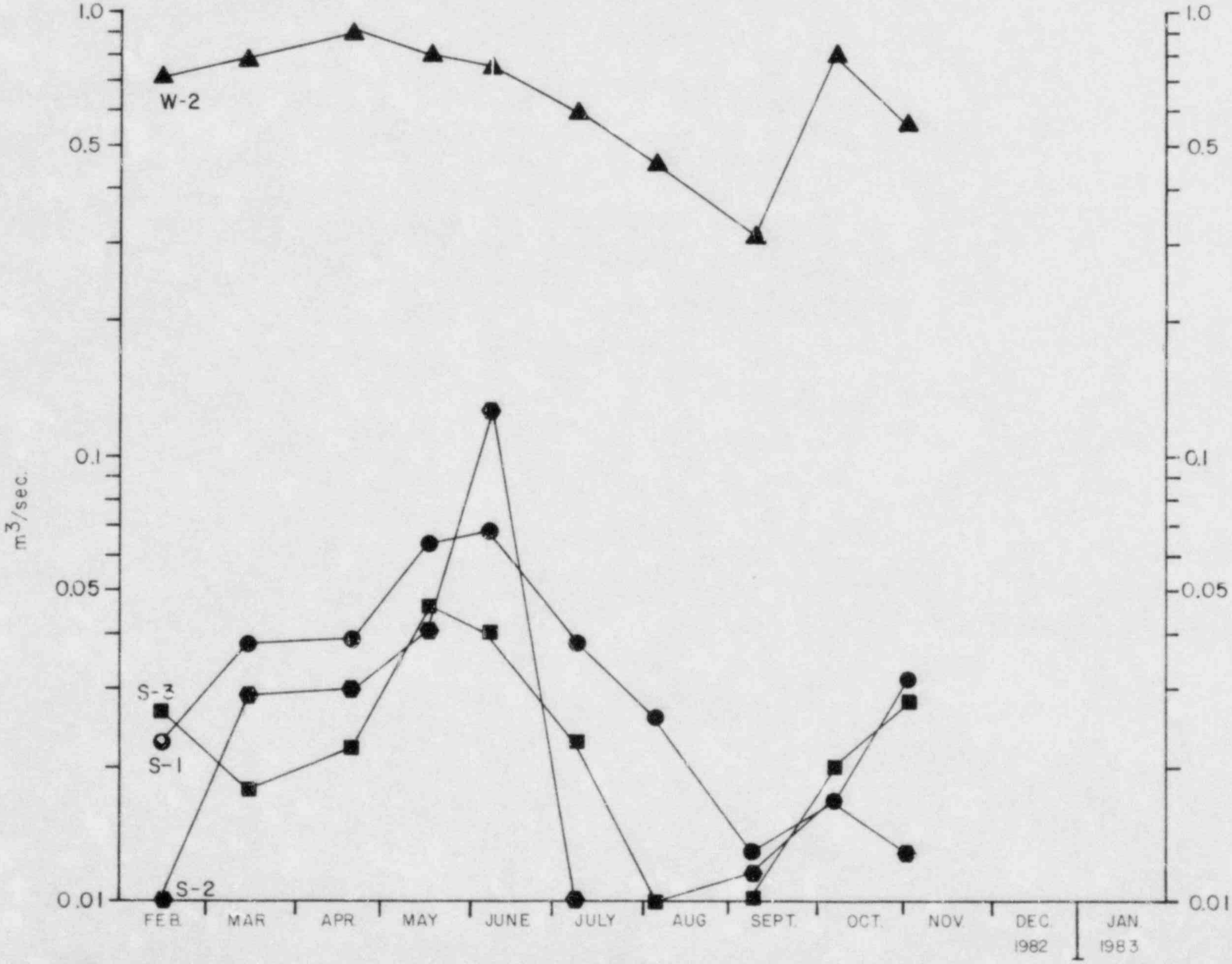
(1) U.S. Dept. of Commerce, 1982, Period of Record 1941-1970.

(2) U.S. Dept. of the Interior, 1981, Period of Record 1931-1980.

FIGURE 2.6-11

STREAM DISCHARGE RATES

WYOMING FUEL CO.
CROW BUTTE R&D PROJECT



12/21/82

(16.6 cfs). Peak rainfall at Harrison and Scottsbluff, Nebraska occurs in May and June (NOAA,1976 and 198[illegible]).

Control Structures. There are no flow control structures located on Squaw Creek either immediately upstream or downstream of the project area. Neither are there any structures located on the unnamed tributary. The nearest dam on Squaw Creek is the impoundment called I-1 in this study. It is approximately 1,905 meters (6250 ft) downstream from the R&D wellfield.

Impoundments. Three impoundments are located within the area 2¼ miles in radius from the project wellfield. The first, I-1 described above is located on Squaw Creek. The other two, I-3 and I-4 are created by dams across English Creek. English Creek originates from two springs in the adjacent watershed west of the project area. Fill water for all these impoundments is dependant on rainfall, runoff and shallow aquifer contribution. Fluctuations in water level may occur seasonally.

Water Quality. Water samples were obtained from Squaw Creek, and the three impoundments during the preoperational monitoring program. Results of these quarterly stream samples and one set of impoundment samples are presented in Section 2.11.

Chemical quality of the Crow Butte area surface water is very high. The water has a low total dissolved solids content and all toxic and objectionable ions are below the EPA and Nebraska maximum concentration levels.

The trilinear diagram shown here, as Figure 2.6-12, is a means of comparing relative ion concentrations in water. Data are included from three Squaw Creek stations, two White River stations and the three impoundments. The White River data shown for comparison is being collected as part of the commercial plant preoperational monitoring program.

Data are plotted as percent of the total milliequivalent ion in solution. All of the surface samples appear very similar in composition. They may be classified as calcium bicarbonate water with varying percentages of sodium and potassium. It is interesting to note that all the Squaw Creek samples have identical percentage composition, indicating that little degradation occurs as the creek flows downstream.

When this trilinear diagram is compared with the one in the previous sub-section on ground water (Figure 2.6-7) an interesting similarity appears. The data points for the Brule aquifer samples lie in almost identical positions to those of the surface water samples. From this, it appears the waters are of similar origin.

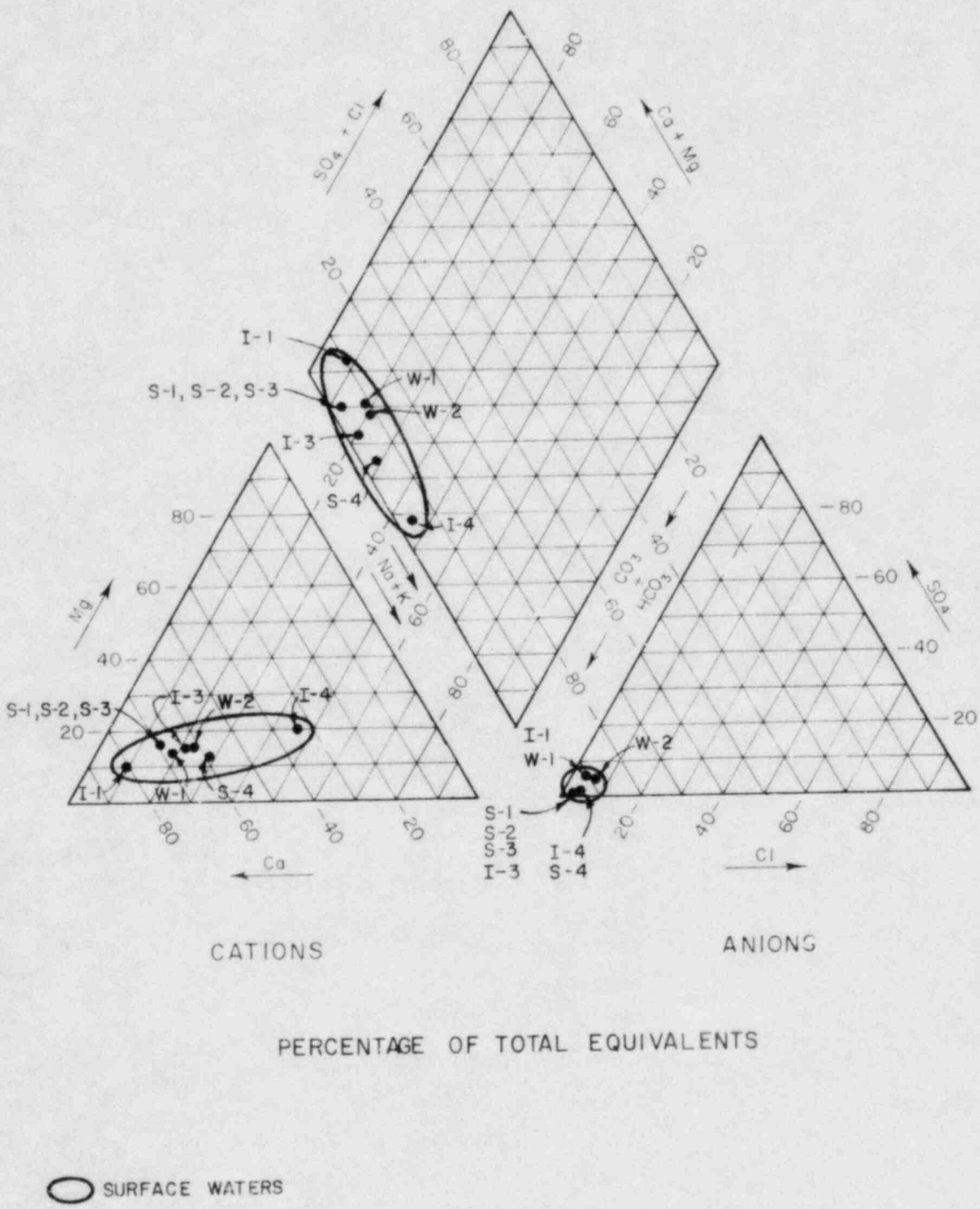
Based on geological information this appears to be correct. At all surface sample points the Brule is the outcropping geologic formation. The surface water quality is influenced in two ways by this. First, seepage from the ground water to the stream will be of Brule composition. Second, water flowing in the stream will contact Brule and some Arikaree material, weathering it to produce a similar ionic species composition to that in the ground water. During periods of high flow, migration of water from the stream into the shallow aquifer also serves to produce similar compositions. In his study of this area Spalding (1982) concluded that the chemical character of the streams is closely associated with the formation they dissect. Trace metal con-

FIGURE 2.6-12

TRILINEAR DIAGRAM

Surface Water Within the Area of Review

Crow Butte R&D Project



centrations may also be influenced by contributions from rain and snow. Increases in surface water may result from wind-blown suspended particulates containing Ag, Al, Cd, Cu, Mn Pb and Zn (Struempler,1976).

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APPENDIX 2.6(A)
HYDROLOGIC TEST DATA

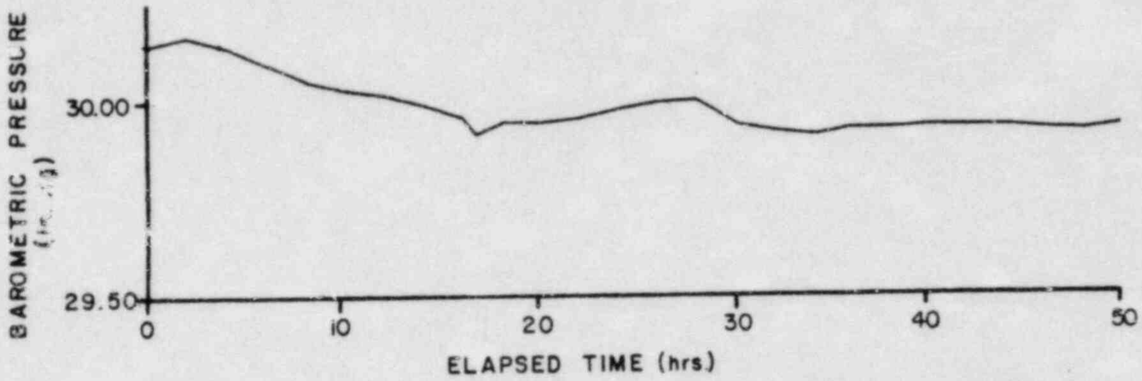
WYOMING FUEL COMPANY

CROW BUTTE PROJECT

Dawes County, Nebraska

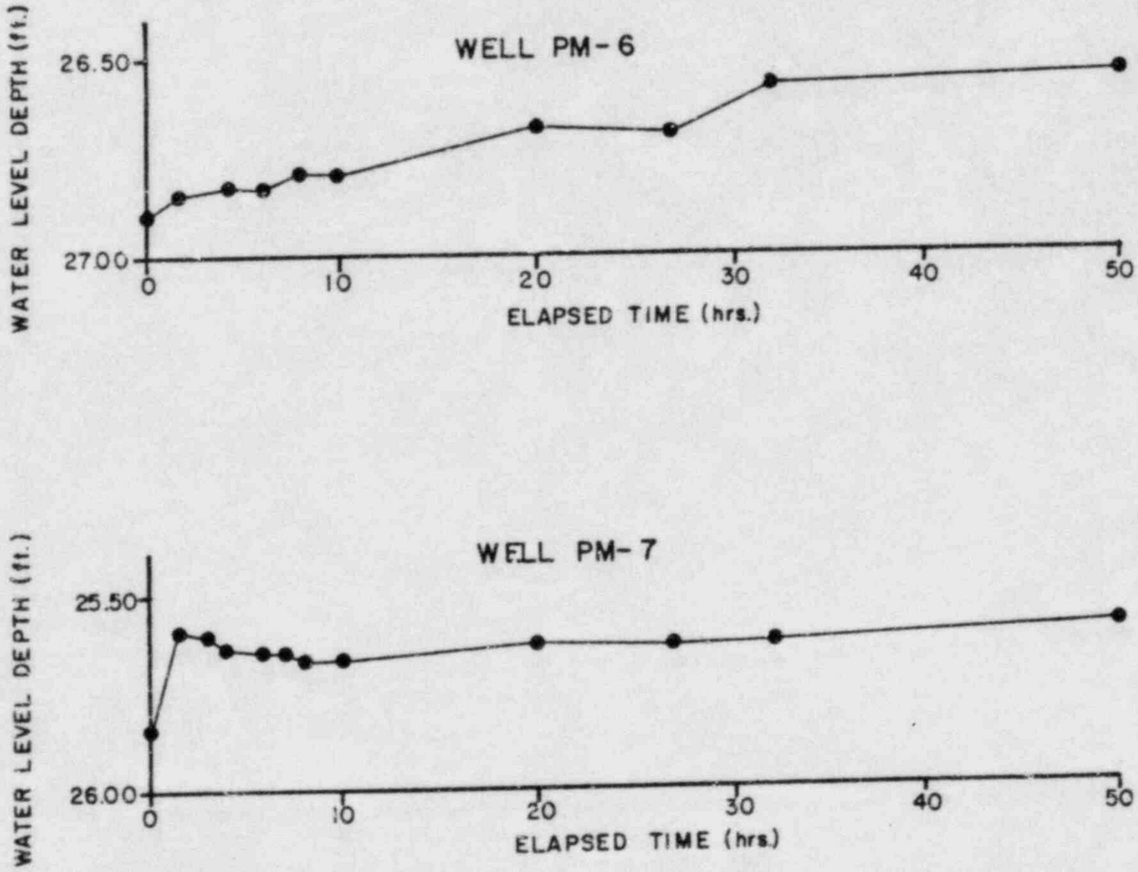
BAROMETRIC PRESSURE vs. ELAPSED TIME OF PUMPING TEST

11/16/82 - 11/18/82



(A)

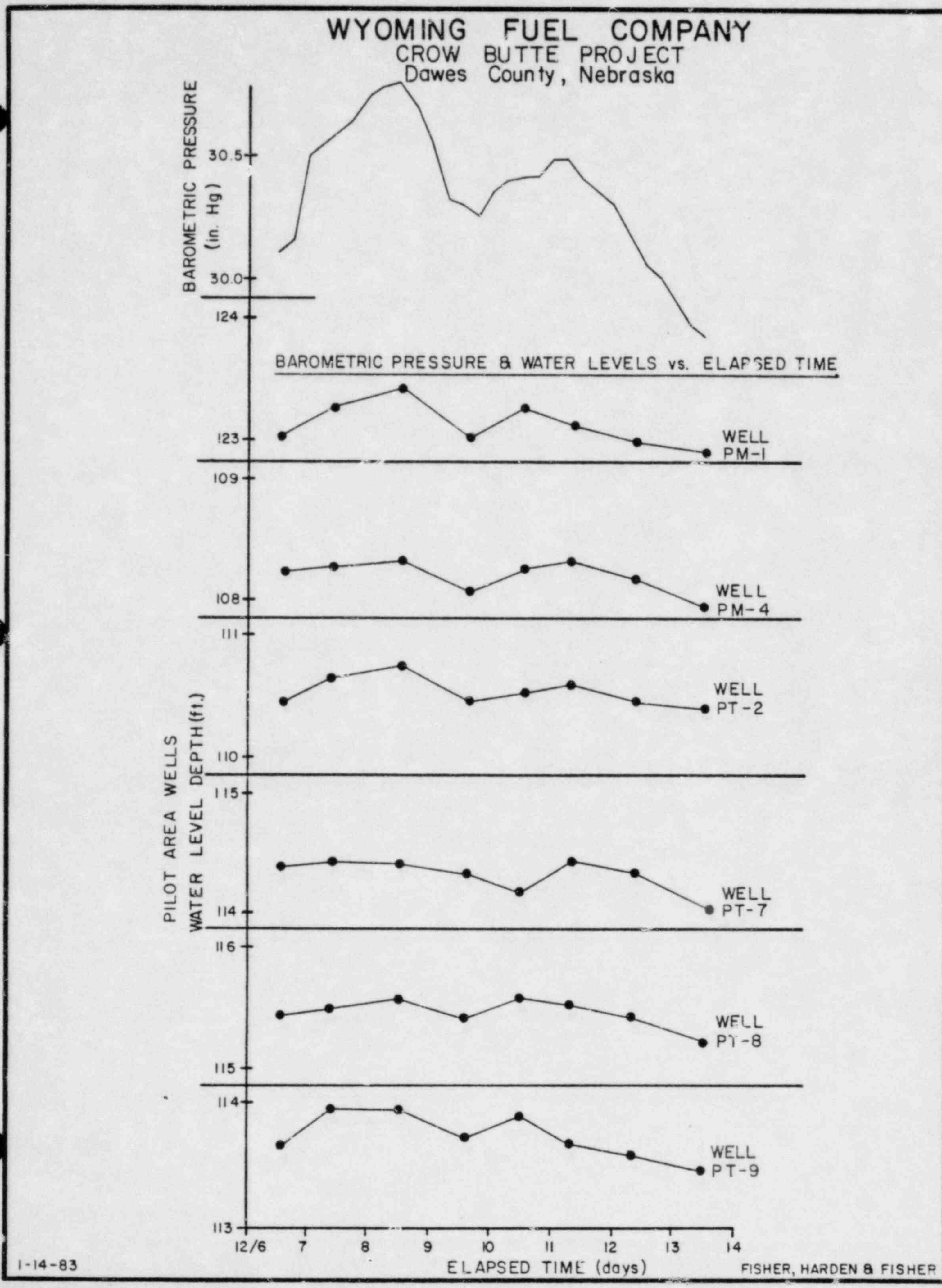
SHALLOW AQUIFIER WATER LEVELS vs. ELAPSED TIME OF PUMPING TEST



(B)

FISHER, HARDEN & FISHER

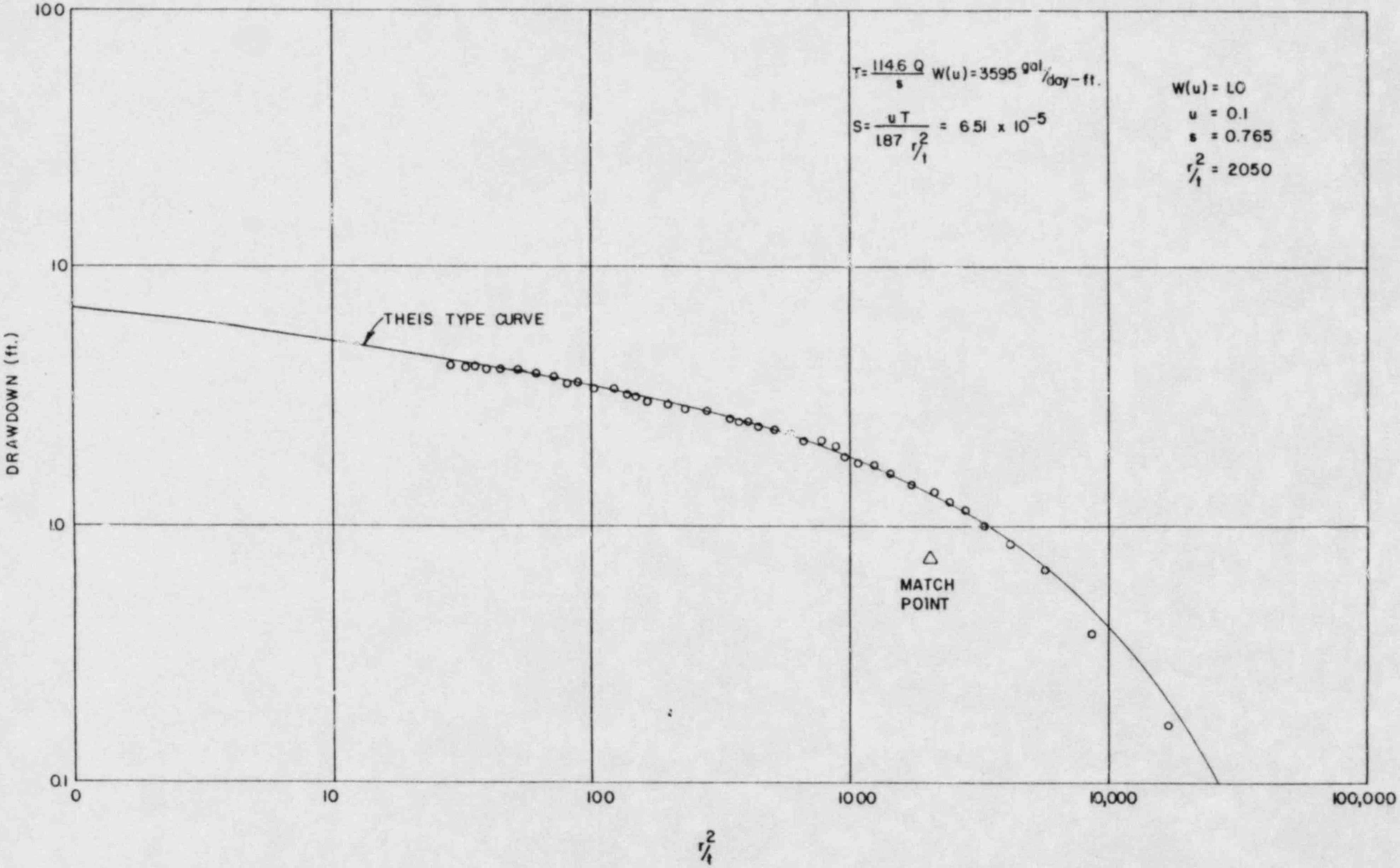
1-14-83



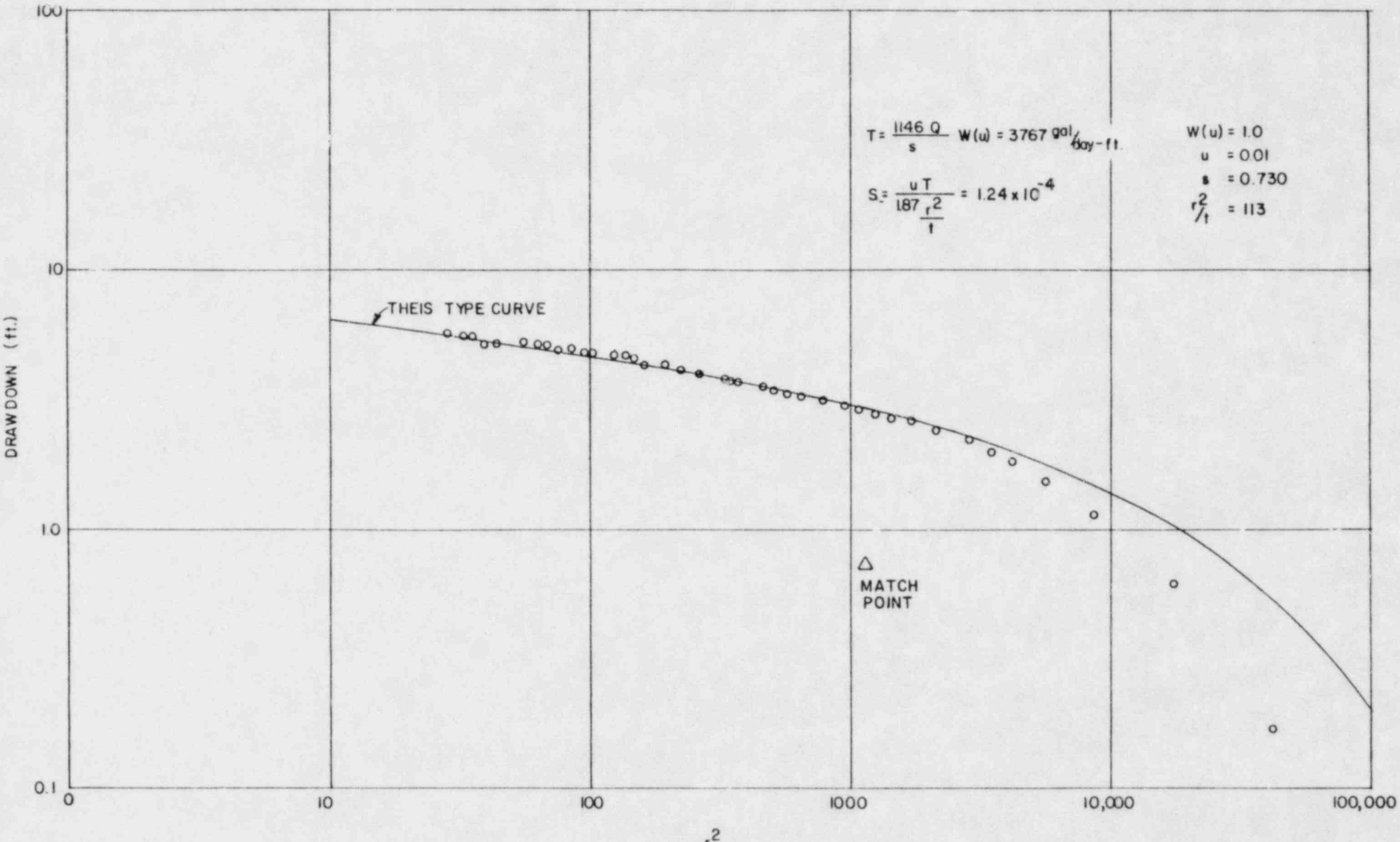
WYOMING FUEL COMPANY
CROW BUTTE PROJECT
Dawes County, Nebraska
BAROMETRIC PRESSURE (in. Hg)
30.5
30.0
BAROMETRIC PRESSURE & WATER LEVELS vs. ELAPSED TIME
124
123
WELL PM-1
109
108
WELL PM-4
111
110
WELL PT-2
115
114
WELL PT-7
116
115
WELL PT-8
114
113
WELL PT-9
PILOT AREA WELLS WATER LEVEL DEPTH (ft.)
12/6
7
8
9
10
11
12
13
14
ELAPSED TIME (days)
1-14-83
FISHER, HARDEN & FISHER

THEIS'S UNSTEADY STATE — CURVE MATCHING METHOD

PM-1

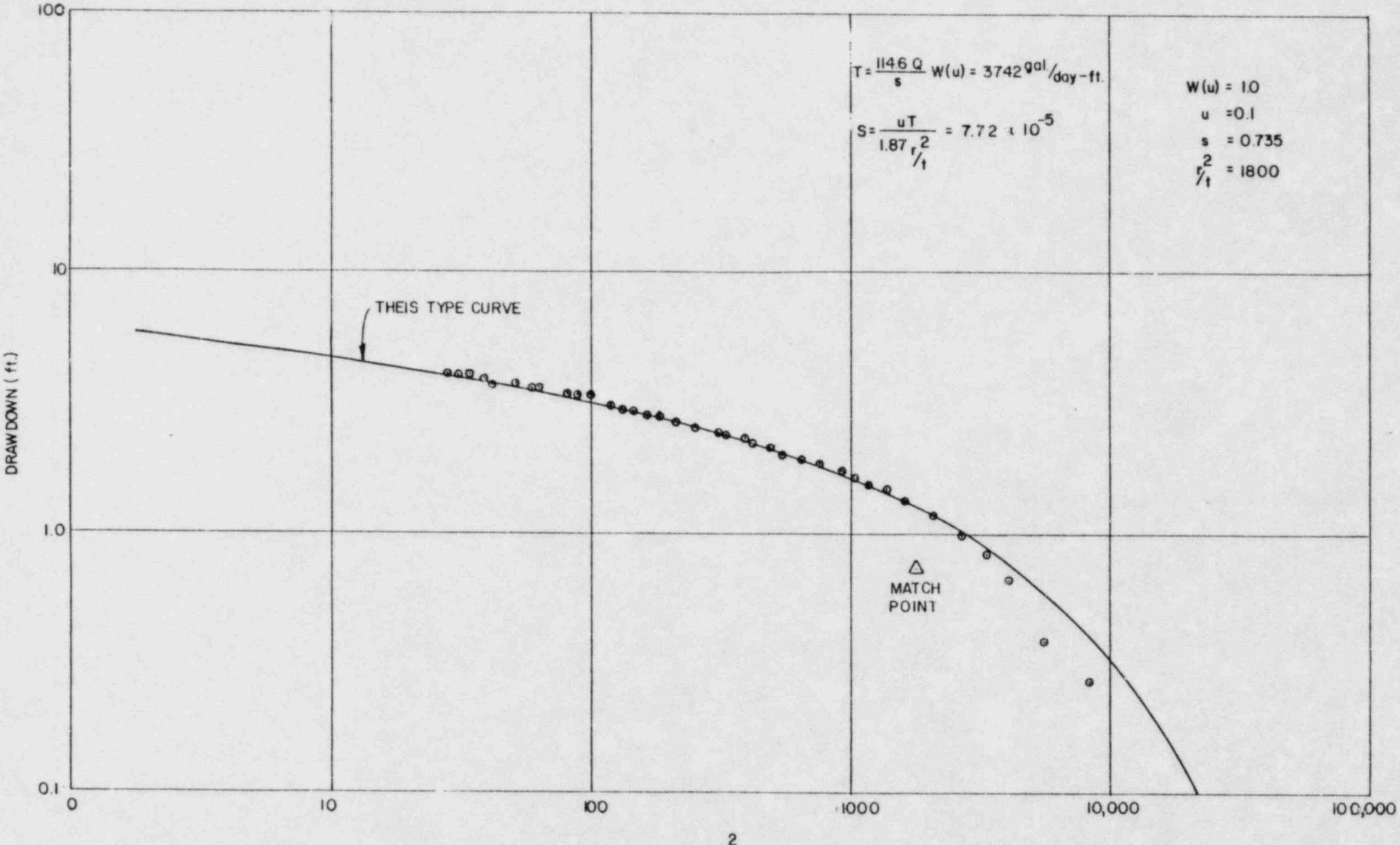


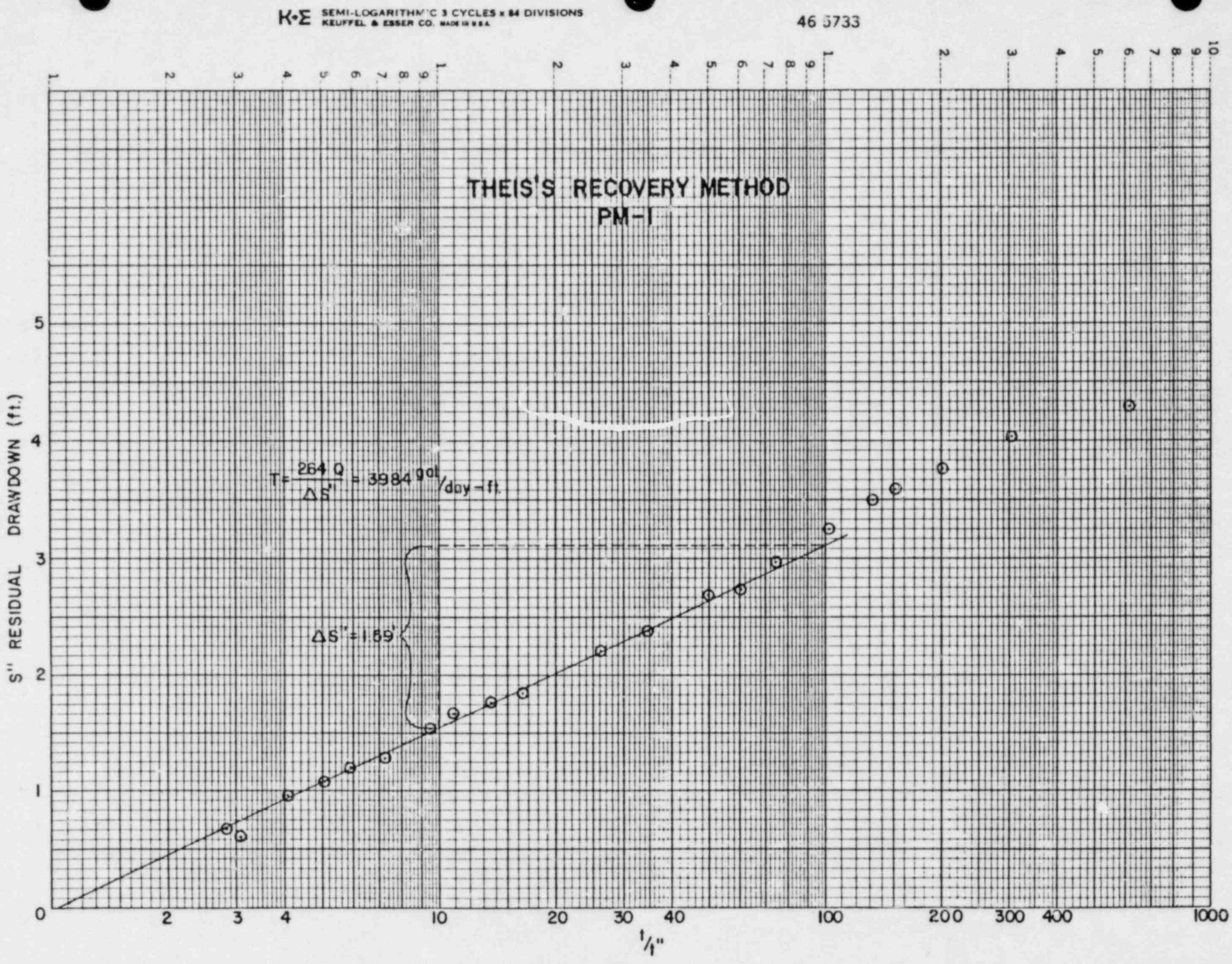
THEIS'S UNSTEADY STATE — CURVE MATCHING METHOD
PT-2



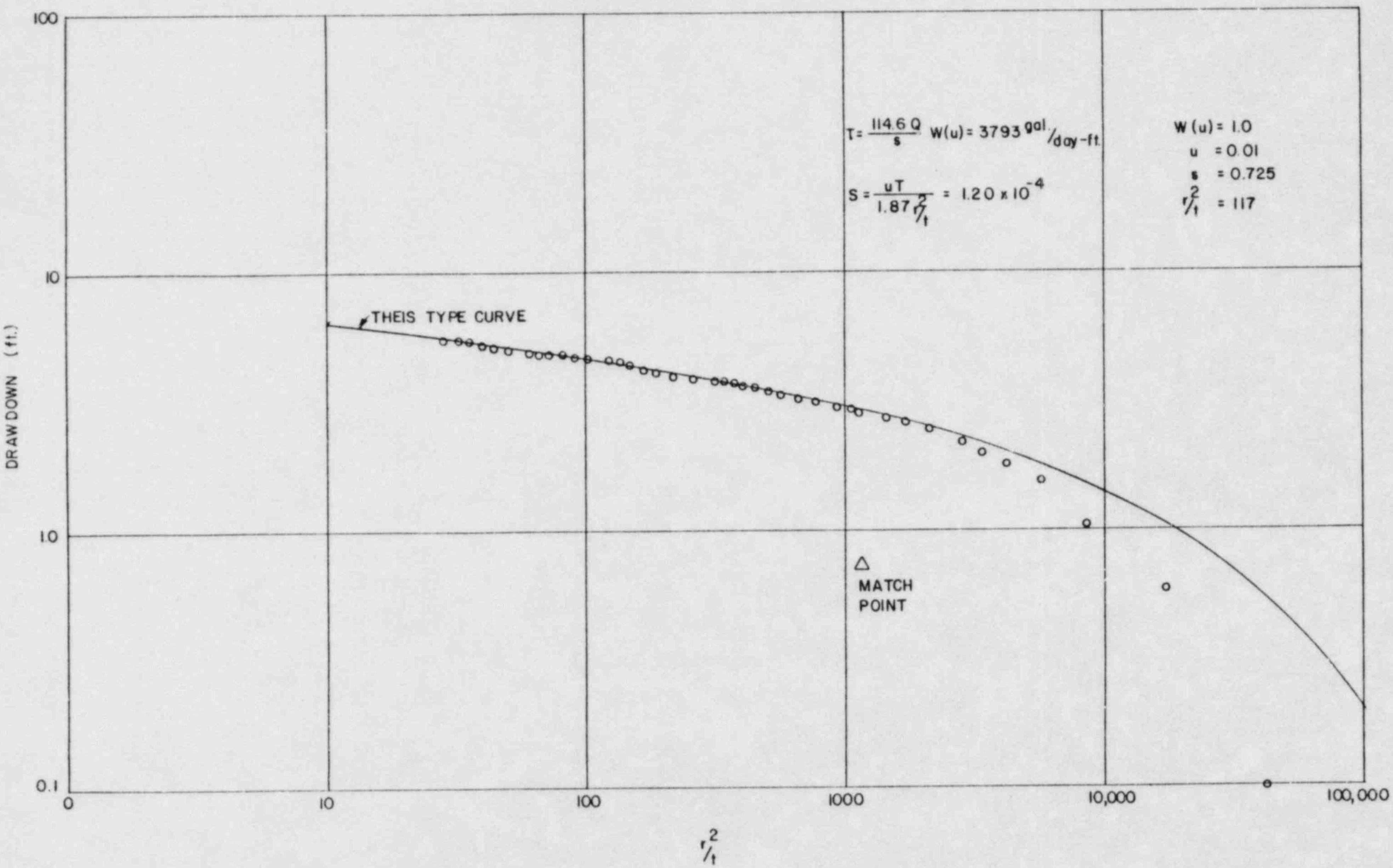
THEIS'S UNSTEADY STATE — CURVE MATCHING METHOD

PM-4

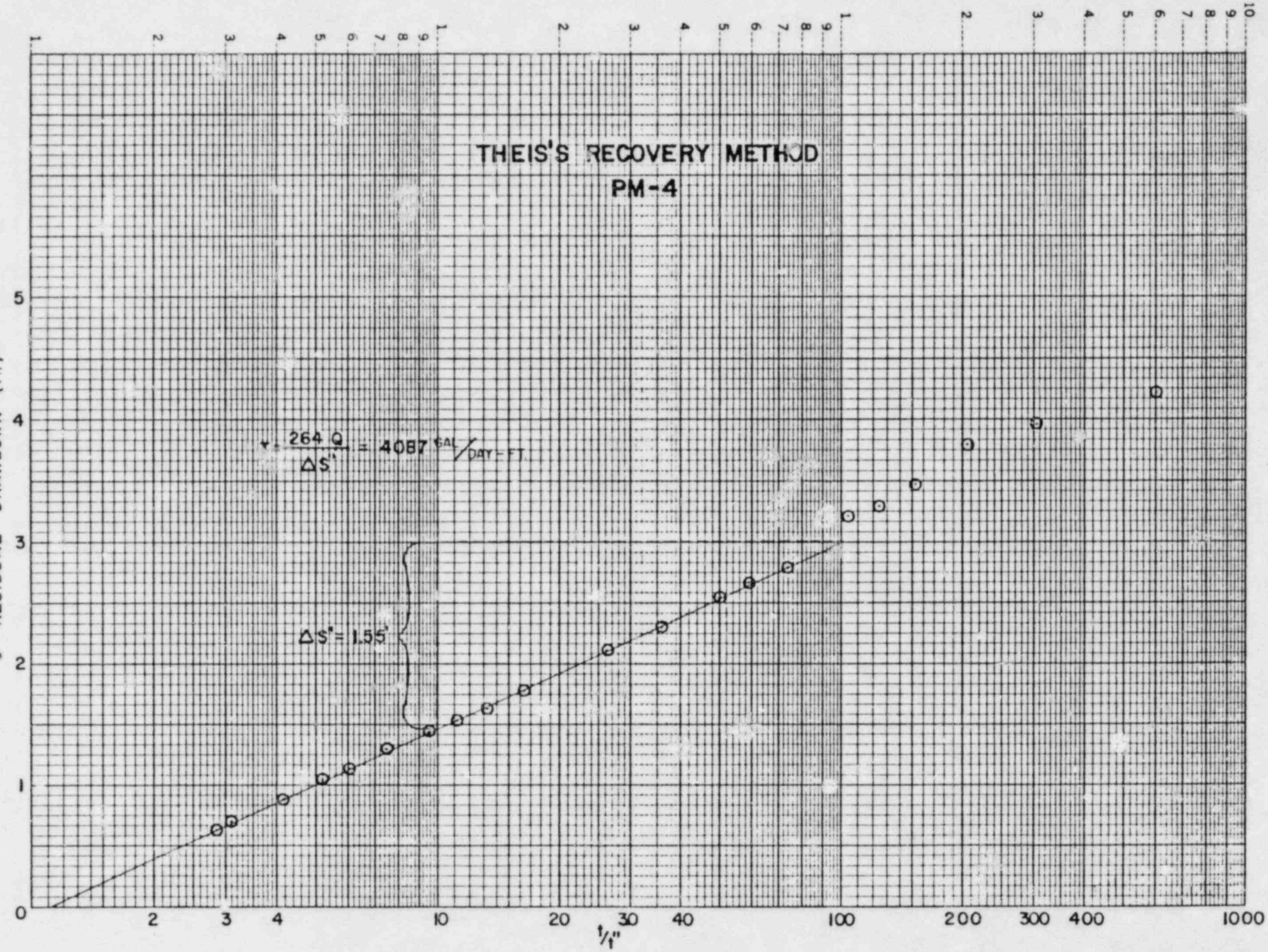



K•E SEMI-LOGARITHMIC 3 CYCLES x 84 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 5733
THEIS'S RECOVERY METHOD
PM-1
T = 264 Q / ΔS'' = 3984 gal/day-ft.
ΔS'' = 1.59'
S'' RESIDUAL DRAWDOWN (ft.)
0
1
2
3
4
5
2
3
4
10
20
30
40
100
200
300
400
1000
t/t''

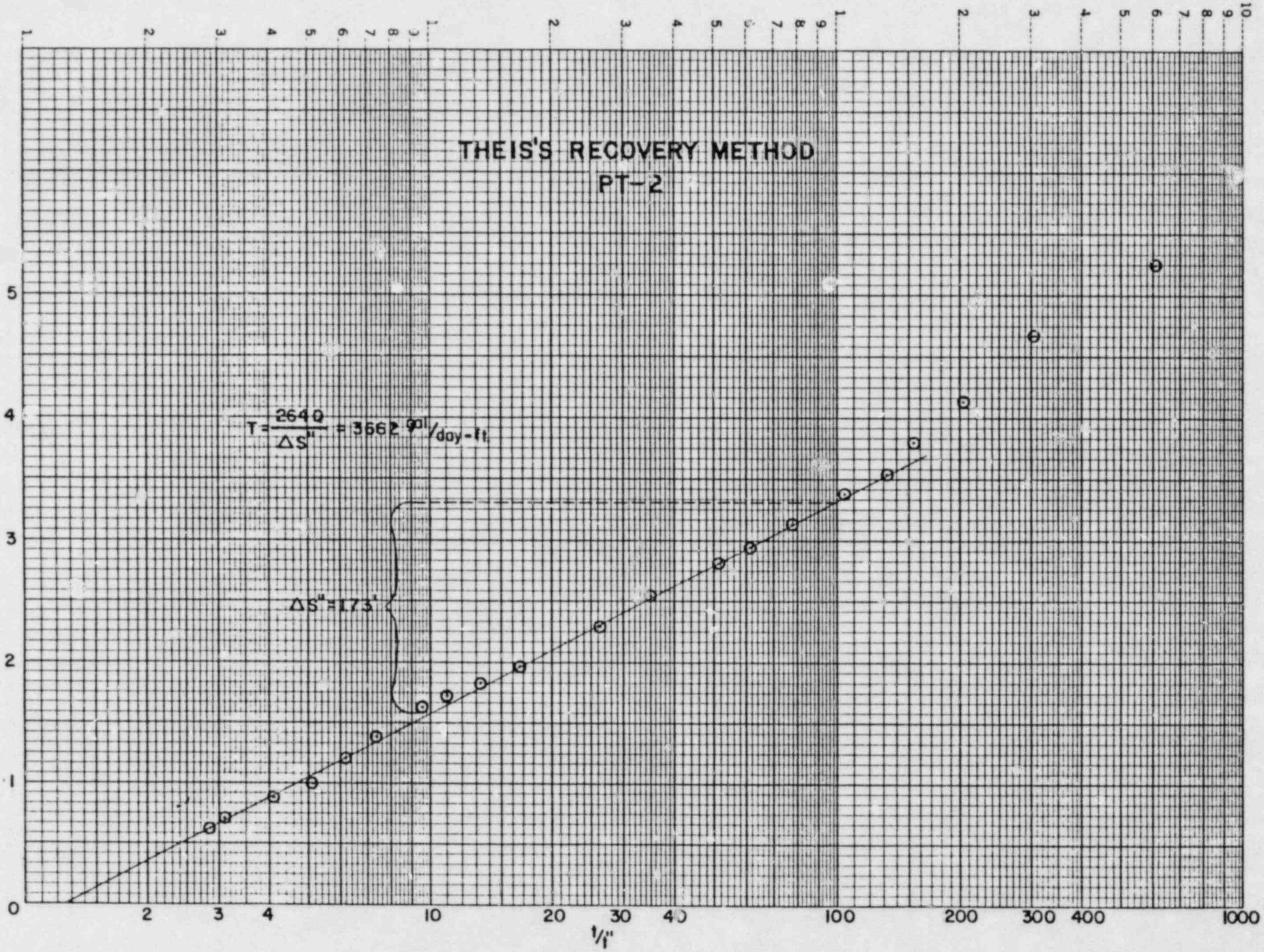
THEIS'S UNSTEADY STATE — CURVE MATCHING METHOD
PT-8

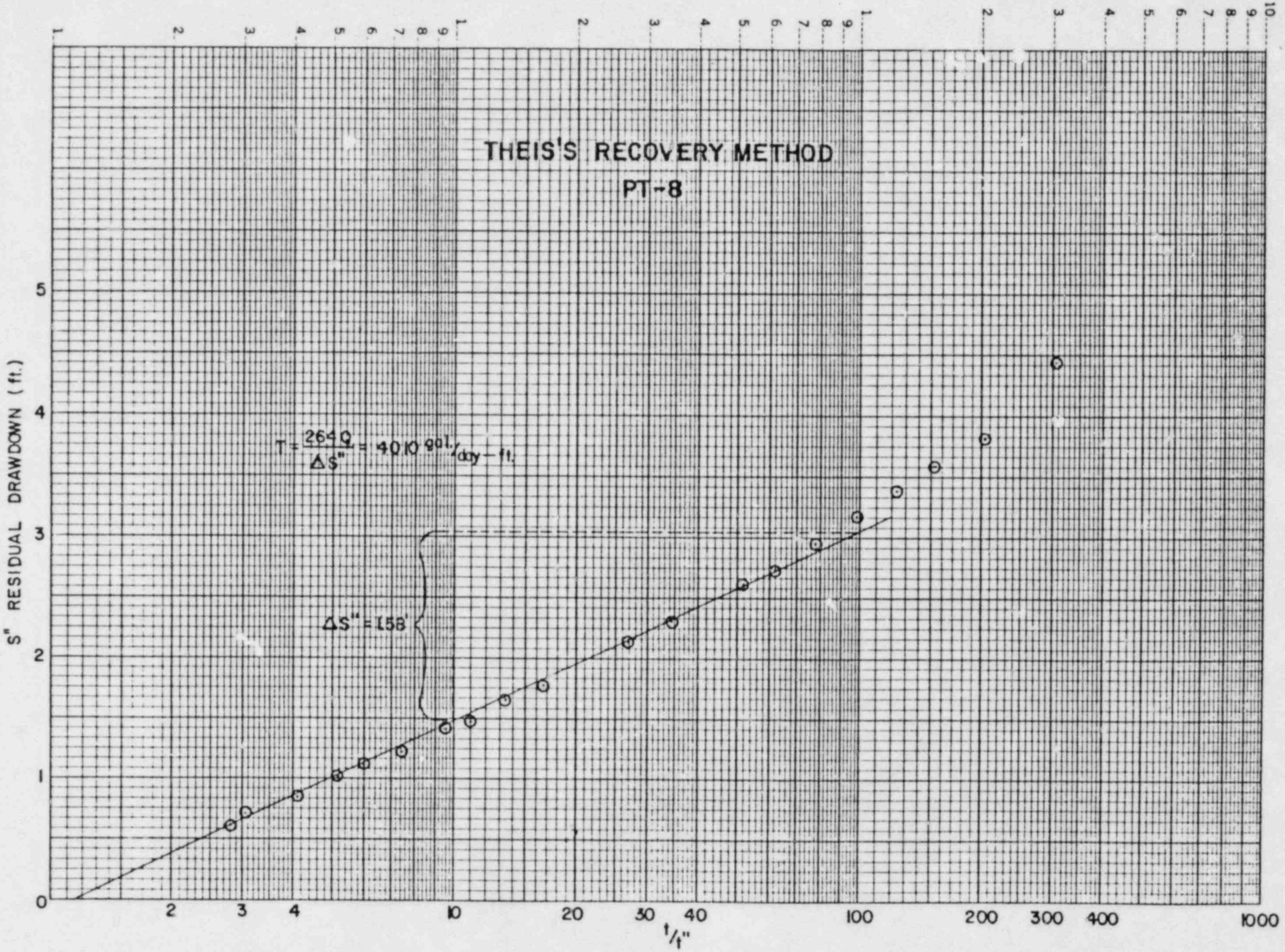


46 5733

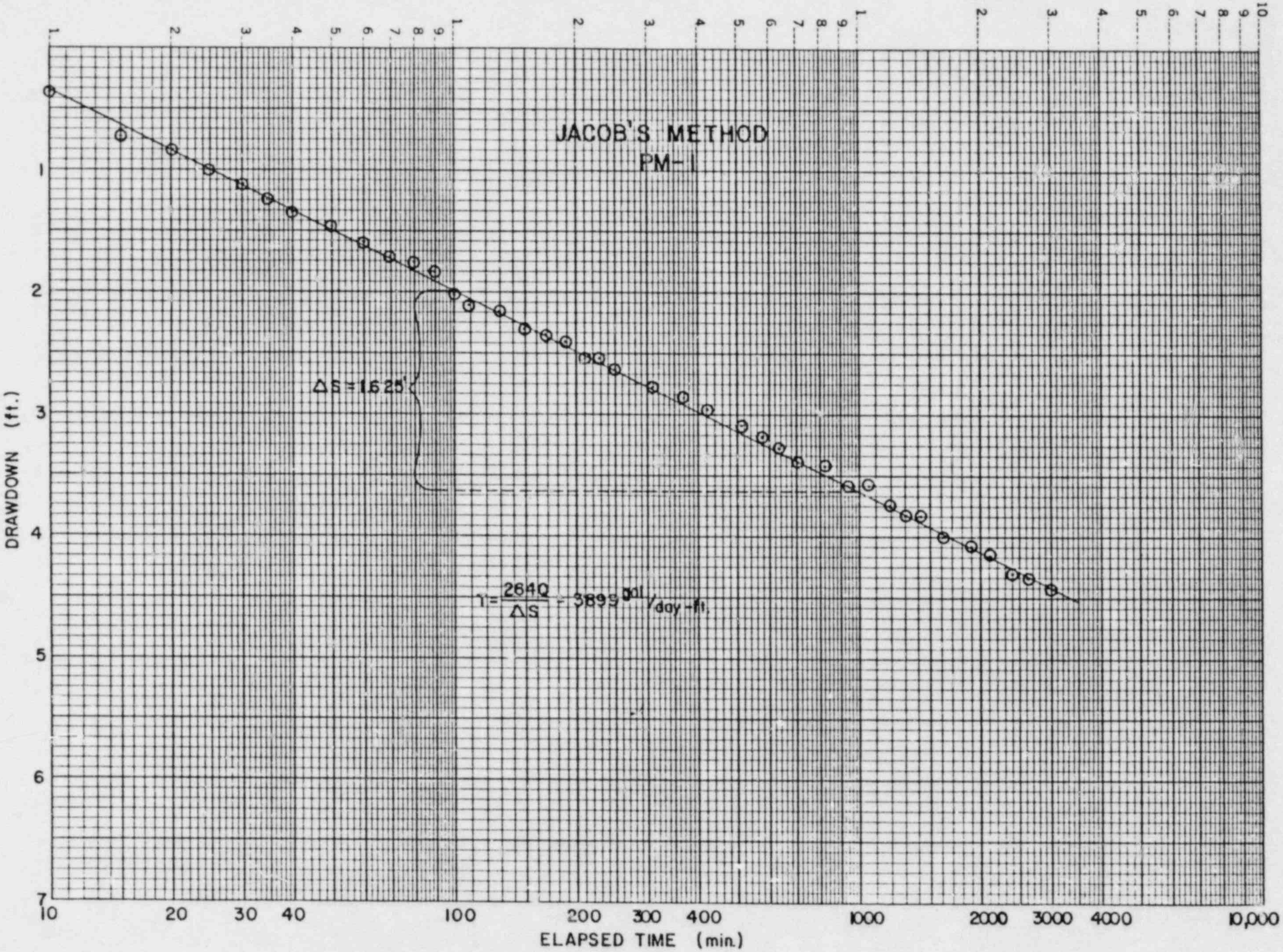

THEIS'S RECOVERY METHOD
PM-4
T = 264 Q / ΔS' = 4087 GAL/DAY-FT
ΔS' = 1.55'
S" RESIDUAL DRAWDOWN (ft.)
t/t"
0
1
2
3
4
5
2
3
4
10
20
30
40
100
200
300
400
1000

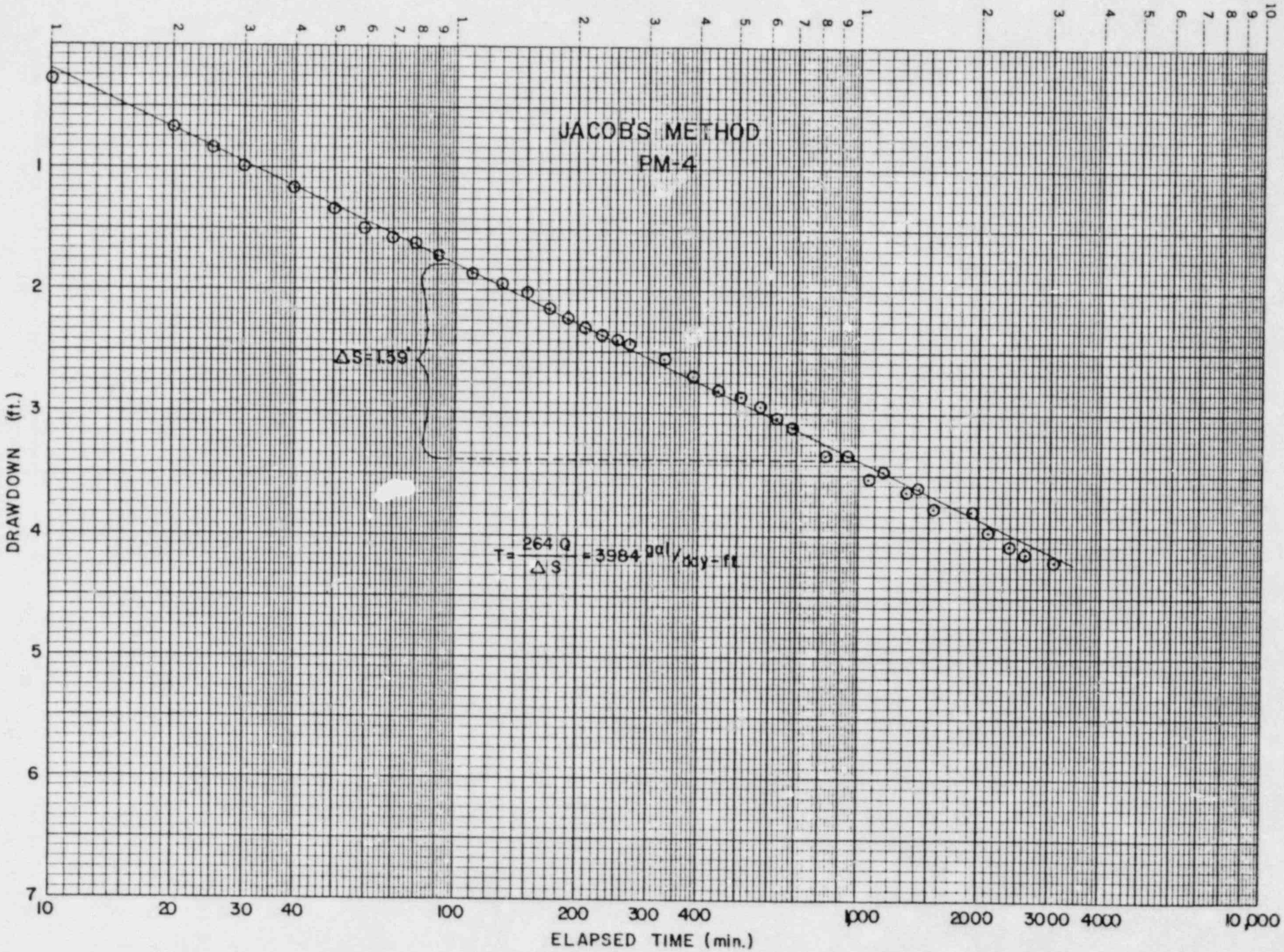
46 5733

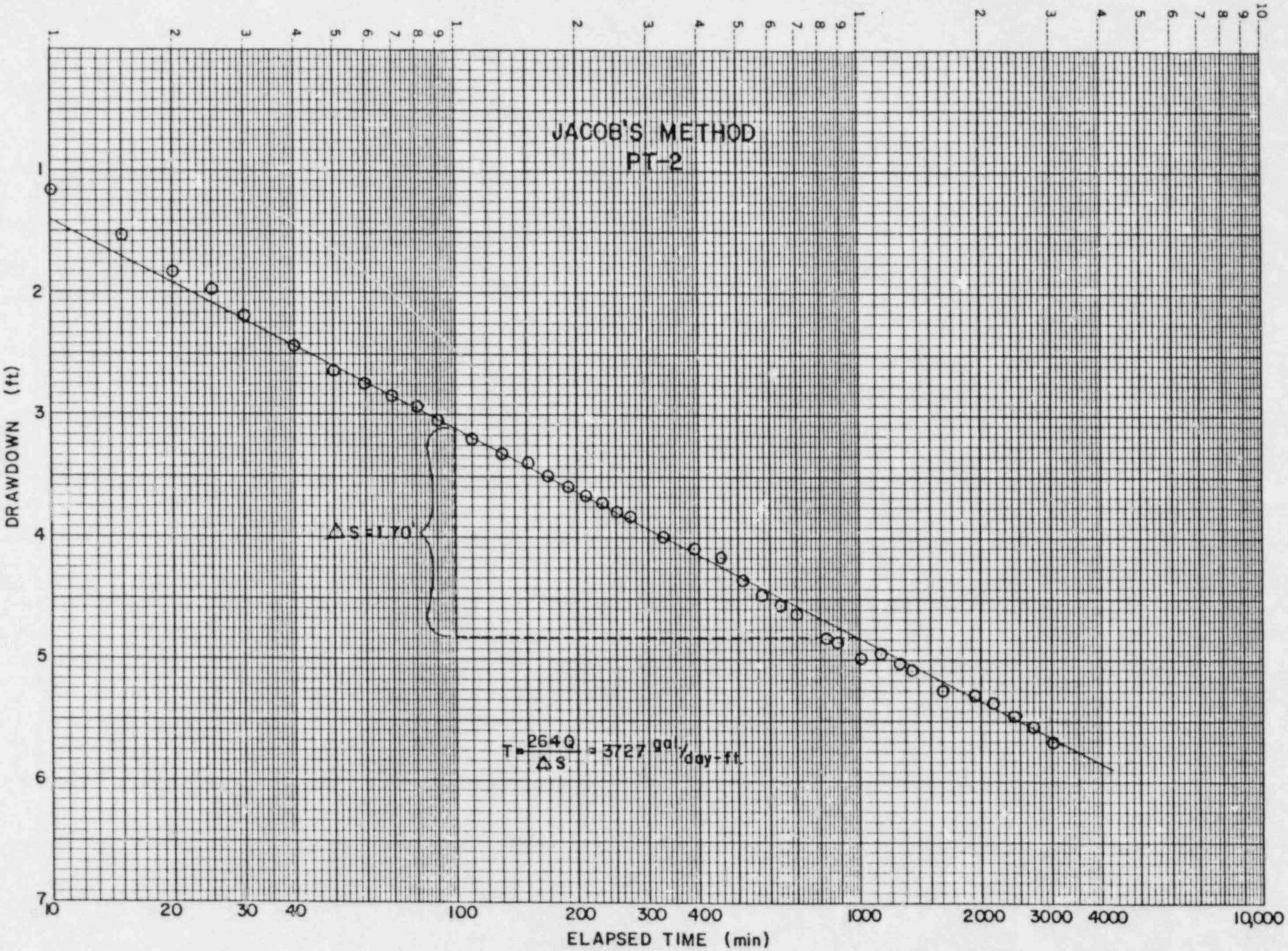

THEIS'S RECOVERY METHOD
PT-2
T = 264 Q / ΔS" = 3662 gal/day-ft
ΔS" = 173'
S" RESIDUAL DRAWDOWN (ft.)
1/t'
0
1
2
3
4
5
2
3
4
10
20
30
40
100
200
300
400
1000

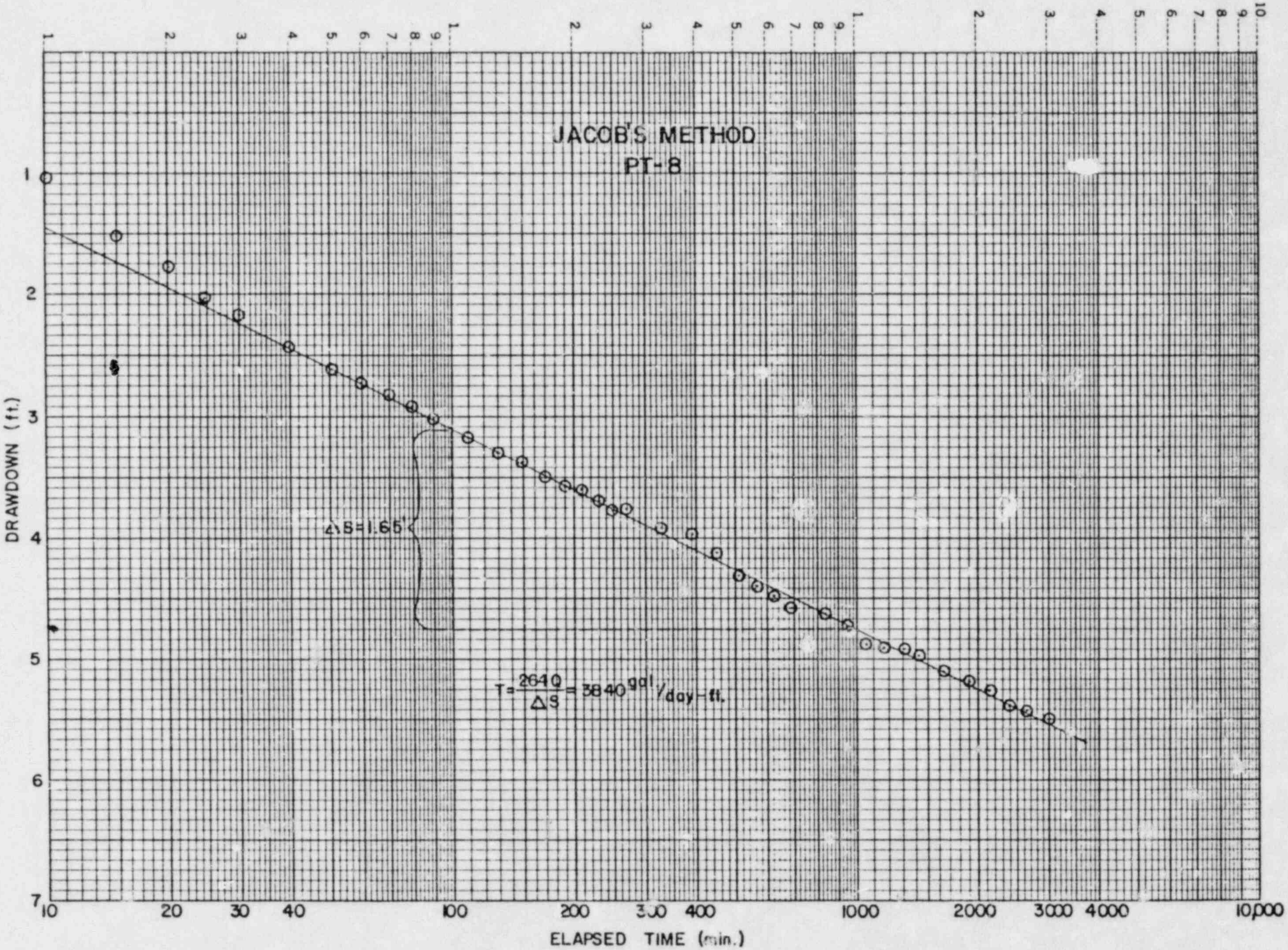

THEIS'S RECOVERY METHOD
PT-8
T = 264 Q / ΔS" = 4010 gal./day-ft.
ΔS" = 1.58'
S" RESIDUAL DRAWDOWN (ft.)
0
1
2
3
4
5
t/t"
2
3
4
10
20
30
40
100
200
300
400
1000

K+E SEMI-LOGARITHMIC 3 CYCLES x 84 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 5733




JACOB'S METHOD
PM-4
ΔS=1.59'
T = 264 Q / ΔS = 3984 gal/day-ft
DRAWDOWN (ft.)
ELAPSED TIME (min.)
10
20
30
40
100
200
300
400
1000
2000
3000
4000
10,000
1
2
3
4
5
6
7


JACOB'S METHOD
PT-2
ΔS=1.70'
T = 264Q / ΔS = 3727 gal/day-ft
DRAWDOWN (ft)
ELAPSED TIME (min)
1
2
3
4
5
6
7
10
20
30
40
100
200
300
400
1000
2000
3000
4000
10,000


JACOB'S METHOD
PT-8
DRAWDOWN (ft.)
ELAPSED TIME (min.)
ΔS=1.65'
T= 264Q / ΔS = 3840 gal/day-ft.
1
2
3
4
5
6
7
10
20
30
40
100
200
300
400
1000
2000
3000
4000
10,000

APPENDIX 2.6(B)
PUMP TEST DATA SHEETS

PUMP WELL- PUMPING TEST DATA SHEET

COMPANY: Wyoming Fuel Company

PROJECT: Crow Butte STATE/COUNTY: Dawes / Nebraska

TEST PERFORMED BY: R. Fisher DATA:

WELL NO.: 1 TYPE:

SURFACE COLLAR ELEV. ______ MSL COMPLETION INTERVAL ______

WATER LEVEL DEPTH ______ TOTAL WELL DEPTH ______

STATIC WATER LEVEL ______ MSL AQUIFER THICKNESS ______

MEASURING POINT ______ FT. TO GROUND LEVEL ______

EQUIPMENT: E-LINE ______ STEEL TAPE ______ RECORDER ______

PUMP SIZE 7.5 H.P. AVG. PUMP RATE 24 GPM

DEPTH SETTING ______

PUMP START 7:15 (TIME) / 11-16-82 (DATE) PUMP FINISH 9:28 (TIME) / 11-18-82 (DATE)

TIME	ELAPSED TIME (MINUTES)	TOTALIZER	FLOW (GPM)	WATERLEVEL	DRAWDOWN (FEET)
7:15		+300	—		
7:20		1475	24.33		
7:26		1621	25.4		
7:33		1799			
7:40		1954	24.3		
7:46		2100	24.5		
7:50		2198	24.2		
7:56		2343	24.0		
8:06		2583	23.8		
8:16		2821			
8:26		3057	23.8		
8:36		3295	24.1		
8:48		3584	23.8		
9:08		4060	23.8		
9:38		4775	24.2		
9:48		5017	24.1		
10:08		5499	24.0		
10:28		5979	23.9		
10:48		6457	24.0		
11:28		7424	23.7		
12:28		8847	23.6		
14:28		11678	23.9		
15:28		13111	23.5		
16:28		14523	24.2		

TIME	ELAPSED TIME (MINUTES)	TOTALIZER	FLOW (GPM)	WATERLEVEL	DRAWDOWN (FEET)
17:28		15979	24.2		
18:28		17431	25.06		
19:02		18283	23.78		
21:16		21470	24.38		
22:52		23810	23.78		
1:07		27020	23.92		
2:50		29484	23.92		
3:28		30128	24.3		
5:25		32976	23.9		
7:06		35386	23.6		
9:07		38243	23.8		
10:35		40337	23.9		
13:40		44761	23.9		
15:20		47147	23.9		
18:45		52053	23.7		
23:17		58508	23.7		
3:35		64625	23.8		
9:25		73028	23.87		

WELL - PUMPING TEST DATA SHEET

COMPANY Wyoming Fuel Company
PROJECT Crow Butte STATE / COUNTY Dawes / Nebraska
TEST PERFORMED BY R. Fisher DATA
WELL NO. PM-1 TYPE Pilot Test Monitor
SURFACE / COLLAR ELEV. MSL COMPLETION INTERVAL
WATER LEVEL DEPTH TOTAL WELL DEPTH
STATIC WATER LEVEL MSL AQUIFER THICKNESS
MEASURING POINT FT. TO GROUND LEVEL
EQUIPMENT: E-LINE ✓ STEEL TAPE RECORDER
RADIUS FROM PUMPED WELL (r) 294.1 FEET
PUMP SIZE 7.5 H.P. PUMP RATE 24 GPM
PUMP START 7:15 / 11-16-82 PUMP FINISH 9:22 / 11-18-82
TIME DATE TIME DATE

TIME	WATER LEVEL		DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t (FT^2/MIN)	REMARKS
7:16	124'	10.0"	0	1	0	
7:17	124'	11.0"	0.083	2	43247	
7:20	125'	0.0"	0.167	5	17299	
7:25	125'	2.5"	0.379	10	8649	
7:30	125'	7.0"	0.667	15	5766	
7:35	125'	8.25"	0.854	20	4325	
7:40	125'	10.25"	1.020	25	3460	
7:45	125'	11.75"	1.150	30	2883	
7:50	126'	1.0"	1.250	35	2471	
7:55	126'	2.50"	1.375	40	2162	
8:05	126'	3.75"	1.480	50	1730	
8:15	126'	5.25"	1.600	60	1442	
8:25	126'	6.75"	1.730	70	1236	
8:35	126'	7.25"	1.770	80	1081	
8:45	126'	8.25"	1.850	90	961	
9:05	126'	10.50"	2.040	100	865	
9:25	126'	11.50"	2.125	110	786	
9:45	127'	0.0"	2.170	130	665	
10:05	127'	1.75"	2.310	150	577	
10:25	127'	2.50"	2.375	170	509	
10:45	127'	3.0"	2.420	190	455	
11:05	127'	4.75"	2.560	210	412	
11:25	127'	4.75	2.560	230	376	
11:45	127'	5.75"	2.650	250	346	

TIME	WATER LEVEL	DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t ($FT.^2/MIN$)	REMARKS
12:46	127' 7.50"	2.790	310	279	
13:48	127' 8.25"	2.850	372	233	
14:48	127' 9.50"	2.960	432	200	
15:52	127' 11.0"	3.080	517	167	
16:50	128' 0.25"	3.190	580	149	
17:52	128' 1.50"	3.290	642	135	
18:57	128' 2.75"	3.400	707	122	
21:06	128' 3.0"	3.420	836	103	
22:55	128' 5.0"	3.580	945	91.5	
0:56	128' 5.0"	3.580	1066	81.1	
3:12	128' 7.0"	3.750	1202	72.0	
5:20	128' 7.75"	3.810	1330	65.0	
7:00	128' 8.0"	3.830	1425	60.7	
10:52	128' 10.0"	4.000	1657	52.2	
15:08	128' 10.75"	4.060	1913	45.2	
19:02	128' 11.75	4.150	2147	40.3	
23:34	129' 1.5"	4.290	2419	35.8	
3:53	129' 2.0"	4.330	2678	32.3	
9:19	129' 3.0"	4.420	3004	28.8	

9/82 FISHER, HARDEN & FISHER ENVIRONMENTAL & ENGINEERING CONSULTANTS

WELL NO. PM-1

WELL - PUMPING TEST DATA SHEET

COMPANY Wyoming Fuel Company
PROJECT Crow Butte STATE / COUNTY Dawes / Nebraska
TEST PERFORMED BY R. Fisher DATA
WELL NO. PM-4 TYPE Production Well
SURFACE COLLAR ELEV. MSL COMPLETION INTERVAL
WATER LEVEL DEPTH TOTAL WELL DEPTH
STATIC WATER LEVEL MSL AQUIFER THICKNESS
MEASURING POINT FT. TO GROUND LEVEL
EQUIPMENT: E-LINE ✓ STEEL TAPE RECORDER
RADIUS FROM PUMPED WELL (r) 288.75 FEET
PUMP SIZE 7.5 H.P. PUMP RATE 24 GPM
PUMP START 7:15 (TIME), 11-16-82 (DATE) PUMP FINISH 9:22 (TIME), 11-18-82 (DATE)

TIME	WATER LEVEL	DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t (FT^2/MIN)	REMARKS
7:16	109' 5.5"	0	1		
7:17	109' 6.0"	0.02	2	41688	
7:20	109' 6.5"	0.06	5	16675	
7:25	109' 9.0"	0.27	10	8338	
7:30	109' 11.5"	0.479	15	5558	
7:35	110' 1.75"	0.667	20	4169	
7:40	110' 3.75"	0.833	25	3335	
7:45	110' 5.5"	0.980	30	2779	
7:55	110' 7.75"	1.167	40	2084	
8:05	110' 10.0"	1.350	50	1668	
8:15	110' 11.75"	1.500	60	1390	
8:25	111' 0.5"	1.560	70	1191	
8:35	111' 1.5"	1.650	80	1042	
8:45	111' 2.5"	1.730	90	926	
9:05	111' 4.0"	1.850	110	758	
9:25	111' 5.0"	1.940	130	641	
9:45	111' 6.0"	2.020	150	556	
10:05	111' 7.5"	2.150	170	490	
10:25	111' 8.5"	2.230	190	439	
10:45	111' 9.25"	2.290	210	397	
11:05	111' 10.0"	2.350	230	363	
11:25	111' 10.5"	2.400	250	334	
11:45	111' 11.0"	2.440	270	309	
12:49	112' 0.5"	2.560	334	250	

TIME	WATER LEVEL	DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t ($FT.^2/MIN$)	REMARKS
13:46	112' 2.0"	2.69	390	214	
14:47	112' 3.5"	2.81	450	185	
15:42	112' 4.25"	2.875	510	163	
16:40	112' 5.0"	2.940	570	146	
17:35	112' 6.0"	3.020	625	133	
18:42	112' 7.0"	3.100	692	120	
20:59	112' 10.5"	3.400	829	101	
22:48	112' 10.5"	3.400	938	88.9	
0:51	113' 0"	3.520	1061	78.6	
2:55	112' 11.5"	3.480	1185	70.4	
5:06	113' 1.25"	3.625	1316	63.4	
6:58	113' 1.0"	3.600	1428	58.4	
10:44	113' 2.75"	3.750	1645	50.7	
15:17	113' 3.25"	3.790	1927	43.3	
18:50	113' 5.0"	3.940	2135	39.1	
23:22	113' 6.5"	4.060	2407	34.6	
3:41	113' 7.25"	4.130	2666	31.3	
9:22	113' 8.0"	4.190	3007	27.7	

WELL-PUMPING TEST DATA SHEET

COMPANY: Wyoming Fuel Company
PROJECT: Crow Butte — STATE/COUNTY: Dawes/Nebraska
TEST PERFORMED BY: R. Fisher — DATA:
WELL NO.: PT-2 — TYPE: Production Well
SURFACE/COLLAR ELEV. ______ MSL COMPLETION INTERVAL ______
WATER LEVEL DEPTH ______ TOTAL WELL DEPTH ______
STATIC WATER LEVEL ______ MSL AQUIFER THICKNESS ______
MEASURING POINT ______ FT. TO GROUND LEVEL ______
EQUIPMENT: E-LINE ✓ STEEL TAPE ______ RECORDER ______
RADIUS FROM PUMPED WELL (r) 93.49' FEET
PUMP SIZE 7.5 H.P. PUMP RATE 24 GPM
PUMP START 7:15 / 11-16-82 (TIME / DATE) PUMP FINISH 9:22 / 11-18-82 (TIME / DATE)

TIME	WATER LEVEL	DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t (FT^2/MIN)	REMARKS
7:16	111' 5.25"	0.06	1	8649	
7:17	111' 6.50"	0.167	2	4324	
7:20	111' 11.75"	0.625	5	1730	
7:25	112' 6.50"	1.167	10	865	
7:30	112' 11.0"	1.540	15	577	
7:35	113' 2.50"	1.830	20	432	
7:40	113' 5.0"	1.98	25	346	
7:45	113' 6.75"	2.19	30	288	
7:55	113' 9.75"	2.44	40	216	
8:05	114' 0.0"	2.625	50	173	
8:15	114' 1.5"	2.750	60	144	
8:25	114' 2.75"	2.850	70	124	
8:35	114' 3.75"	2.940	80	108	
8:45	114' 5.0"	3.040	90	96.1	
9:05	114' 6.75"	3.190	110	78.6	
9:25	114' 8.25"	3.310	130	66.5	
9:45	114' 9.25"	3.400	150	57.7	
10:05	114' 10.50"	3.500	170	50.9	
10:25	114' 11.75"	3.600	190	45.5	
10:45	115' 0.50"	3.670	210	41.2	
11:05	115' 1.25"	3.730	230	37.6	
11:25	115' 2.0"	3.790	250	34.6	
11:45	115' 2.5"	3.830	270	32.0	
12:43	115' 4.5"	4.000	328	26.4	

TIME	WATER LEVEL	DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t ($FT.^2/MIN$)	REMARKS
13:44	115' 5.5"	4.080	389	22.2	
14:45	115' 6.5"	4.170	450	19.2	
15:49	115' 8.75"	4.350	514	16.8	
16:47	115' 10.25	4.480	572	15.1	
17:47	115' 11.25	4.560	632	13.7	
18:51	116' 0.0"	4.625	696	12.4	
21:10	116' 2.50"	4.830	835	10.4	
22:59	116' 2.75"	4.850	884	9.78	
1:00	116' 4.50"	5.000	1005	8.61	
3:08	116' 4.00"	4.960	1133	7.63	
5:16	116' 5.00"	5.040	1261	6.86	
6:58	116' 5.50"	5.080	1363	6.35	
10:48	116' 7.50"	5.250	1593	5.43	
15:17	116' 8.0"	5.290	1922	4.50	
18:58	116' 8.75"	5.350	2143	4.04	
23:31	116' 10.25"	5.430	2416	3.58	
3:50	116' 11.0"	5.540	2675	3.23	
9:22	117' 0.50"	5.670	3007	2.88	

WELL-PUMPING TEST DATA SHEET

COMPANY: Wyoming Fuel Company

PROJECT: Crow Butte STATE/COUNTY: Dawes / Nebraska

TEST PERFORMED BY: R. Fisher DATA: ______

WELL NO.: PT-8 TYPE: Production Well

SURFACE COLLAR ELEV. ______ MSL COMPLETION INTERVAL ______

WATER LEVEL DEPTH ______ TOTAL WELL DEPTH ______

STATIC WATER LEVEL ______ MSL AQUIFER THICKNESS ______

MEASURING POINT ______ FT. TO GROUND LEVEL ______

EQUIPMENT: E-LINE ✓ STEEL TAPE ______ RECORDER ______

RADIUS FROM PUMPED WELL (r) 93.69' FEET

PUMP SIZE 7.5 H.P. PUMP RATE 24 GPM

PUMP START 7:09 (TIME) / 11-16-82 (DATE) PUMP FINISH 9:25 (TIME) / 11-18-82 (DATE)

TIME	WATER LEVEL	DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t (FT^2/MIN)	REMARKS
7:09	113' 8.25"	0	0	0	
7:16	113' 8.5"	0.021	1	8649	
7:17	113' 9.75"	0.104	2	4325	
7:20	114' 2.0"	0.479	5	1730	
7:25	114' 8.75"	1.040	10	865	
7:30	115' 2.5"	1.520	15	577	
7:35	115' 5.75"	1.790	20	432	
7:40	115' 8.5"	2.020	25	346	
7:45	115' 10.25"	2.170	30	288	
7:55	116' 1.5"	2.440	40	216	
8:05	116' 3.5"	2.600	50	173	
8:15	116' 5.0"	2.730	60	144	
8:25	116' 6.25"	2.830	70	124	
8:35	116' 7.25"	2.920	80	108	
8:45	116' 8.50"	3.020	90	96.1	
9:05	116' 10.25"	3.170	110	78.6	
9:25	116' 11.75"	3.290	130	66.5	
9:45	117' 0.75"	3.375	150	57.7	
10:05	117' 2.25"	3.500	170	50.9	
10:25	117' 3.0"	3.560	190	45.5	
10:45	117' 3.5"	3.600	210	41.2	
11:05	117' 4.75"	3.690	230	37.6	
11:25	117' 5.50"	3.770	250	34.6	
11:45	117' 5.50"	3.770	270	32.0	

TIME	WATER LEVEL	DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t ($FT.^2/MIN$)	REMARKS
12:45	117' 7.25"	3.920	330	26.2	
13:45	117' 8.00"	3.980	390	22.2	
14:45	117' 9.5"	4.100	450	19.2	
15:45	118' 0"	4.310	510	17.0	
16:44	118' 1.0"	4.400	570	15.2	
17:40	118' 2.0"	4.480	630	13.7	
18:46	118' 3.25"	4.580	695	12.4	
21:13	118' 3.75"	4.630	838	10.3	
23:02	118' 5.0"	4.730	947	9.13	
1:04	118' 6.75"	4.880	1069	8.09	
3:02	118' 7.0"	4.900	1187	7.29	
5:12	118' 7.25"	4.920	1317	6.57	
6:55	118' 8.0"	4.980	1420	6.09	
10:41	118' 9.5"	5.100	1646	5.25	
15:14	118' 10.5"	5.190	1919	4.51	
18:54	118' 11.25"	5.250	2139	4.04	
23:27	119' 0.75"	5.380	2412	3.59	
3:45	119' 1.50"	5.440	2670	3.24	
9:25	119' 2.25"	5.500	3010	2.87	

WELL-PUMPING TEST DATA SHEET

COMPANY Wyoming Fuel Company

PROJECT Crow Butte STATE/COUNTY Dawes/Nebraska

TEST PERFORMED BY R. Fisher DATA

WELL NO. PM-7 TYPE

SURFACE COLLAR ELEV. MSL COMPLETION INTERVAL

WATER LEVEL DEPTH TOTAL WELL DEPTH

STATIC WATER LEVEL MSL AQUIFER THICKNESS

MEASURING POINT FT. TO GROUND LEVEL

EQUIPMENT: E-LINE ✓ STEEL TAPE RECORDER

RADIUS FROM PUMPED WELL (r) FEET

PUMP SIZE 7.5 H.P. PUMP RATE 24 GPM

PUMP START / (TIME DATE) PUMP FINISH / (TIME DATE)

TIME	WATER LEVEL	DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t ($FT.^2/MIN$)	REMARKS
0	25' 10.25"				
8:21	24' 9.0"				
8:53	25' 7.0"				
8:53	24' 10.0"				
10:15	25' 7.25"				
11:30	25' 7.50"				
12:17	25' 7.50"				
13:13	25' 7.50"				
14:26	25' 7.50"				
15:15	25' 8.0"				
17:20	25' 8.0"				
3:18	25' 7.5"				
10:35	25' 7.5"				
15:12	25' 7.5"				
9:25	25' 7.25"				

WELL-PUMPING TEST DATA SHEET

COMPANY Wyoming Fuel Company
PROJECT Crow Butte STATE/COUNTY Dawes /Nebraska
TEST PERFORMED BY R. Fisher DATA
WELL NO. PM-6 TYPE
SURFACE COLLAR ELEV. MSL COMPLETION INTERVAL
WATER LEVEL DEPTH TOTAL WELL DEPTH
STATIC WATER LEVEL MSL AQUIFER THICKNESS
MEASURING POINT FT. TO GROUND LEVEL
EQUIPMENT: E-LINE ✓ STEEL TAPE RECORDER
RADIUS FROM PUMPED WELL (r) FEET
PUMP SIZE 7.5 H.P. PUMP RATE 24 GPM
PUMP START / 11-16-82 (TIME / DATE) PUMP FINISH 9:26 / 11-18-82 (TIME / DATE)

TIME	WATER LEVEL		DRAWDOWN (FEET)	ELAPSED TIME (MINUTES)	r^2/t ($FT.^2/MIN$)	REMARKS
0	26'	10.75"				
8:22	26'	0.0"				
8:56	26'	10.25"				
8:56	25'	11.75"				
10:15	26'	11.0"				
11:30	26'	10.0"				
12:18	26'	9.75"				
13:15	26'	10.0"				
14:24	26'	9.25"				
15:17	26'	9.25"				
17:22	26'	9.50"				
3:20	26'	7.75"				
10:37	26'	8.25"				
15:14	26'	6.75"				
9:26	26'	6.50"				

2.7 GEOLOGY

TABLE OF CONTENTS

2.7 GEOLOGY

2.7.1 GEOLOGY

Regional Setting

The Crow Butte project area is located in Dawes County in northwestern Nebraska (Figure 2.7.1). Crawford is the principle town in the area and lies approximately four miles northwest of the proposed Research and Development (R&D) site. Crawford is 25 miles west of Chadron and seventy miles north of Scottsbluff, Nebraska. Crawford is 21 miles south of the South Dakota state line and 33 miles east of the Wyoming state line. The topography consists of low rolling hills dominated by the Pine Ridge south and west of the project area.

General Stratigraphy

Sedimentary strata ranging from late Cretaceous through Tertiary are exposed throughout the project area (Map 2.7.1). Pleistocene alluvial and colluvial material are abundant along the north slope of the Pine Ridge. Figure 2.7.2 is a generalized stratigraphic column for the area.

Pierre Shale

The Pierre Shale of late Cretaceous age is the oldest formation encountered in Wyoming Fuel Company's test holes. The Pierre is a widespread dark gray to black marine shale, with relatively uniform composition throughout. The Pierre outcrops extensively in Dawes County north of the project area (Map 2.7.2). The Pierre is essentially impermeable, to the degree that in areas of outcropping Pierre, water for domestic and agricultural needs is piped in from wells from other formations.

Although the Pierre is up to 5,000 ft thick in other areas, in Dawes County deep oil tests have indicated thicknesses of 1,200-1,500 feet. Aerial exposure and subsequent erosion greatly reduced the vertical thicknesses of the Pierre prior to Oligocene sedimentation. Consequently, the top of the present day Pierre contact marks a major unconformity and exhibits a paleotopography with considerable relief (DeGraw, 1969).

As a result of the extended exposure to atmospheric weathering, an ancient soil horizon or Paleosol was formed on the surface of the Pierre Shale. It is known as the "Interior Paleosol Complex" of the Pierre Shale (Shultz and Stout, 1955, p.24) and is readily observed in certain outcrop exposures. The Paleosol is absent in the R&D permit area.

White River Group

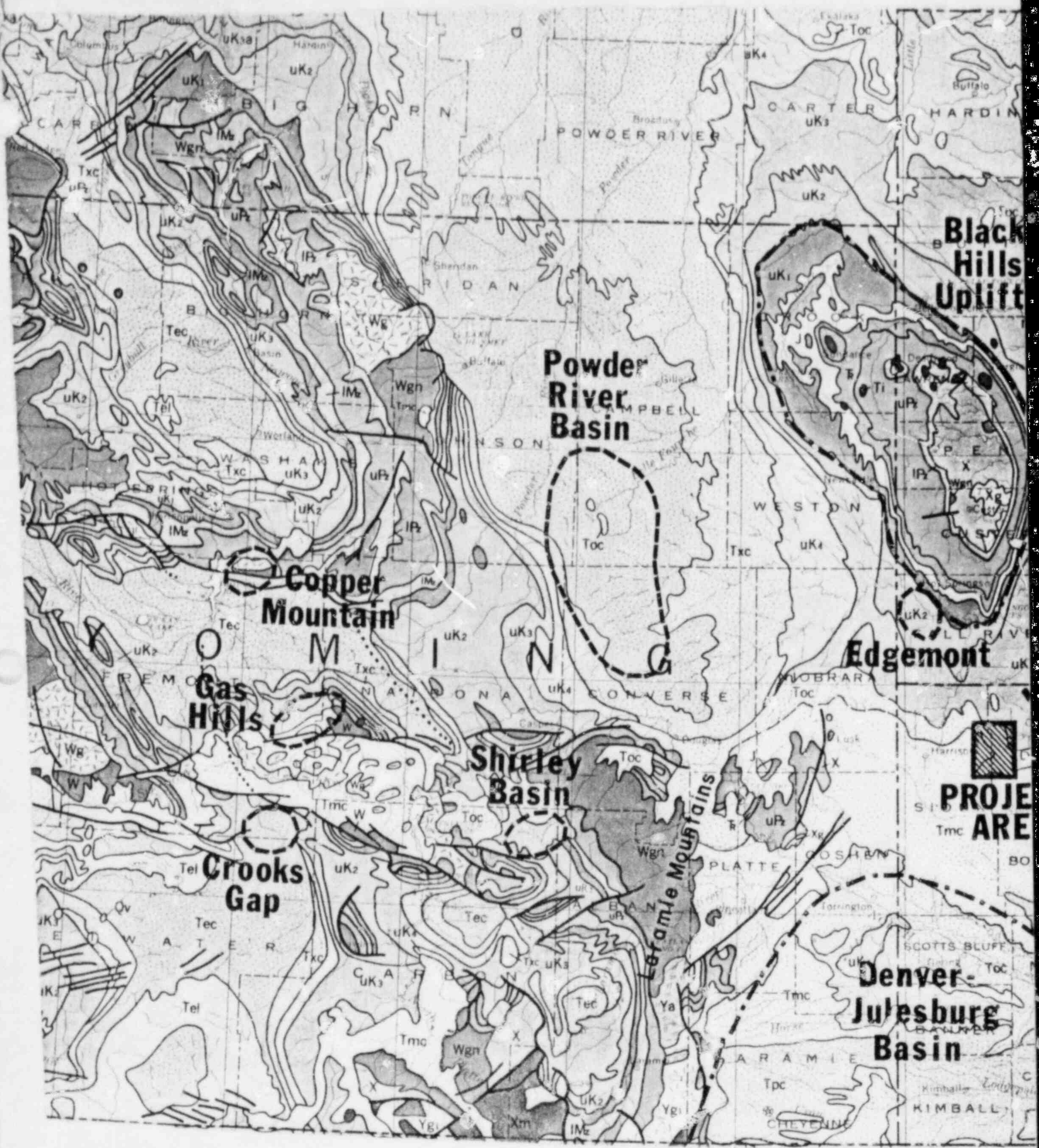
The White River Group is Oligocene in age and consists of the Chadron and Brule Formations.

Chadron Formation

The Chadron is the oldest Tertiary formation of record in northwest Nebraska (Map 2.7.1, Cross Sections 2.7.1 and 2.7.2). It lies with marked unconformity on top of the Pierre Shale. The Chadron formation is comprised of three distinct members. Regionally, the vertical thickness of the Chadron Formation varies greatly. This is attributed to the extreme variable thickness of the basal sand unit.

Basal Sandstone Member: The Basal Sandstone is the depositional product of a large, vigorous braided stream system which occurred during early Oligocene (approximately 36-40 million years before present). Regionally, the Basal Sandstone thicknesses range from 0 to 350 feet.

Occasionally the lower portion of the B al Member is a very coarse, very poorly sorted conglomerate. Where present the conglomerate consists of well rounded, predominately quartz and chalcedony cobbles ranging up to six inches across.

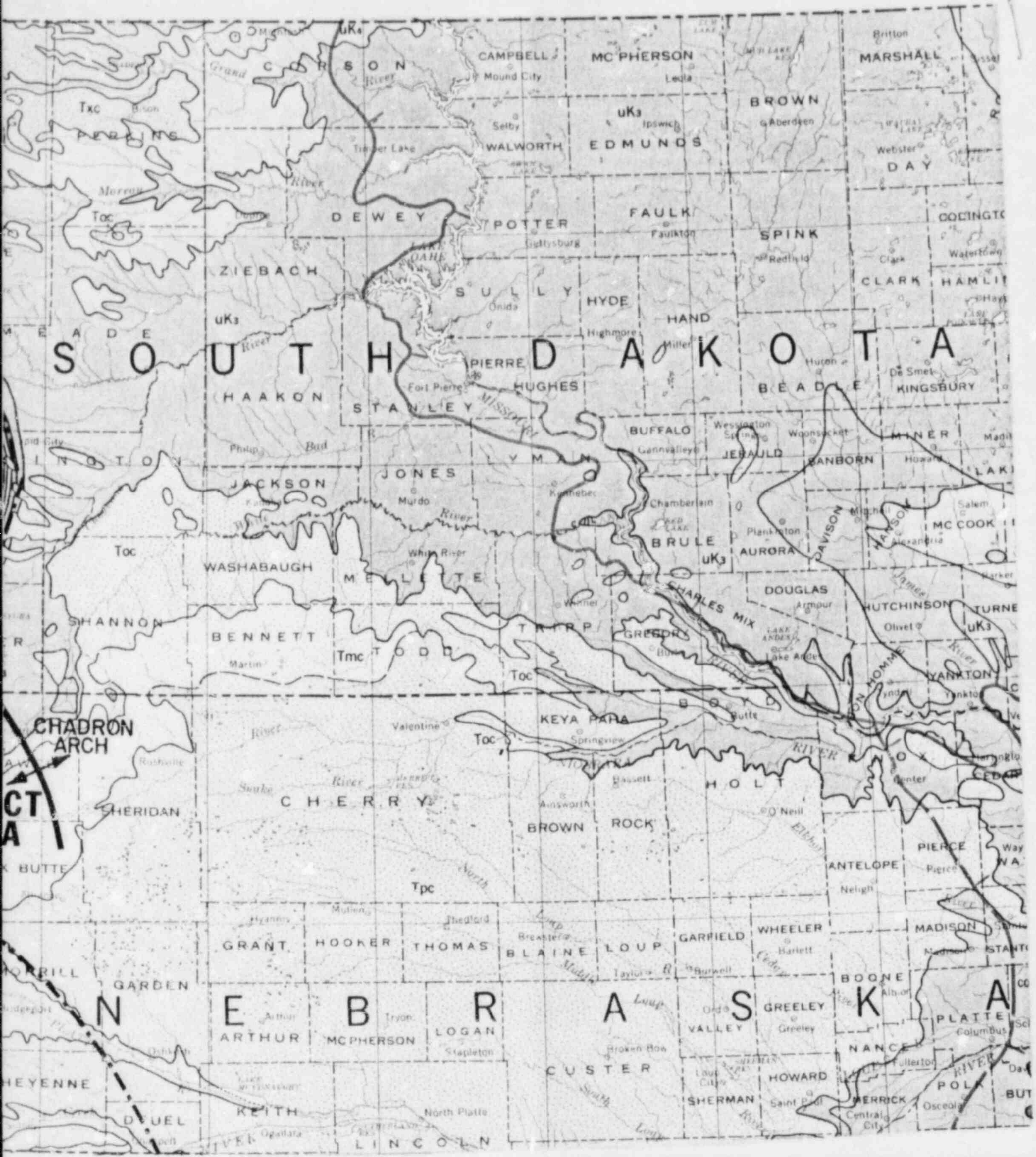


URANIUM DISTRICTS

STRUCTURAL FEATURE

CHADRON FORMATION

Printed from
GEOLOGIC MAP of the UNITED STATES
1974



SCALE

1 : 2,500,000
1" = 40 Miles

N

REV	BY	DATE

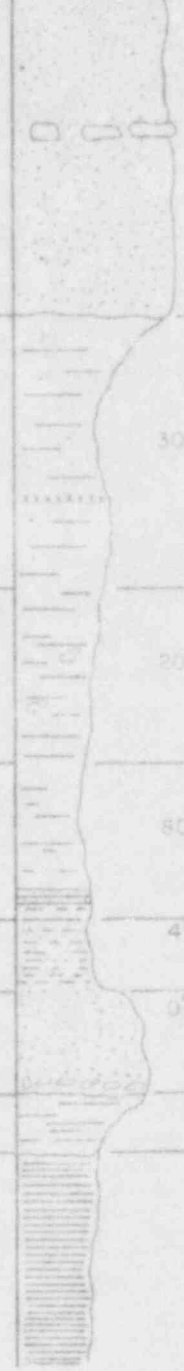
WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Northwestern Nebraska

REGIONAL GEOLOGIC MAP

PREPARED BY: SPCollings — 82-3401-015

DWN BY: SADavis — DATE: 1/20/82 — FIG. 2.7-1



Series	Group	Formation	Member	Thickness	Description
MIOCENE	ARIKAREE GROUP	MONROE CREEK		400'-600'	BROWN TO BUFF, FREQUENT THIN WELL CEMENTED, HARD SS STRINGERS, PIPY CONCRETIONS INTERBED WITH FINE TO MEDIUM GRAIN LOOSELY CEMENTED SS
		GERING			
OLIGOCENE	WHITE RIVER GROUP	BRULE	Whitney	300'-400'	BUFF SILTSTONE, FAIRLY MASSIVE, OCCASIONAL ASH LAYERS, SL. SANDY NEAR MIOCENE CONTACT
			Orella	200'-250'	BROWN SILTSTONE, MASSIVE, WITH PERSISTENT SPOTTY GREEN CLAY NODULES
		CHADRON	Upper	80'-150'	GREEN-GRAY SILTSTONE AND CLAY MASSIVE, OCCASIONAL LIMESTONE AND GYPSUM
			Middle	40'-100'	RED AND/OR GRAY CLAY, BENTONITIC WITH GREEN CLAY AND VERY FINE GRAIN DISPERSED SAND
			Basal	0'-350'	LIGHT GRAY TO BRIGHT GREEN SS CLEAN COARSE PREDOM QTZ WITH GREEN AND WHITE FLDS TRACE CHERT AND PYRITE LOCAL CONG WITH QTZ PEBBLES AND CHALCEDONY OCCASIONAL INTERBEDDED CLAY
EOCENE ?		PALEOSOL		0'-30'	REDISH-PINK AND YELLOW-BROWN MOTTLED CLAY
CRETACEOUS		PIERRE SHALE		1200'	DARK GRAY TO BLACK, NON-CALCAREOUS SHALE

REV	BY	DATE
1	RK	4/7/82

WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Dawes County, Nebraska

STRATIGRAPHIC COLUMN

PREPARED BY: RKnode

DWN BY: SADavis DATE 1/20/82

FIG. 2.7-2

The Basal Sandstone is the host member of the Crow Butte uranium ore deposit and will be discussed in more detail under Permit Area Geology.

Middle Chadron Member: The Middle Chadron Member represents a distinct and rapid facies change from the underlying Basal Sandstone. The lower portion of the Middle Chadron is characterized by green clay with dispersed very fine sand grains and red interbedded clays. The green clay grades upward into a brick red clay with interbedded gray-white bentonitic clay. The brick red clay can be observed on outcrop in northern Dawes and Sioux Counties and serves as an excellent marker bed in drill hole cuttings. The Middle Chadron member has been observed in virtually all drill holes along the mineral trend but is less likely to occur in drill holes outside of the Basal Sandstone channels. Thickness of the Middle Chadron ranges from 40-100 feet throughout the project area.

Upper Chadron Member: The Upper Chadron consists of massive claystones and siltstones. These range in color from a dark blue-green to greenish-brown. The sequence of green siltstones and mudstones are generally considered fluvial channel and flood plain deposits, with limited lacustrine and eolian material present (Vondra, 1958, p.41). Well developed sand channels are rarely encountered in test holes, and have very limited lateral extent when observed. The Upper Chadron averages 100 feet thick throughout the project area.

Brule Formation

The Brule Formation lies conformably on top of the Chadron Formation and with the Chadron comprises the White River Group (Map 2.7.1 and Cross Sections 2.7.1 and 2.7.2).

The Brule has been subdivided into two separate members (Shultz and Stout, 1938) the Orella and the Whitney. Differentiation of the two members in drill hole cuttings or with geophysical logs is very difficult.

The Orella lies directly on the Chadron Formation and an approximate Brule-Chadron contact can be detected in drill hole cuttings but usually not in geophysical logs (Cross Sections 2.7.1 and 2.7.2). The Orella is compose of buff to brown siltstones, with persistent spotty green nodules as it grades into the green clays of the Chadron.

The Whitney Member of the Brule is comprised of fairly massive buff to brown siltstones, in part probably eolian in origin (Vondra, 1958, p.19). Several volcanic ash horizons have been reported in outcrops but are rarely distinguishable in drill hole cuttings. The Whitney Member frequently becomes coarser grained upward near the Miocene contact. This is marked by an increase in grain size which is difficult to detect in drill hole cuttings but usually can be observed on electric logs. Some moderate to well defined channel sands can be observed in both drill holes and on outcrops. These upper Brule channels are limited in lateral extent and continuity but may occasionally be water saturated in the otherwise generally impermeable Brule.

Arikaree Group

The Arikaree Group includes three Miocene sandstone formations which are present locally and regionally but in the R&D permit area are absent due to erosion (Map 2.7.1).

Gering Formation

The Gering Formation is the oldest formation of the Arikaree Group. The Gering Formation is Miocene in age and lies unconformably on the Brule Formation (Map 2.7.1 and Cross Sections 2.7.1 and 2.7.2). The Gering is predominately buff to brown, fine grained sandstones and siltstones. These represent channel and flood plain deposits of higher velocity than the underlying Brule. Thickness of the Gering Formation ranges from 100-200 feet (Witzel, 1974, p.50).

Careful observation usually makes it possible to distinguish the Gering from the Brule Formations in drill hole cuttings. However, it is usually much more obvious when observed on an electric log.

Monroe Creek Formation

The Monroe Creek Formation overlies the Gering and is the middle member of the Arikaree Group. The Monroe Creek is lithologically similar to the Gering with buff to brown, fine grained sandstone. The unique characteristic of the Monroe Creek is the presence of large "pipy" concretions. These concretions consist of fine grained sand similar to the rest of the formation with calcium carbonate cement and are extremely hard and resistant to weathering.

The reported thickness of the Monroe Creek Formation is 280-360 feet (Lugan, 1938, in Witzel, 1974, p.53).

Harrison Formation

The Harrison Formation is the youngest member of the Arikaree Group. To date, this formation has rarely been penetrated in any Wyoming Fuel Company drill holes, thus little first hand information is available. It is described as lithologically similar to the Gering and Monroe Creek Formations, with fine grained unconsolidated sands buff to light gray in color. The Harrison Formation is also noted for its abundance in fossil remains (Witzel, 1974, p.55).

Regional Structure

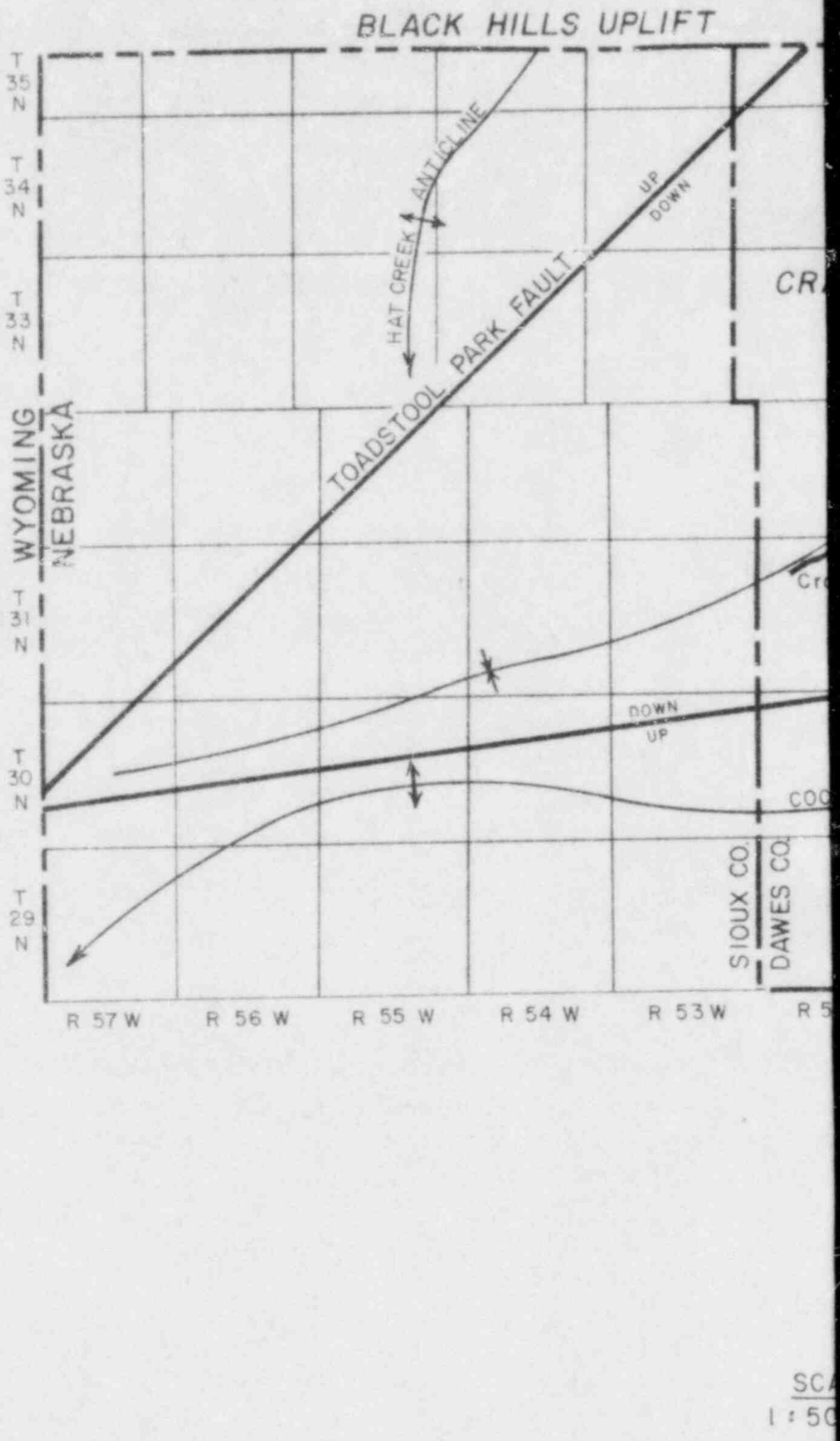
The most prominent structural expression in northwest Nebraska is the Chadron Arch (Figure 2.7.1 and Cross Section 2.7.1). This anticlinal feature strikes roughly northwest-southeast along the northeastern boundary of Dawes County. The only surficial expression of the Chadron Arch is in the northeastern corner of Dawes County, as well as small portions of Sheridan County and Shannon County, South Dakota.

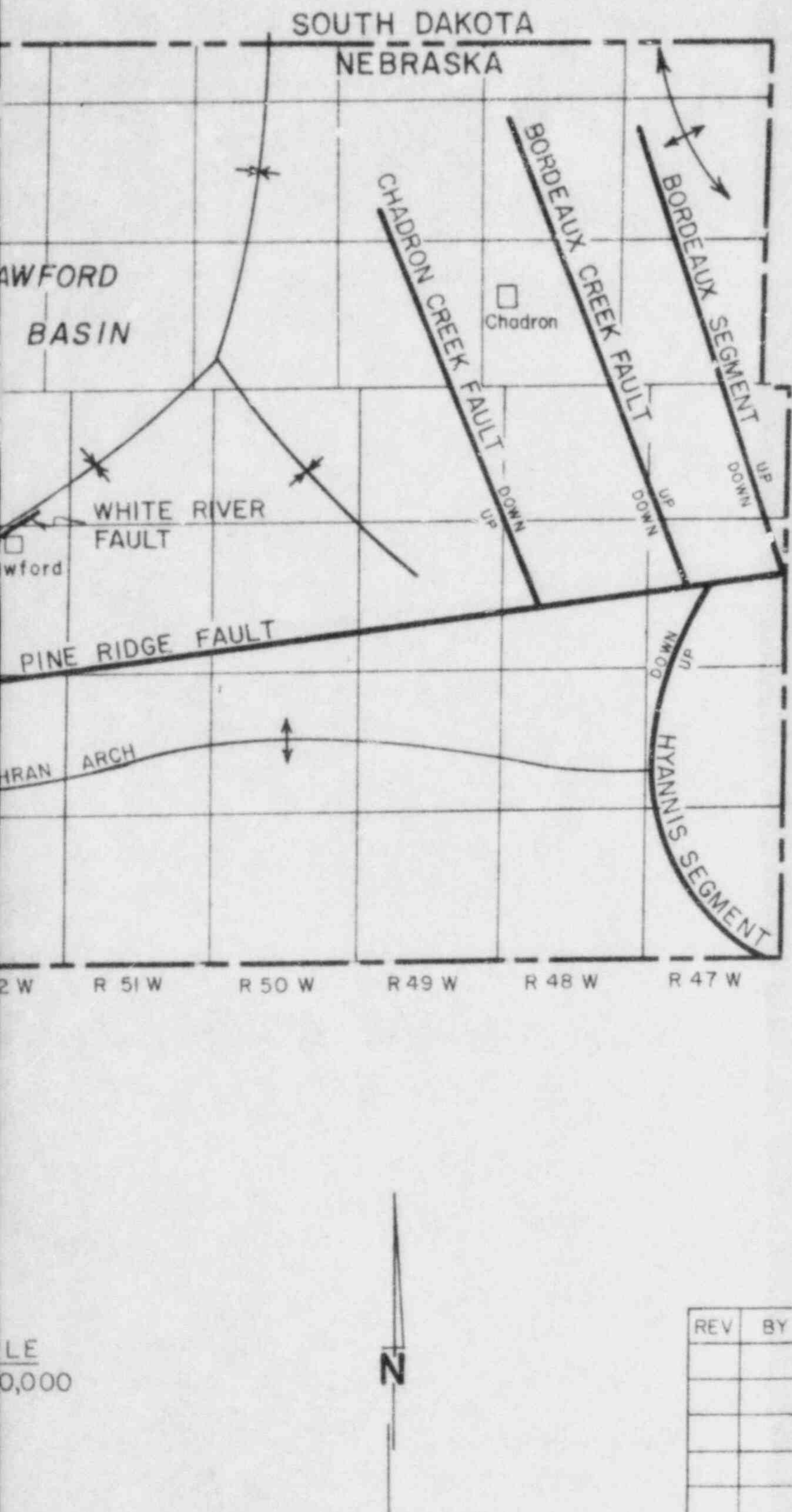
The Black Hills lie just north of the Sioux and Dawes Counties in southwestern South Dakota (Figure 2.7.1). Together with the Chadron Arch, the Black Hills Uplift has produced many of the prominent structural features presently observed in the area today. As a result of the uplift, formations underlying the project area dip gently to the south. The Tertiary deposits dip slightly less than the older Mesozoic and Paleozoic formations (Witzel, 1974, p.18).

The Crow Butte ore body lies in what has been named the Crawford Basin (DeGraw, 1969). DeGraw made detailed studies of the pre-Tertiary subsurface in western Nebraska using primarily deep well hole information. He was able to substantiate known structural features and propose several structures not earlier recognized (Figure 2.7.3). The Crawford Basin was defined by DeGraw as being a triangular asymmetrical basin bounded by the Toadstool Park Fault on the northwest, the Chadron Arch and Bordeaux Fault to the east and the Cochran Arch and Pine Ridge Fault to the south (Figure 2.7.3).

The Toadstool Park Fault and the Bordeaux Fault and other faults (Figure 2.7.3) occur outside the project area of Wyoming Fuel Company and are assumed to exist as described by DeGraw and others. The Pine Ridge Fault (Figure 2.7.3) has also been inferred from subsurface data and proposed by DeGraw (1969, p.36). This is an east-west trending fault running across Sioux and Dawes Counties. The fault is subparallel to the Cochran Arch and has a reported displacement of about 300 feet with the south side upthrown. Wyoming Fuel Company drill hole data has not substantiated the existence of this fault (Map 2.7.2).

The Cochran Arch (Figure 2.7.3, Maps 2.7.1 and 2.7.2) was also proposed by DeGraw (1969, p.36) on the basis of subsurface data. The Cochran Arch trends east-west through Sioux and Dawes Counties, parallel to the aforementioned Pine Ridge Fault. The structural high of the Cochran Arch has been observed in drill hole


BLACK HILLS UPLIFT
T 35 N
T 34 N
T 33 N
T 31 N
T 30 N
T 29 N
HAT CREEK ANTICLINE
TOADSTOOL PARK FAULT
UP
DOWN
WYOMING
NEBRASKA
DOWN
UP
SIOUX CO.
DAWES CO.
R 57 W
R 56 W
R 55 W
R 54 W
R 53 W



REV	BY	DATE	WYOMING FUEL COMPANY	
			CROW BUTTE PROJECT Sioux and Dawes Co's, Neb.	
			STRUCTURAL GEOLOGY	
			PREPARED WFC & DeGraw	
			DWN BY SADavis DATE 4/8/82	FIG. 2.7-3

data (Cross Section 2.7-1), and the existence of the Cochran Arch alone is enough to explain the structural high south of Crawford. The Pine Ridge Fault is not believed to be present in Dawes County.

The synclinal axis of the Crawford Basin trends roughly east-west and plunges west into what is informally referred to as the inner Crawford Basin by Wyoming Fuel Company (Map 2.7-2). The inner Basin is characterized by a rather sharp paleotopographic change in the Pierre Shale with dramatic increase in the thickness of the Basal Chadron Sandstone. To the east the plunging syncline is sharply truncated in the east half of Section 19, Township 31 West, Range 51 North, adjacent to the R&D permit boundary (Map 2.7-2).

The single most prominent structural feature within the Crawford Basin is the previously unnamed White River Fault (Figure 2.7-3, Map 2.7-2). It is located directly north of Crawford, and strikes northeast-southwest with the upthrown side to the south. The total vertical displacement is 300-400 feet; no strike-slip movement has been detected. The disturbance of the Chadron and Brule Formations date the fault as post-Oligocene.

Permit Area Geology

Pierre Shale

The Pierre Shale is the oldest formation encountered in any Wyoming Fuel Company test holes within the permit area (Map 2.7-1 and Cross Sections 2.7-3, 2.7-4 and 2.7-5). The description provided under General Stratigraphy describes the Pierre within the permit boundary. The Pierre is 1200-1500 feet thick within the permit area based on deep oil well tests. The ancient soil horizon known as the Paleosol has been scoured away by the overlying Basal Chadron Sandstone and is non-existent within the permit boundary.

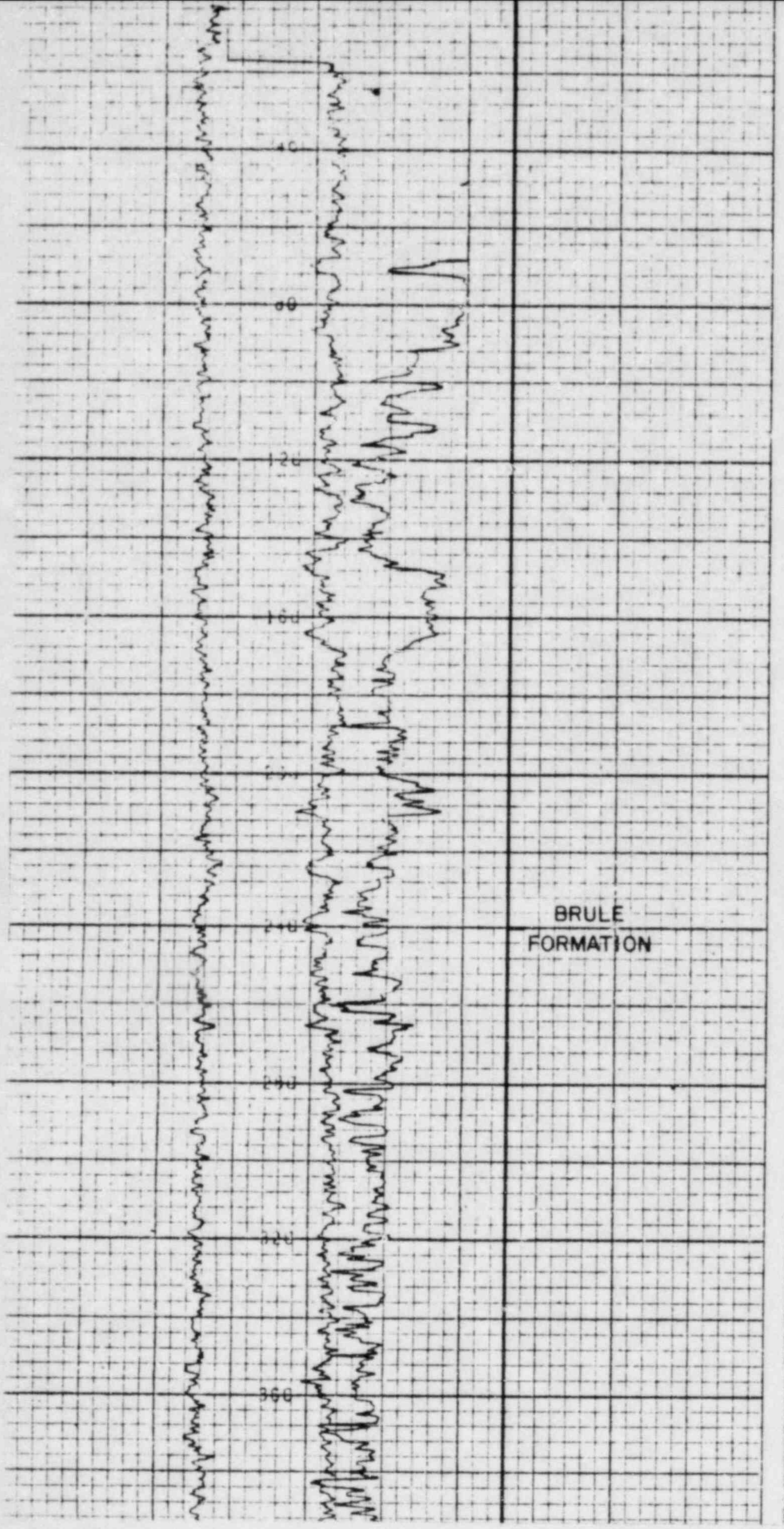
The Pierre Shale is the confining bed below the Basal Chadron Sandstone member which is the host for uranium mineralization. The black marine shale is an ideal confining bed with measured permeabilities in the proposed well field of less than 0.01 millidarcies. The log characteristics of the Pierre Shale are shown on Figure 2.7-4 and illustrate its impermeable nature.

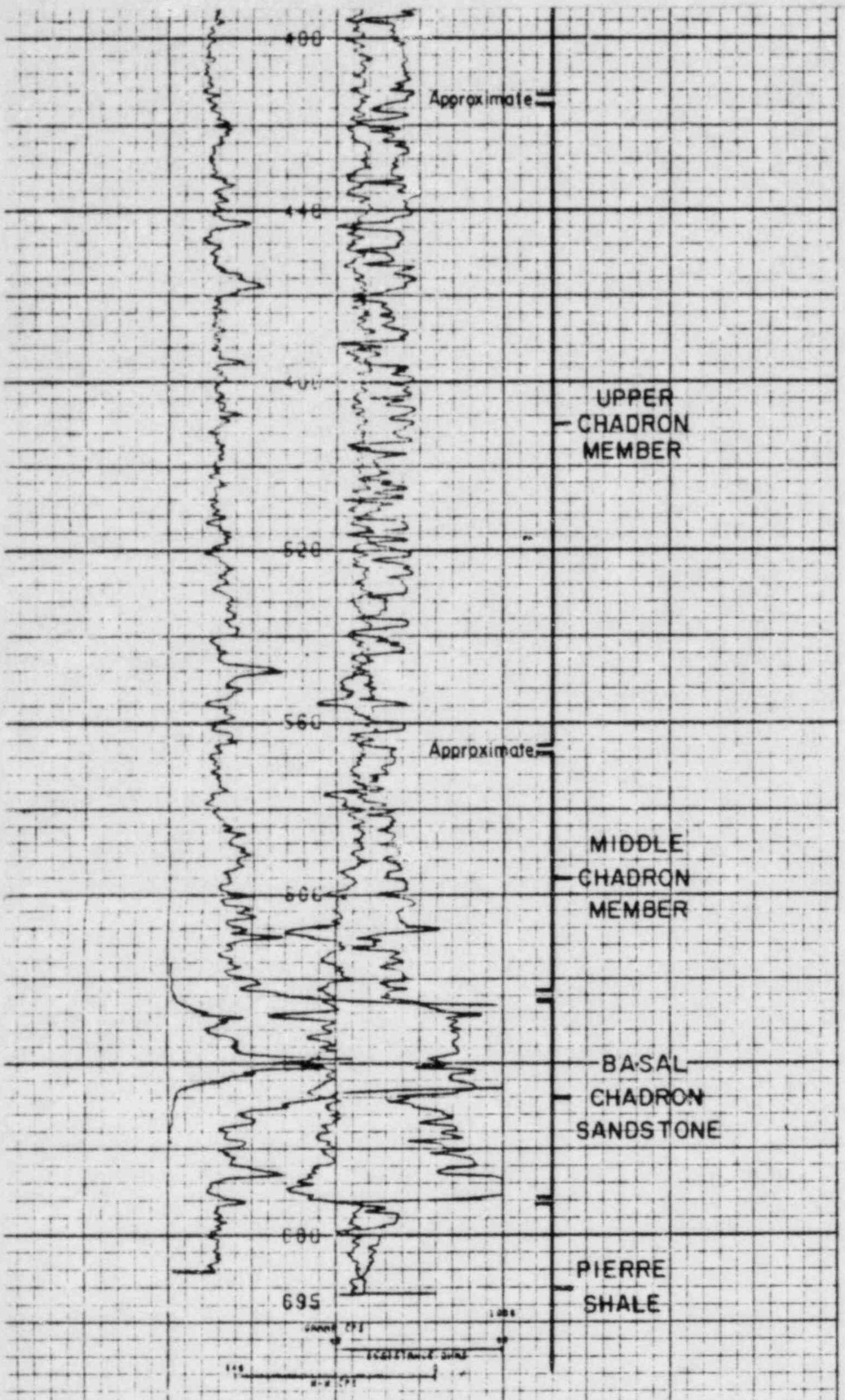
Chadron Formation

The Basal Chadron Sandstone is the host for the Crow Butte uranium deposit (Cross Section 2.7-3, 2.7-4, 2.7-5) for the proposed R&D test. Uranium mineralization occurs exclusively within the Basal Chadron Sandstone Member of the Chadron Formation. The Basal Chadron is a coarse grained sandstone with frequent interbedded thin clays. Vertical thickness of the Basal Chadron within the permit boundary is 40 feet (Figure 2.7-4, Cross Section 2.7-3, 2.7-4, 2.7-5). The Basal Chadron is an arkosic sandstone. Thin section examination reveals composition to be 50% monocrystalline quartz, 30-40% undifferentiated feldspar, plagiclase feldspar, and microcline feldspar. The remainder includes polycrystalline quartz, chert, chalcedonic quartz, various heavy minerals and pyrite.

Core samples of the Basal Chadron exhibit numerous clay galls up to a few inches in diameter. In addition, the Basal Member contains frequent thin silt and clay lenses of varying thickness and continuity. These represent flood plain or low velocity deposits which normally occur during fluvial sedimentation. These lenses vary in thickness from several inches to one or two feet in the proposed wellfield site. X-ray diffraction of the Basal Sandstone has identified the following clay minerals: kaolinite, illite, smectite and expandable mixed layer illite-smectite.

The Middle Chadron Member (Figure 2.7-4, Cross Section 2.7-3, 2.7-4, 2.7-5) is in the upper confining bed overlying the Basal Sandstone Member. The Middle Chadron represents a distinct and rapid facies change from the Basal Sandstone Member. Vertical thickness of the Middle Chadron averages 60 feet throughout the R&D permit area. The lower part of the Middle Member is a light to medium green clay


40
80
120
160
240
360
BRULE
FORMATION



WYOMING FUEL COMPANY
CROW BUTTE PROJECT
Dawes, County, Nebraska
LOG CHARACTERISTICS OF
GEOLOGIC UNITS IN R&D AREA

PREPARED BY SPCollings
DWN BY SADavis DATE 2/3/83 FIG. 2.7-4

with dispersed very fine grained sand. Locally, and within the permit area, the lower portion of the Middle Member is a relatively impermeable claystone with dispersed sand grains. This is observable by the epigenetic occurrence of the uranium mineralization, which is strictly confined to the Basal Chadron Sandstone Member. The upper part of the Middle Member is a brick red clay with interbedded green and light gray clays.

The Upper Chadron Member (Figure 2.7-4, Cross Section 2.7-3, 2.7-4, 2.7-5) in the premit area averages 150 feet in thickness. It is comprised of medium green to dark green-blue siltstones and claystones. Clay content of the Upper Chadron increases with depth as it gradually grades into the Middle Chadron Member.

Brule Formation

The Brule Formation lies conformably on top of the Chadron (Figure 2.7-4, Cross Section 2.7-3, 2.7-4, 2.7-5). The Brule outcrops throughout the permit area (Map 2.7-1). It is made up almost entirely of siltstones with minor sand channels. In drill hole cuttings, the Brule can be identified by its buff to medium brown color in contrast to the greens of the underlying Chadron.

Within the permit boundary occasional sand units are encountered in the upper 250 feet of the drill hole. These represent small Brule channel sands known to occur intermittently in the Whitney Member. The small sand units have very limited lateral continuity and thus are not considered aquifers. This has been demonstrated in Wyoming Fuel Company drill holes and can be observed in the cross sections through the permit area (Cross Section 2.7-3, 2.7-4, 2.7-5).

Throughout the permit area, approximately 100 feet below the surface is a zone of sandy siltstone. The unit is characterized by very fine sand grains dispersed in a siltstone matrix.

Quaternary Alluvium

Quaternary alluvial and colluvial material are present in the permit area ranging in depth from 0-40 feet. The material consists of Miocene rock fragments, sand, gravel and sandy soil horizons.

Permit Area Structure

Regionally, the White River strata dip gently south at about one degree. Within the permit boundary the beds are generally flat lying with a slight dip to the west. This slight westerly dip is associated with the plunging synclinal axis of the Crawford Basin and more specifically the abrubt synclinal plunge originating in the west half of Section 19, Township 31 North, Range 51 West, adjacent to the permit area (Map 2.7-2).

Close spaced drill data throughout the permit area indicate that no faulting is present. The closest fault to the permit area is the aforementioned White River Fault which is five miles northwest of the permit area (Map 2.7-2). No fracture systems have been detected during drilling operations. This would be recognized by lost circulation of the drilling fluids in the fracture zones which have not been observed in the permit area.

Confining Strata

The Crow Butte ore body represents a situation favorable for in situ mining of uranium. The lower confining bed is the Pierre Shale (Figure 2.7-4, Cross Sections 2.7-1, 2.7-2, 2.7-3, 2.7-4 and 2.7-5). The Pierre is one of the most laterally extensive formations in the region. It is thick, homogenous black shale with very low permeability.

The upper confining bed is the Middle Member of the Chadron Formation (Figure 2.7-4, Cross Sections 2.7-1, 2.7-2, 2.7-3, 2.7-4 and 2.7-5). The Middle Chadron is a thick sequence of interbedded clays which grade immediately upward into several hundred feet of massive siltstones and claystones. The Middle and Upper Chadron

Members along with the Orella Member of the Brule (Figure 2.7-4) separate the zone of injection (Basal Chadron) from the nearest upper aquifer with several hundred feet of clay and siltstone. The Middle Chadron clay also has large lateral extent. It has been observed in virtually all regional test holes which have the Basal Sandstone present and all holes within the permit area.

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2.8 SEISMOLOGY

2.8 SEISMOLOGY

The Crow Butte Project Area in northwest Nebraska is within the Stable Interior of the United States. The project area along with most of Nebraska is in seismic risk Zone 1 on the Seismic Risk Map for the United States compiled by Algermissen (1969). Most of the central United States is within seismic risk Zone 1 and only minor damage is expected from earthquakes which occur within this area. The nearest area to the project area of higher seismic risk is in the southeastern part of Nebraska within the eastern part of the central Nebraska Basin (Burchett, 1979) about 300 miles from the project area.

Although the project area is within an area of low seismic risk occasional earthquakes have been reported. Over 1100 earthquakes have been catalogued within the Stable Interior of the U.S. since 1699 by Docekal (1970). This study considered complete to 1966 noted several earthquake epicenters within northwest Nebraska. All but two of these earthquakes were classified within the lowest category, Intensity I-IV, on the Modified Mercalli Intensity Scale of 1931.

An earthquake of Intensity VI on the Modified Mercalli Scale occurred on July 30, 1934 near Chadron. This earthquake resulted in minor damage to chimneys and plaster. A milder earthquake occurred in the same area on March 9, 1963. This earthquake was classified as Intensity of II-III (Burchett, 1979; Von Hake, 1974; Chadron Record, June 24, 1981).

An earthquake of Intensity VII on the Modified Mercalli occurred on March 28, 1964 near Merriman about 85 miles east of the project area. This earthquake resulted in minor damage to roads, plaster, and dishes (Burchett, 1979).

On May 7, 1978 an earthquake of Intensity V was reported in southwest Cherry County about 90 miles east of the project area. No major damage was reported from the earthquake (Burchett, 1979).

Little is known about the causes of earthquakes in Nebraska (Burchett, 1979, p.14). Some may be related to structural features and faults shown on Figure 2.7-3 (see Section 2.7, Geology) (Burchett, 1979). Although the risk of a major earthquake in Nebraska is slight (Burchett, 1979, p.14), some low-to-moderate tectonic activity is occurring along the Chadron and Cambridge Archs (Rothe, 1981, p.63). This activity will probably result in occassional earthquakes up to Invensity V-VI on the Modified Mercalli Scale (Docekal, 1970, p.11).

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CROW BUTTE URANIUM PROJECT
Dawes County, Nebraska

Application and Supporting Environmental
Report for Research and Development
Source Material License

Volume II

Submitted to:
United States Nuclear Regulatory Commission
Washington, D.C.

February 11, 1983

Prepared and Submitted by:
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(303) 989-5037

00081

SECTION 2.9

ECOLOGY

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SUMMARY

Beginning in March, 1981, plans were initiated to undertake ecological studies for Wyoming Fuel Company's Crow Butte Uranium Prospect near Crawford, Nebraska. At this time, all appropriate state and federal regulations pertaining to uranium solution mining were reviewed, and studies were designed which were deemed appropriate to comply with legislative precedents in the region, drawing heavily upon U.S. Nuclear Regulatory Commission guidelines for ecological studies.

Information deemed necessary for completion of a suitable permit application was outlined in a detailed task analysis, which identified the following objectives:

1. Describe the flora and the fauna in the vicinity of the site, their habitats and distributions.

2. Identify "Important Species" - species which are:

    a. commercially or recreationally valuable
    b. threatened or endangered
    c. likely to affest the well-being of species in the above categories
    d. critical to the structure and function of the ecological system
    e. biological indicators of radionuclides or chemical pollutants in the environment.

3. Identify and provide information on the relative abundance of the majority of terrestrial and aquatic organisms.

4. Provide count data on domestic animals and important game animals.

5. Provide a map of the principal plant communities.

6. Discuss species-environmental relationships, diversity measurements, and predatory-prey relationships of "important" species.

7. For "Important" species, discuss:

    a. life histories
    b. seasonal population fluctuations
    c. habitat requirements
    d. food chains and interspecies relationships.

8. Identify any pre-existing environmental stresses.

9. Describe the status of ecological succession within each plant community type.

10. Discuss histories of any infestations, epidemics or catastrophes.

11. Present the information in two separate subsections, "Terrestrial Ecology" and "Aquatic Ecology".

12. Identify sources of information and list pertinent published information dealing with the ecology of the region.

13. Reference and describe all ecological and biological studies of the site or its environs currently in progress or planned.

Subsequently, methods of investigation were chosen which would address the above objectives. A review of literature was completed, and discussions were held with local representatives of the state and federal agencies, and with the faculty of Chadron State College.

Finally, a detailed work plan was developed, and studies were undertaken in January, 1982.

The attached report presents findings of the study through July, 1982, when it was deemed that the data base was sufficient to address the terms of reference of a Research and Development permit application. However, sutdies were contined through December, 1982, in order to provide a full year's data on the site. The information is intended to comply with any future requirements for development on the site.

Stated in its simplest terms, the ecological study entailed, 1) the identification and documentation of plant communities and wildlife habitat types, and 2) the systematic documentation of wildlife species within each type.

In the attached report, emphasis is placed on the relationships of plants and animals to particular habitat types. This "habitat affinity" approach allows one to address potential impacts in a systematic manner. If a particular habitat type is disturbed, it can be anticipated that the representative plant and animal species will be affected in direct proportion to the level of disturbance. Conversely, undisturbed habitat types, and their representative species, should not be adversely affected. On the site in questions, for example, if only mixed grass habitat is disturbed, one should not expect such species as fox squirrels and white-tailed deer, which reside in streambank forest, to be adversely affected.

The baseline information presented in the attached report is intended not only as a basis for assessing anticipated impacts, but as a basis for reference against which to measure impacts as they occur. It should be understood that such studies are considered important not only in terms of the public welfare, but also to protect the interests of the company. If, for example, years hence a "decline" in the fishery of Squaw Creek were to be suggested and attributed to mining activities, it would be appropriate to note from the baseline study that there was no significant fishery at the outset of mining activities.

Intensive investigations were conducted throughout the 13-section "Commercial Study Area", with special emphasis on the section containing the proposed "Research and Development Restricted Area". Equivalent studies were conducted within a 5-mile (8-km) "Adjacent Area". Finally, extensive studies were conducted within a 50-mile (80-km) "Outer Area". Hence, it was possible to compare conditions within the proposed area of development to conditions in the general vicinity and to a much larger area. It was subsequently possible to make statements concerning the relative importance of the permit areas on a local and regional basis.

In the course of the study, no phenomena were discovered which would preclude issuance of permits for development of the property in the current legal and socio-economic environment. Although the Pine Ridge area contains a wealth of plant and animal species nearby unique in the region, and is regarded as an important hunting and fishing unit, environmental conditions within the Commercial Study Area proper are relatively degraded due to widespread deleterious land practices. The proposed 80-acre Research and Development Restricted Area is particularly degraded. Populations of "important" wildlife species are relatively low, and fishing opportunities non-existent.

Of threatened, endangered and rare species, one bald eagle was recorded on the Commercial Study Area, outside the Restricted Area. The species is an uncommon winter resident throughout the region. Critical habitat for the species does not exist on or near the study area.

From a purely ecological point of view, perhaps the most significant aspect of the study was the diversity of raptors (birds-of-prey) with 21 species documented within the study area from January through July. No adverse impacts, however, are anticipated since no reduction in the prey base is expected to result from project activities. Quire to the contrary, there is considerable opportunity to enhance conditions for raptors, if attention is given to improving habitat conditions in the reclamation phase. It would appear appropriate, however, to monitor raptor activities and nesting success within two miles of the proposed development.

2.9.1 Terrestrial Ecology

2.9.1.1 Introduction

General

A one-year ecological baseline study was initiated in January, 1982, in conjunction with the Crow Butte Uranium Prospect, Dawes County, Nebraska. Studies were outlined in conjunction with Standard Format and Content of License Applications, Including Environmental Reports, for in Situ Uranium Solution Extraction, Task FP 818-4, July 1981, U.S. Nuclear Regulatory Commission.

The principal Study Area is shown in Fig. 2.9-1. Intensive studies were conducted with emphasis on the proposed Section 19 research and development Restricted Area Boundary (RAB) and proposed Commerical Study Area (CSA). Comparable investigations were conducted within an 8-km (5-mi) Adjacent Area (AA), in order to assess the ecological importance of the CSA in relation to the immediate environs. Extensive investigations were conducted within an 80-km (50-mi) Outer Area (OA) centered on Section 19, drawing primarily upon published sources of information.

The information presented in this section includes findings of the project through mid-July, 1982, when the data base was deemed sufficient to comply with federal and state requirements for Research and Development License applications, and sufficient to assess the probable impacts of the project.

Description of the Study Area

The project area lies within Dawes County in northwestern Nebraska. The 8-km AA includes portions of Sioux County on the west. The 80-km OA includes portions of South Dakota on the north and Wyoming to the west.

The climate is dry continental. The normal annual amount of precipitation is about 19 inches (48 cm). Seventy percent of that amount falls during the growing season. The winters are cold, with January having a low mean temperature of about -8°C. Warmest temperatures occur during late July, when mean highs range from 35-38°C. The growing season averages about 130 days. The latest killing frost occurs during mid-May, and the earliest in fall occurs during late September (Visher 1954, Urbatsch and Eddy 1969). Violent thunderstorms, accompanied by high winds, torrential rains, and hail, can be expected to occur each spring and summer.

The Study Area lies in two physiographic provinces. The Pine Ridge Escarpment, the region's most prominent geological feature, marks the northern boundary of the Northern High Plains and the southern boundary of the unglaciated Missouri Plateau. The Pine Ridge, which lies along the southern boundary of the CSA, is characterized by buttes, ridges, vertical slopes and deep canyons. The Missouri Plateau, which represents the northern portion of the Study Area, is distinguished from the High Plains by deep erosion and has badlands developed at some sites (Fenneman 1931). The White and Niobrara Rivers are the two major streams which drain the region, the former traversing the Study Area (Fig. 2.9-1).

The soils of the Study Area have a tremendous range, from clays in the north, to sands in the south, with an intermittance of badlands and relatively fertile soils. The clays (Pierre series) developed from shales in the northern part of Dawes County, where badlands outcrops of tertiary sandstone, and alkaline flats also occur. Soils of the Commercial Study Area are predominantly of a sandstone origin.

Elevations within the primary Study Area (CSA and AA) range from 3,400 feet (1,100m) to 4,600 feet (1,480 m). The CSA lies primarily in a foothill and valley bottom situation, surrounded by buttes and escarpments to the east, south, and west, and expansive plains to the north. The Research and Development Restricted Area Boundary site is located on sandy strata in a foothill-plains situation.

2.9.1.2 Methods

Methods of investigation were chosen, taking into account the principal floral and faunal species of the area, and following discussions with agency biologists (J. Peterson, H. Suetsuga, Nebraska Game and Parks Commission). Whenever possible, methods were employed which would provide continuity and comparability with on-going investigations in the state and the region.

Plant Collections were conducted throughout the growing season in order to prepare a comprehensive voucher of plant species within the Study Area.

Vegetation Mapping was completed at a scale of 1:12,000 for the Commercial Study Area and Research and Development Restricted Area Boundary site, and at a scale of 1:24,000 for the Adjacent Area. Vegetation/Habitat types were chosen in compliance with the system developed by the Montana Agriculture Experiment Station (Coenenberg et al. 1977), modified to conform to the ecological characteristics of the Crow Butte area. The system was deemed appropriate to describe floristic characteristics and to describe wildlife habitat affinities.

General Observation was utilized to generate a species list for the Study Area and to obtain information on faunal distribution. In addition to routine sighting, observation time was programmed specifically for 1) raptor nest surveys, 2) big game surveys, 3) movement and mirgration route delimitation, 4) game bird winter concentrations, 5) game bird brood counts, 6) grouse strutting ground "lek" surveys, 7) water fowl breeding pair counts, 8) waterfowl brood surveys and production counts, 9) prairie dog colony surveys, 10) carnivore dens, and 11) reptile and amphibian surveys.

Indirect evidence of wildlife was recorded to supplement visual documentation. Such evidence included tracks, scat, hair or quills, feathers, vocalization, and evidence of forage utilization. Fresh snowfall afforded special documentation opportunities, e.g. radius of action and behavioral phenomena.

Aerial observation was the primary means of documenting big game use within the Study Area. Nesting activity of raptors was monitored by aircraft, and an aerial search was made for grouse leks. Flight lines for big game were oriented north-south and spaced at ½-mile intervals within the CSA and AA.

Transects were used to determine relative utilization of the major habitat types by wildlife and to document seasonal songbird activity. One, 1,000-m transect was placed in each major habitat type. Transects were sampled at 2-week intervals from sunrise to no later than 3 hrs after sunrise. Perpendicular distance of each observation was used to compute density by species (Emlen 1977).

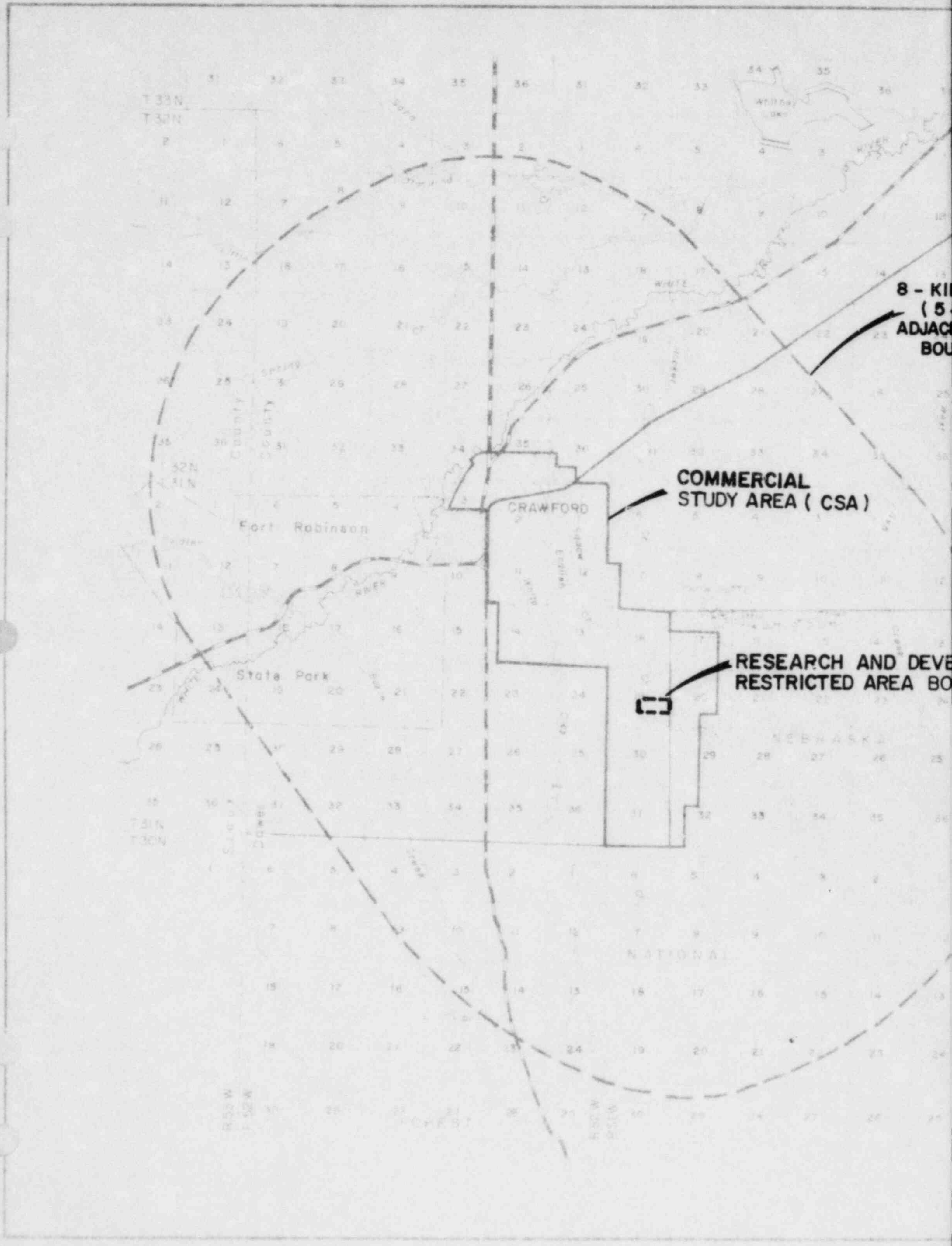
Time-area counts were incorporated to provide consistency in sampling wildlife use within special habitat types, e.g. ponds and impoundments.

Rodent trapping was conducted over a 3-day period in spring, to provide an index of abundance by habitat type. Fifty traps were placed parallel to each flush transect (above) for 3 consecutive days and nights (150 trap-nights per habitat type).

Spotlight routes were employed to document the status of carnivores, and to provide herd structure data for ungulates. Four routes, each about 80 km long, were run monthly.

Data reduction and analysis. All field data were recorded on prepared forms or on cassette recorders. Raw data were reduced onto Fortran coding forms for permanent storage and analysis. Locations of the major wildlife species were recorded to within 50m, and for certain phenomena, e.g. raptor nests to within 10m with reference to the Universal Transverse Mercator (UTM) system and encoded on mylar overlays at a scale of 1:24,000.

Further details of methodologies are discussed in association with specific taxa.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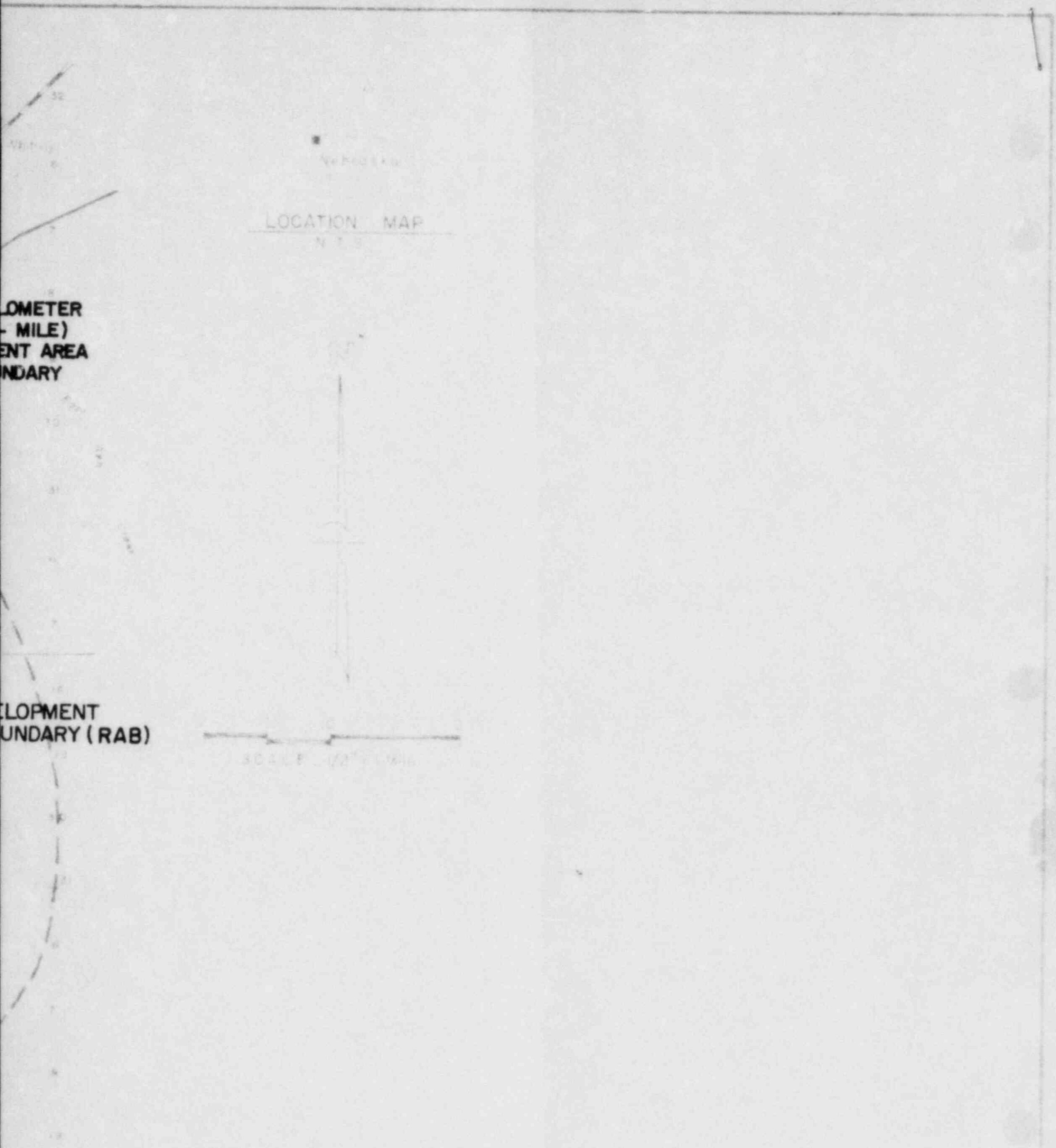


WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Dawes County, Nebraska

ECOLOGICAL STUDY AREA

F. Harrington & Assoc.

D&D Graphics 8-1-82 FIG. 2.9-1

2.9.3 Vegetation

The Pine Ridge area of Nebraska, as in the case of the adjacent Black Hills of South Dakota, is represented by two principal vegetation regions (Van Bruggen 1977). These are outlined briefly below:

1. Plains and Prairie Flora. This vegetation region is comprised of two sub-regions - the True Prairie Flora and the Great Plains Grassland Flora. The transition from True Prairie in the eastern part of the state to Great Plains Grassland westward is primarily a factor of reduced effective precipitation. Many species are common to both sub-regions. There is a general conformity in the composition of the plant cover. A dominance of grasses, absence of trees, rolling topography, and a characteristic xerophytic flora are the main features. Species occurring on the study area which tend to represent the True Prairie (Tall Grass) subregion are *Andropogon gerardi, Andropogon scoparius, Elymus canadensis, Poa pratensis, Amorpha canescens, Artemisia ludoviciana, Astragalus crassicarpus, Echinacea angustifolia, Onosmodium molle, Psoralea esculenta, Solidago missouriensis* and related. Species typical of the Great Plains Grassland (Shortgrass, Mid-grass) include *Bouteloua gracilis, Agropyron smithii, Buchloe dactyloides, Koeleria pyramidata, Allium textile, Artemisia frigida, Carex filifolia, C. eleocharis, Oxytropis lambertii, Penstemon albidus* and *Rosa arkansana*.

2. Rocky Mountain Forest Flora (Black Hills Montane Element). Although geographically separated from the Rocky Mountains, the Pine Ridge and Black Hills have affinities to this region, which lies principally 200 km to the west. Floral species suggest that the two areas were contiguous during Pleistocene times. Species on the study area typical of this region include *Berberis repens, Juniperus scopulorum, Pinus ponderosa, Calochortus nuttallii*, and *Gaillardia aristata*.

In addition to the above vegetation regions, there are several other plant communities which are noteworthy. Wooded Bottomlands display certain characteristics of the Eastern Deciduous Flora. Representative species include *Populus deltoides, Fraxinus pennsylvanica, Acer negundo, Salix amygdaloides, Salix exigua, Toxicodendron rydbergii, Ulmus americana*, and *Vitis riparia*.

Lakes, Ponds, and Prairie Potholes display a characteristic vegetation, including *Cicuta maculata, Equisetum hyemale, Scirpus validus, S. americanus, S. maritimus, Eleocharis erythropoda, Typha latifolia, Carex nebraskensis, Polygonum coccinia* and *Potamogeton pectinatis*.

The Great Basin Flora is sparsely represented in the northern portion of the study area, where saline conditions exist. Typical species include *Sarcobatus vermiculatus*, *Artemisia cana*, and several species of halophytic forbs.

The Circumpolar and Circumboreal Alpine Groups, well represented in the Black Hills, are poorly represented in the Pine Ridge area, due to the lower elevations and warmer summer temperatures, but species which occur include *Arnica rydbergii, Juniperus communis, and Epilobium angustifolium*.

A large number of Exotic Species occurs, representative of Europe, Asia, and elsewhere in North America. Indeed, as a result of cultivation and range rehabilitation, perhaps 30 percent of species and more than 50 percent of plant cover is comprised of exotics. Species which are conspicuously successful include *Bromus inermis, B. japonicus, B. tectorum, Melilotus officinalis, M. alba*, and a large number of the Brassicaceae, including the genera *Sisymbrium, Descrurainia, Thlaspi, Brassica*, and *Capsella*. Cultivated species include wheat, oats, rye, corn, milo and alfalfa.

Van Bruggen (1977) points out that the Black Hills / Pine Ridge region is not an area where endemics occur. If one assumes a less than conservative taxonomic interpretation of the species present, it is doubtful that any endemics are present in the Pine Ridge area.

Study Area Vegetation/Habitat Types

A vegetation classification system (Table 2.9-1) was derived for the study area, sufficient to include the flora within the 80-km Outer Area, taking into account regional precedents - terrestrial flora (Coenenberg et al. 1977), and wetlands (Stewart and Kantrud 1971), with particular reference to generating a system useful in identifying faunal habitat affinities. Individual habitat types are described briefly below:

Wetlands (000-009). These types correspond directly to those of Stewart and Kantrud (1971), with the addition of 008 (Dugouts) and 009 (Excavated Wetlands, usually abandoned gravel pits). All wetland types are represented within the 80-km Outer Area, but are poorly represented on the Study Area (CSA and AA). A few prairie potholes exist in the northern portion of the Study Area. Those are Temporary and Seasonal wetlands (Class II and III, resp.) representing wet meadow and shallow marsh vegetation types. One wetland (Class II - Wet Meadow) exists on the RAB site (Fig. 2.9-3). It consists of a small depression basin and "playa" of about 1.6 ha in size. During the heavy rains of May, 1982, it held water about 6 days. *Agropyron smithii* predominates.

TABLE 2.9-1

HABITAT CLASSIFICATION SYSTEM

000 - Wetlands (Closed Basin Features)

- 001 - Class I Wetland (Mixed Grass Prairie)
- 002 - Class II Wetland (Wet Meadow)
- 003 - Class III Wetland (Shallow Marsh Flora)
- 004 - Class IV Wetland (Deep Marsh Flora)
- 005 - Class V Wetland (Permanent Marsh)
- 006 - Class VI Wetland (Alkaline Lake)
- 007 - Class VII Wetland (Fen/Bog)
- 008 - Dugout
- 009 - Excavated Wetland

010 - Special Features

- 011 - Cliff
- 012 - Talus Slope, Scree
- 013 - Caves
- 014 - Marl Formation ("Badlands")

050 - Riverine Habitats (Open Basin and Drainage Features)

- 050 - Complex Riparian
- 051 - Mixed Grass Prairie Riparian
- 052 - Wet Meadow Riparian
- 053 - Shallow Marsh Riparian
- 054 - Deep Marsh Riparian
- 055 - Permanent Water - Streams and Rivers
- 056 - Alkaline Streambank
- 057 - Streamside Bog
- 058 - Stream Dugout
- 059 - Impoundments - Lakes and Ponds

100 - Woodlands

- 110 - Deciduous Streambank Forest
- 111 - Deciduous Basin Forest
- 120 - Deciduous "Wooded Draw" - Intermittent Drainages
- 130 - Tree Plantings - Orchards, Shelterbelts, Plantations
- 140 - Ponderosa Pine Forest
  - 141 - Ponderosa Pine / Juniper
  - 142 - Ponderosa Pine / Deciduous Woodland
  - 143 - Ponderosa Pine / Grassland
  - 144 - Ponderosa Pine / Shrubland
- 150 - Juniper
- 160 - Aspen

TABLE 2.9-1
(Continued)

HABITAT CLASSIFICATION SYSTEM

200 - Xerophytic Shrublands

- 211 - Big Sagebrush
- 212 - Big Sagebrush / Grassland
- 221 - Sand Sagebrush
- 222 - Sand Sagebrush / Grassland
- 231 - Sumac / Grassland
- 240 - Mixed Shrub / Half Shrub

300 - Mesophytic Shrublands

- 311 - Upland Drainage Seep
- 320 - Chionophilous Copse
- 330 - Flood Plain / Mud Flat Shrubland

400 - Grasslands

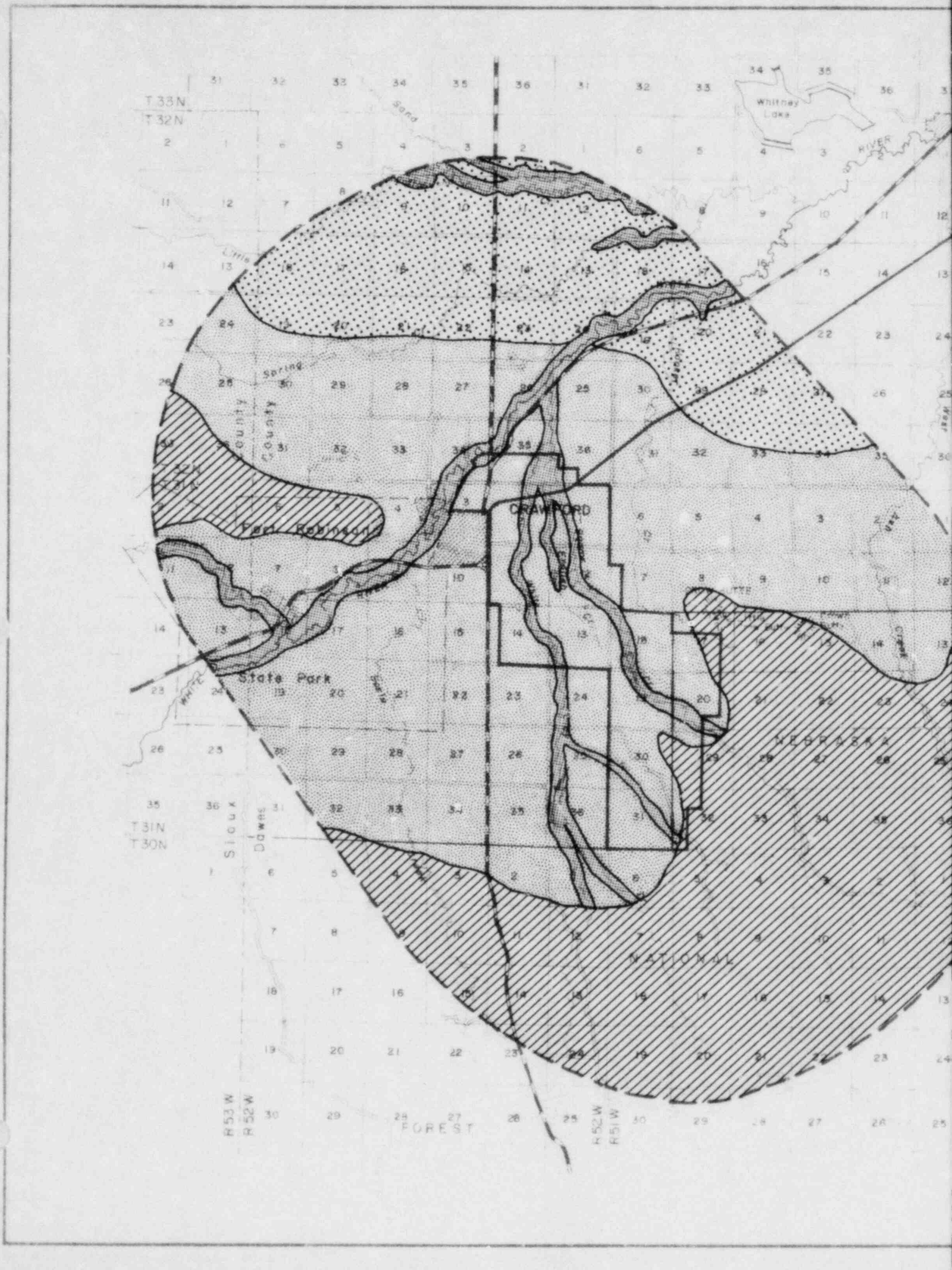
- 405 - Shortgrass Prairie
- 410 - Mixed Grass Prairie
- 420 - Range Rehabilitation

500 - Cultivated

- 510 - Grains
- 520 - Hay
- 530 - Root Crops
- 540 - Vegetables
- 550 - Fallow
  - 551 - Bare Ground / Summer Fallow
  - 552 - Annual Weed Complex

600 - Structure Biotopes

- 610 - Surface Disturbance Unreclaimed
- 611 - Surface Disturbance Reclaimed
- 630 - Human Biotopes - Towns, Buildings, Farmyards
- 640 - Cemeteries, Parks
- 650 - Roads and Roadside/Fencerow Complex



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Spring
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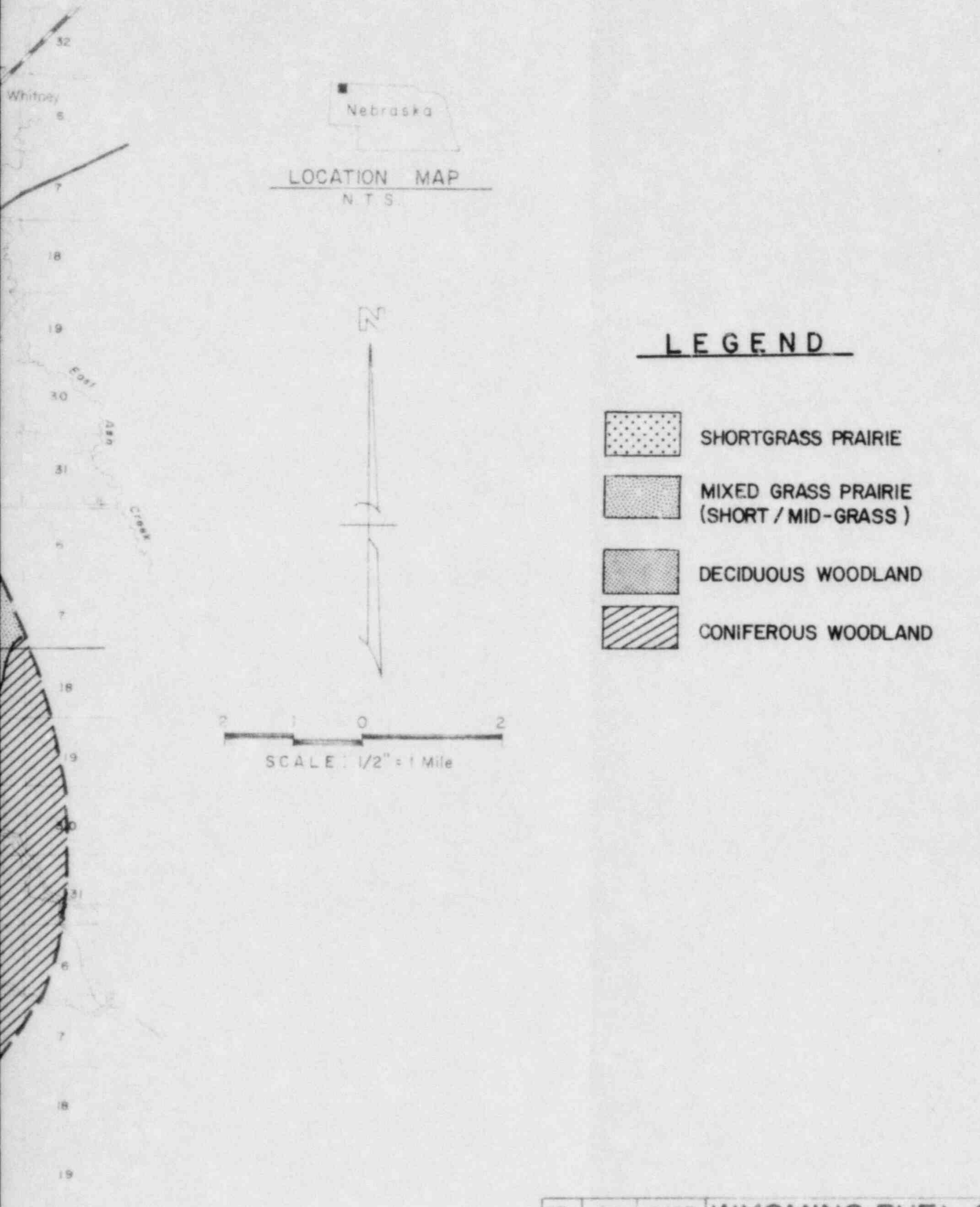

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TABLE 2.9-2

COMMERCIAL STUDY AREA HABITAT TYPES

Habitat Classification	Acreage	Hectares	Percent
002 (Wet Meadow)	4.07	1.65	0.05
051 (Mixed Prairie - Riparian)	119.65	48.42	1.38
052 (Wet Meadow - Riparian)	47.27	19.13	0.55
054 (Deep Marsh - Riparian)	23.50	9.51	0.27
055 (Riverine)	32.86	13.34	0.38
059 (Impoundment)	46.57	18.84	0.54
110 (Deciduous Streambank Forest)	510.43	206.56	5.89
130 (Shelterbelts, Tree Plantings)	27.27	11.04	0.31
140 (Ponderosa Pine)	325.85	131.86	3.76
410 (Mixed Grass Prairie)	2840.18	1149.42	32.74
420 (Range Rehabilitation)	1370.77	554.74	15.80
500 (Cultivated	2856.08	1155.86	32.92
610 (Surface Disturbance)	2.58	1.04	0.03
630 (Human Biotopes)	105.05	42.51	1.21
640 (Cemeteries)	5.02	2.03	0.06
650 (Roads and Roadside Complex)	356.55	144.30	4.11
Totals	8673.70	3510.25	100.00

TABLE 2.9-2A

RESEARCH AND DEVELOPMENT RESTRICTED AREA
HABITAT TYPES

Habitat Classification	Acreage	Hectares	Percent
051 (Mixed Prairie - Riparian)	13.30	5.40	16.6
110 (Deciduous Streambank Forest)	6.10	2.50	7.6
410 (Mixed Grass Prairie)	60.60	24.50	75.8
Totals	80.00	32.40	100.0

Special Features (010-014). Cliffs, rock outcrops and escarpments are common in the south, west, and east portions of the Study Area. Badlands, typical of out-croppings of the Pierre and Brule formations are encountered within the northeast portion of the Study Area. By definition, these are areas almost devoid of vegetation, except for a few representatives of the Mixed Grass element.

Riverine Habitats (050-059). These types directly correspond, floristically, to wetland types, and are discussed further in the Aquatic Ecology section (2.9.2).

Woodlands (100-160). The Deciduous Streambank Forest occupies streamside sites adjacent to all perennial streams and rivers of the Study Area, except where it has been destroyed by cultivation and/or grazing. *Populus deltoides* dominates throughout. Other species present include *Fraxinus pennsylvanica*, *Acer negundo*, *Ulmus americana*, *Salix amygdaloides*, *S. exigua*, *S. lucida*, *Prunus americana*, and *P. virginiana*. Understory vegetation varies greatly, depending primarily upon the amount of grazing which occurs. Where reasonable protection is afforded, such species as *Clematis ligusticifolia*, *Parthenocissus vitacea*, *Vitis riparia*, and *Bromus inermis* tend to predominate. Where heavy grazing has been conducted, the understory is characterized by *Urtica dioica*, *Toxicodendron rydbergii*, *Apocynum cannabinum*, *Euphorbia podperae*, *Croton texensis*, *Chorispora tenella*, *Bromus tectorum*, *Conium maculatum*, and other poisonous plants and noxious weeds.

Floristic characteristics of the Deciduous Basin Forest are identical to the above, but with floral zones representing moisture gradients and periods of shoreline inundation. This type is not represented within the Study Area proper, owing to the absence of sizeable wetland/lake basins.

The Deciduous Wooded Draw is similar to the Deciduous Streambank Type, but occupying, as it does intermittent upland drainages, is characterized by species with a greater tolerance to aridity. *Acer negundo*, for example, may predominate over *Populus deltoides*, and mesophytic shrubland species (below), such as *Shepherdia argentea*, are closely associated.

Tree Plantings are common on the Study Area, including the Commercial Study Area, but are absent from the Research and Development Restricted Area Boundary. Species most commonly selected for shelterbelts and farmyards are *Ulmus pumila*, *U. americana*, *Populus deltoides*, *Juniperus virginiana*, and to a much lesser extent, *Cornus stolonifera*, *Pinus ponderosa*, and *Salix* spp. Many shelterbelts are comprised exclusively of *Ulmus* spp., and are rapidly disappearing as a result of wide-spread disease.

The Ponderosa Pine (*Pinus ponderosa*) Complex dominates the highlands of the Study Area, but is not well represented at the lower elevations which characterize the Commercial Study Area. Ponderosa - Juniper (*P. ponderosa* - *Juniperus scopulorum*) is found on the more dissected terrain, growing on calcareous lithosols. Very few understory species are present. The type is not represented on the Commercial Study Area. Ponderosa Pine - Deciduous Woodland Type is the most complex on the Study Area, where the Deciduous Streambank flora penetrates the Ponderosa Pine Woodland flora at the middle to upper elevations. The Ponderosa Pine - Grassland occupies foothills and the plateaus at the higher elevations, above the level of the escarpments. Typical Mixed Grass meadows (below) are interspersed with the stands of pine. Understory species found in association with Ponderosa Pine throughout include *Thermopsis rhombifolia*, *Anemone patens*, *Galium boreale*, *Potentilla* spp., *Penstemon glaber*, and related species common to the Rocky Mountain element. Ponderosa Pine - Shrubland occurs sporadically on ridge-tops and southern exposures. Associated shrubs are few - predominantly *Rhus aromatica* var. *trilobata*, and *Ribes odorata*. The absence of well developed shrublands within the Ponderosa Type is not understood, but the role of fire in the past is probably responsible in large measure.

The Juniper Type (*Juniperus scopulorum*) is not represented on the primary Study Area, but pure stands, usually with few associated understory species, are found on lithosols to the north and west.

The Aspen Type (*Populus tremuloides*) is the rarest community on the Study Area, and is not found on the Commercial Study Area. One stand, consisting of about 20 trees, was found on a steep, shaded, northern exposure in West Ash Creek, about 4 km east of the Commercial Study Area. No regeneration is evident. The species probably constitutes a Pleistocene relict in the area, is at the extremity of its range, and will probably disappear over the next few decades.

<u>Xerophytic Shrublands</u> (200-240) are poorly represented on the Commercial Study Area, and are absent from the Research and Development Restricted Area Boundary, but are common in the northern por-

tion of the Outer Area. Big Sagebrush (*Artemisia tridentata*) and Big Sagebrush - Grassland form expansive communities about 30 km northwest of the Commercial Study Area.

Sand Sagebrush (*Artemisia filifolia*) and associated psammophytic flora are found on sandy soils throughout the Study Area, but expansive stands are absent from the Commercial Study Area. Rarely are stands of this species more than 1 ha in extent. Most often, the species is found along roadways in sandy areas.

Mesophytic Shrublands (300-330). The Upland Drainage Seep Type is comprised primarily of *Prunus americana, P. virginiana,* and *Shepherdia argentea*. These copses are found along intermittent water courses and upland plains sites with temporarily high water tables. The type is represented on the Commercial Study Area and Research and Development Restricted Area Boundary, but with stands usually less than 0.5 ha in extent. The Chionophilous Copse Type is comprised almost exclusively of *Symphoricarpos occidentalis*. The species typically occupies snow-accumulation sites on the downwind side of hills and escarpments, and reaches its greatest expansion on the plateaus at the higher elevations. It is poorly represented on the Commercial Study Area.

Grasslands (400-420). Characteristics of the grassland types were described earlier. Within the Study Area, the differentiation between the Shortgrass Type and the Mixed Grass Type could be made only on a subjective basis. The Shortgrass Type tends to be dominated by *Boulelous gracilis* and *Buchloe dactyloides*, whereas the Mixed Grass Type exhibits a more diverse grass component. In practice, differentiation was based on the presence or absence of Tall Grass species, e.g. *Andropogon scoparius*. Classification is complicated by the over-grazed nature of the range, whereby much of the Mixed Grass Type has been degraded and now takes on a Shortgrass aspect. Figs. 2.9-2 and 2.9-3 represent our estimation of potential grassland vegetation.

Range Rehabilitation areas are increasing in size, as lands within the Commercial Study Area are subjected to increasingly intensive management. Species most commonly selected for seeding are *Bromus inermis, Poa pratensis, Agropyron cristatum, A. pectiniforme, A. smithii, A. intermedium, A. elongatum,* and *Elymus* Spp. The quality and composition of the type varies greatly, depending upon the interval between seeding and grazing, and the intensity of the grazing. The aspect varies from pure to sparse grass stands, to annual weed complex or bare ground.

Cultivated (500-552). This type comprises about one-third of the Commercial Study Area. Winter wheat cultivation is the most common practice, typically with a 50 percent rotation (summer-fallow) pattern. Other crops include oats, barley, milo, rye, corn, alfalfa and small vegetable gardens. The northeast ¼ of the Research and Development Restricted Area Boundary section is presently under wheat production, and the southeast corner (ca. 5 ha) is in alfalfa.

Structure Biotopes (600-650). Man-made features other than cultivation include gravel pits, buildings and farmyards, parks, cemeteries, roads, highways, and roadside rights-of-way, and comprise about 5 percent of the Commercial Study Area and 5 percent of the Research and Development Restricted Area Boundary.

Research and Development Restricted Area Boundary

The northeast ¼ of Section 19 is under wheat cultivation. The Burlington - Northern railroad traverses the southwest ¼. The area southwest of the railroad is under alfalfa cultivation. An abandoned farmstead is located in the east-central portion of the section. The Old Crow Butte cemetery lies along the western boundary of the section. The remainder is in a natural, albeit degraded state - Deciduous Streambank Forest and Mixed Grass Prairie (Fig. 2.9-3). About 30 cattle graze the area from 1 May to 1 November.

Squaw Creek, which passes through Section 19, is characterized by steep, eroded banks, due to livestock trampling. The riparian forest is comprised chiefly of *Populus deltoides*, with a few specimens of *Fraxinus pennsylvanica* and *Acer negundo*. Copses of *Prunus virginiana* and *P. americana* occur along the watercourse as well. The bottomland vegetation is comprised principally of indicators of over-grazing - noxious weeds and poisonous plants - *Croton texensis, Euphorbia podperae, Urtica dioica, Galium aparine, Toxicodendron rydbergii*, and several members of the Brassicaceae. The Mixed Grass community, which comprises about 65 percent of the section, is in poor condition, but with a moderate to high plant cover. The most evident indicator of over-grazing is *Yucca glauca*, which is the aspect dominant over much of the site. Other indicators of disclimax conditions include high percentages of *Bromus tectorum, B. japonicus, Festuca octoflora, Opuntia fragilis, Carex filifolia, C. rossii, Oxytropis lambertii*, and various cushion plants - *Arenaria hookeri, Paronychia jamesii*, and *Phlox andicola*.

A preliminary estimate of grazing capacity of the range, in its present condition, based on experience elsewhere in the region, would suggest a proper stocking rate from 5-15 acres per animal-unit-month. Present stocking rates are about 1.7 acres per animal-unit-month, or about 3-8 times in excess of proper stocking rates, not uncommon for the area.

Plant Species List

According to the Great Plains Flora Association (1977), about 1,020 species of plants should be expected to occur within 80 km of the Commercial Study Area. The Chadron State College herbarium (Urbatsch and Eddy 1969) contains 468 species from Dawes County.

In the course of the current study, between March and mid-July, 1982, more than 400 species of plants were collected within the Study Area (RAB, CSA, AA). Of that number, 163 species were recorded within Section 19 (Table 2.9-3).

No species of the state or federal concern has been found on the Commercial Study Area or Research and Development Restricted Area Boundary. The species considered "most rare" was *Townsendia exscapa* (Easter-Daisy). About 20 specimens were observed on the site. The species, traditionally collected by pioneers during the Easter season, enjoys a wide distribution in the region, but is evidently nowhere abundant. The species does not merit considered as endangered or threatened. All other species are generally considered common to abundant in the region.

TABLE 2.9-3

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
EQUISETACEAE	
Equisetum laevigatum	Smooth Horsetail
PINACEAE	
Pinus ponderosa	Ponderosa Pine
RANUNCULACEAE	
Anemone patens	Pasque-flower
Clematis ligusticifolia	Western Clematis
Ranunculus abortivus	Early Wood Buttercup
Thalictrum dasycarpum	Purple Meadowrue
PAPAVERACEAE	
Argemone polyanthemos	Prickle Poppy
FUMARIACEAE	
Corydalis aurea	Golden Corydalis
ULMACEAE	
Ulmus americana	American Elm
Ulmus pumila	Siberian Elm
CANNABACEAE	
Humulus lupulus	Common Hop
URTICACEAE	
Urtica dioica	Stinging Nettle
CACTACEAE	
Coryphantha vivipara	Pincushion Cactus
Opuntia fragilis	Brittle Prickly Pear
CARYOPHYLLACEAE	
Arenaria hookeri	Hooker Sandwort
Cerastium arvense	Prairie Chickweed
Paronychia jamesii	James Nailwort
Stellaria media	Common Chickweed
CHENOPODIACEAE	
Chenopodium album	Lamb's-quarters
Chenopodium fremontii	Fremont Goosefoot
Chenopodium leptophyllum	Maple-leaved Goosefoot

TABLE 2.9-3
(Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
CHENOPODIACEAE	
Kochia scoparia	Kochia
Salsola iberica	Russian Thistle
AMARANTHACEAE	
Amaranthus graecizans	Tumbleweed
Amaranthus retroflexus	Rough Pigweed
POLYGONACEAE	
Polygonum convolvulus	Wild Buckwheat
Polygonum ramosissimum	Bushy Knotweed
MALVACEAE	
Malva rotundifolia	Common Mallow
Sphaeralcea coccinea	Red False Mallow
VIOLACEAE	
Viola canadensis	Canada Violet
Viola nuttallii	Yellow Prairie Violet
SALICACEAE	
Populus deltoides	Plains Cottonwood
Salix exigua	Coyote Willow
CAPPARACEAE	
Cleome serrulata	Rocky Mountain Beeplant
BRASSICACEAE	
Arabis holboellii	Rockcress
Brassica kaber	Charlock
Capsella bursa-pastoris	Shepherd's Purse
Chorispora tenella	Blue Mustard
Descurainia pinnata	Tansy Mustard
Descurainia sophia	Flixweed
Draba reptans	White Whitlowwort
Erysimum asperum	Western Wallflower
Erysimum repandum	Bushy Wallflower
Lesquerella ludoviciana	Bladderpod
Sisymbrium altissimum	Tumbling Mustard
Thlaspi arvense	Penny Cress

TABLE 2.9-3
(Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
PRIMULACEAE	
Androsace occidentalis	Western Rock Jasmine
SAXIFRAGACEAE	
Ribes odoratum	Buffalo Currant
ROSACEAE	
Prunus americana	Wild Plum
Prunus virginiana	Chokecherry
Rosa acicularis	Prickly Wild Rose
Rosa arkansana	Prairie Wild Rose
Rosa woodsii	Western Wild Rose
FABACEAE	
Astragalus gracilis	Slender Milkvetch
Astragalus missouriensis	Missouri Milkvetch
Lupinus argenteus	Silvery Lupine
Medicago falcata	Yellow Lucerne
Medicago sativa	Alfalfa
Melilotus alba	White Sweetclover
Melilotus officinalis	Yellow Sweetclover
Oxytropis lambertii	Purple Locoweed
Psoralea argophylla	Silver-leaf Scurf Pea
Psoralea esculenta	Breadroot Scurf Pea
Psoraela lanceolata	Lemon Scurf Pea
Vicia americana	American Vetch
ONAGRACEAE	
Gaura coccinea	Velvety Gaura
Oenothera caespitosa	Gumbo Lily
Oenothera nuttallii	White-stemmed Evening Primrose
CORNACEAE	
Comandra umbellata	Bastard Toadflax
EUPHORBIACEAE	
Croton texensis	Texas Croton
Euphorbia podperae	Leafy Spurge
VITACEAE	
Parthenocissus vitacea	Woodbine

TABLE 2.9-3
(Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
ACERACEAE	
Acer negundo	Box Elder
ANACARDIACEAE	
Rhus aromatica	Aromatic Sumac
Toxicodendron rydbergii	Poison Ivy
ZYGOPHYLLACEAE	
Tribulus terrestris	Puncture Vine
LINACEAE	
Linum perenne	Blue Flax
Linum rigidum	Stiffstem Flax
POLYGALACEAE	
Polygala alba	White Milkwort
APIACEAE	
Lomatium nuttallii	Wild Parsley
APOCYNACEAE	
Apocynum cannabinum	Hemp Dogbane
ASCLEPIADACEAE	
Asclepias speciosa	Showy Milkweed
SOLANACEAE	
Solanum rostratum	Buffalo Bur
CONVOLVULACEAE	
Convolvulus arvensis	Field Bindweed
Convolvulus sepium	Hedge Bindweed
POLEMONIACEAE	
Phlox andicola	Moss Phlox
BORAGINACEAE	
Cryptantha jamesii	James' Cryptantha
Lappula redowskii	Low Stickseed
Lithospermum incisum	Narrow-leaved Puccoon

TABLE 2.9-3
(Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
LAMIACEAE	
Mentha arvensis	Field Mint
Monarda pectinata	Spotted Beebalm
PLANTAGINACEAE	
Plantago patagonica	Buckhorn
OLEACEAE	
Fraxinus pennsylvanica	Green Ash
SCROPHULARIACEAE	
Penstemon albidus	White Beardtongue
Penstemon angustifolius	Narrow Beardtongue
Penstemon glaber	Smooth Beardtone
Penstemon grandiflorus	Large Beardtongue
Verbascum thapsus	Common Mullein
CAMPANULACEAE	
Campanula rotundifolia	Harebell
RUBIACEAE	
Galium aparine	Catchweed Bedstraw
CAPRIFOLIACEAE	
Symphoricarpos occidentalis	Western Snowberry
ASTERACEAE	
Achillea millefolium	Yarrow
Agoseris glauca	False Dandelion
Antennaria rosea	Rose Pussytoes
Artemisia campestris	Western Sagebrush
Artemisia frigida	Fringed Sagebrush
Artemisia ludoviciana	White Sage
Chrysopsis villosa	Golden Aster
Cirsium undulatum	Wavyleaf Thistle
Cirsium vulgare	Bull Thistle
Crepis runcinata	Hawk's-beard
Echinacea angustifolia	Purple Coneflower
Erigeron pumilus	Low Fleabane
Grindelia squarrosa	Curly-top Gumweed
Gutierrezia sarothrae	Broom Snakeweed

TABLE 2.9-3
(Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
ASTERACEAE	
Helianthus annuus	Common Sunflower
Helianthus petiolaris	Plains Sunflower
Lygodesmia juncea	Skeleton-weed
Ratibida columnifera	Prairie Coneflower
Rudbeckia hirta	Black-eyed Susan
Senecio plattensis	Prairie Ragwort
Taraxacum officinale	Dandelion
Townsendia exscapa	Easter Daisy
Tragopogon dubius	Goatsbeard
COMMELINACEAE	
Tradescantia occidentalis	Prairie Spiderwort
JUNCACEAE	
Juncus balticus	Baltic Rush
CYPERACEAE	
Carex filifolia	Thread-leaved Sedge
Carex hystericina	Bottlebrush Sedge
Carex lanuginosa	Wooly-headed Sedge
Carex nebraskensis	Nebraska Sedge
Carex rossii	Ross' Sedge
POACEAE	
Agropyron cristatum	Crested Wheatgrass
Agropyron intermedium	Intermediate Wheatgrass
Agropyron pectiniforme	Smooth Crested Wheatgrass
Agropyron smithii	Western Wheatgrass
Andropogon scoparius	Little Bluestem
Aristida longiseta	Red Threeawn
Bouteloua gracilis	Blue Grama
Bromus inermis	Smooth Brome
Bromus japonicus	Japanese Brome
Bromus tectorum	Cheatgrass
Buchloe dactyloides	Buffalo-grass
Cenchrus longispinus	Field Sandbur
Elymus canadensis	Canada Wild Rye
Festuca octoflora	Six-weeks Fescue
Hordeum jubatum	Foxtail Barley
Hordeum pusillum	Little Barley

TABLE 2.9-3
(Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
POACEAE	
Koeleria pyramidata	Junegrass
Oryzopsis hymenoides	Indian Ricegrass
Panicum capillare	Witchgrass
Poa compressa	Canada Bluegrass
Poa pratensis	Kentucky Bluegrass
Poa sandbergii (=*P. secunda*)	Sandberg Bluegrass
Setaria glauca	Yellow Foxtail
Setaria viridis	Green Foxtail
Sitanion hystrix	Squirreltail
Stipa comata	Needle-and-Thread
Stipa viridula	Green Needlegrass
Triticum aestivum	Wheat
LILIACEAE	
Allium textile	White Wild Onion
Calochortus nuttallii	Mariposa Lily
Leucocrinum montanum	Mountain Lily
Smilacina stellata	Spikenard
Yucca glauca	Yucca
Zigadenus venenosus	Death Camass
IRIDACEAE	
Sisyrinchium montanum	Blue-eyed Grass

No species of state or federal concerned has been found on the Permit Area or Pilot Plant site. The species considered "most rare" was *Townsendia exscapa* (Easter-Daisy). About 20 specimens were observed on the site. The species, traditionally collected by pioneers during the Easter season, enjoys a wide distribution in the region, but is evidently nowhere abundant. The species does not merit considered as endangered or threatened. All other species are generally considered common to abundant in the region.

2.9.2.4 Mammals

Domestic ungulates on the Commercial Study Area include cattle, horses, and swine (Table 2.9-4). Cattle management includes cow-calf operations on native range and range rehabilitation areas, winter pasturing, and feedlots. Cattle numbers on the Commercial Study Area range from about 600 to 900 seasonally. In addition, 30 horses and 80 swine are pastured and fed year-round.

Wild Mammals. Thirty-six species of mammals have been documented on the Study Area, and another 28 species, mostly bats, insectivores and small rodents, are deemed likely to occur (Table 2.9-5, 5A).

Big Game Mammals

Mule deer* are distributed primarily along the foothills and escarpments, ranging outward into cultivated land, and are occasionally found along watercourses at the lower elevations (Fig. 2.9-4). During the period 1 January - 15 July 1982, 853 observations of the species were recorded within the Study Area (Table 2.9-6).

The preferred habitat type during the observation period was Cultivation, with about 58 percent of deer recorded in the type. This reflects a high proportion of mule deer occurring in winter wheat fields during the period January - April. Indeed, it was determined that mule deer on the Study Area rely very heavily, and in some cases exclusively, on winter wheat during the late winter period. This is doubtlessly due to the relative absence of well developed shrub communities - typical winter range for the species elsewhere in the region.

Utilization of winter wheat, and the tendency of utilize haystacks in some areas, has been noted by area farmers and ranchers, who commonly voice complaints about deer damage - complaints which are reported in the local press, e.g. "Plague of hay-eating deer herds costs area ranchers plenty." (Page 1, The Crawford Tribune, 17 February 1982.

Group size during the period ranged from 1-39, with largest aggregations observed in March, in winter wheat fields. In May there was a general dispersal of deer into the upper elevations and away from cultivated types. Smallest group size ($\bar{x}$ = 1.7) was observed in June. First fawns were seen in early July.

*Scientific names are included in the faunal species lists.

TABLE 2.9-4

DOMESTIC LIVESTOCK NUMBERS, COMMERCIAL STUDY AREA

Landowner	Cattle	Horses	Swine
Moore	160 (Year-round)	10 (Year-round)	
Taggert	34 (1May-1Nov)		
Franey	59 (1May-1Nov) 80 (1Nov-1May)		
Rising/ McDowell	69 (1May-1Nov) 180 (1Nov-1May)		
Brott	70 (Year-round)		
Stetson	76 (1May-1Nov) 30 (1May-1Nov)*		
Dodd	190 (1Nov-1May)		
Roby	30 (1May-1Sep) 100 (Year-round)		
Lux	130 (1Feb-1May)		
Gibbons	100 (Year-round)		
Ehlers		30 (Year-round)	80 (Year-round)
Totals	~910 (Winter) ~598 (Summer)	40 (Year-round)	80 (Year-round)

* Present on Section 19

TABLE 2.9-5

MAMMAL SPECIES LIST

Common Name	Scientific Name	Status
INSECTIVORA		
Masked Shrew	*Sorex cinereus*	E-CA-U
Dwarf Shrew	*Sorex nanus*	E-CA-U
Merriam Shrew	*Sorex merriami*	E-AA-U
Least Shrew	*Cryptotis parva*	E-CA-U
Eastern Mole	*Scalopus aquaticus*	D-CA-U
CHIROPTERA		
Keen Myotis	*Myotis keeni*	E-CA-U
Little Brown Myotis	*Myotis lucifugus*	E-RA-C
Fringed Myotis	*Myotis thysanodes*	E-CA-U
Long-eared Myotis	*Myotis evotis*	E-CA-U
Long-legged Myotis	*Myotis volans*	E-CA-U
Small-footed Myotis	*Myotis subulatus*	E-CA-U
Silver-haired Bat	*Lasionycteris noctivagans*	E-CA-U
Red Bat	*Lasiurus borealis*	E-AA-U
Big Brown Bat	*Eptesicus fuscus*	E-CA-C
Hoary Bat	*Lasiurus cinereus*	E-CA-U
Western Big-eared Bat	*Plecotus townsendi*	E-AA-U
CARNIVORA		
Raccoon	*Procyon lotor*	D-RA-C
Long-tailed Weasel	*Mustela frenata*	D-CA-U
Mink	*Mustela vison*	D-AA-U
Black-footed Ferret	*Mustela nigripes*	?E-OA-F?
Badger	*Taxidea taxus*	D-AA-U
Spotted Skunk	*Spilogale putorius*	E-AA-U
Striped Skunk	*Mephitis mephitis*	D-RA-C
Coyote	*Canis latrans*	D-CA-U
Swift Fox	*Vulpes velox*	R-AA-S
Red Fox	*Vulpes fulva*	D-RA-U
Bobcat	*Lynx rufus*	D-AA-U
Mountain Lion	*Felis concolor*	R-OA-U
RODENTIA		
Black-tailed Prairie Dog	*Cynomys ludovicianus*	D-CA-U
Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*	D-RA-C
Spotted Ground Squirrel	*Citellus spilosoma*	D-OA-U
Least Chipmunk	*Eutamias minimus*	D-AA-U
Eastern Fox Squirrel	*Sciurus niger*	D-RA-C
Northern Pocket Gopher	*Thomomys talpoides*	D-RA-C
Plains Pocket Gopher	*Geomys bursarius*	E-CA-U

TABLE 2.9-5
(Continued)

MAMMAL SPECIES LIST

Common Name	Scientific Name	Status
RODENTIA		
Wyoming Pocket Mouse	*Perognathus fasciatus*	E-CA-U
Plains Pocket Mouse	*Perognathus flavescens*	E-CA-U
Silky Pocket Mouse	*Perognathus flavus*	E-CA-U
Hispid Pocket Mouse	*Perognathus hispidus*	E-CA-U
Ord Kangaroo Rat	*Dipodomys ordii*	D-CA-C
Beaver	*Castor canadensis*	D-AA-U
Plains Harvest Mouse	*Reithrodontomys montanus*	E-CA-U
Western Harvest Mouse	*Reithrodontomys megalotis*	E-CA-U
White-footed Mouse	*Peromyscus leucopus*	D-CA-C
Deer Mouse	*Peromyscus maniculatus*	D-CA-A
Northern Grasshopper Mouse	*Onychomys leucogaster*	E-CA-U
Eastern Woodrat	*Neotoma floridana*	E-AA-U
Bushy-tailed Woodrat	*Neotoma cinerea*	E-AA-U
Brown Rat	*Rattus norvegicus*	E-CA-U
House Mouse	*Mus musculus*	D-CA-C
Meadow Vole	*Microtus pennsylvanicus*	D-CA-C
Prairie Vole	*Microtus ochrogaster*	D-CA-U
Muskrat	*Ondatra zibethicus*	D-CA-C
Meadow Jumping Mouse	*Zapus hudsonicus*	D-CA-U
Porcupine	*Erethizon dorsatum*	D-CA-C
LAGOMORPHA		
White-tailed Jackrabbit	*Lepus townsendi*	D-RA-C
Black-tailed Jackrabbit	*Lepus californicus*	D-RA-U
Eastern Cottontail	*Sylvilagus floridanus*	D-RA-C
Desert Cottontail	*Sylvilagus auduboni*	?D-AA-U?
ARTIODACTYLA		
Mule Deer	*Odocoileus hemionus*	D-RA-C
White-tailed Deer	*Odocoileus virginianus*	D-RA-C
Pronghorn	*Antilocapra americana*	D-AA-C
Wapiti (Elk)	*Cervus elaphus*	D-AA-U
Bighorn Sheep	*Ovis canadensis*	D-AA-U
Bison	*Bison bison*	D-AA-C
Moose	*Alces alces*	R-OA-U
Mule Deer / White-tailed Deer Hybrid	*O. hemionus* x *virginianus*	D-AA-U

(See Table 2.9-5A for Status Codes)

TABLE 2.9-5A

FAUNAL SPECIES LIST - STATUS CODES

Column 1 - Documentation

D - Documented in the course of the present study

R - Reported by knowledgeable individual(s)

E - Expected to occur - historical or recent evidence

Column 2,3 - Distribution

RA - Within the Restricted Area Boundary

CA - Within the Commercial Study Area Boundary

AA - Within the 8-km Adjacent Area Boundary

OA - Within the 80-km Outer Area Boundary

Column 4 - Abundance

A - Abundant

C - Common

U - Uncommon

O - Occasional, Accidental, or Rare in the study area

F - Federally-listed Rare, Threatened, or Endangered

S - State-listed Rare, Threatened, or Endangered

Column 5,6 - Migratory Status (Birds Only)

pr - permanent resident

sr - summer resident

sv - summer visitor

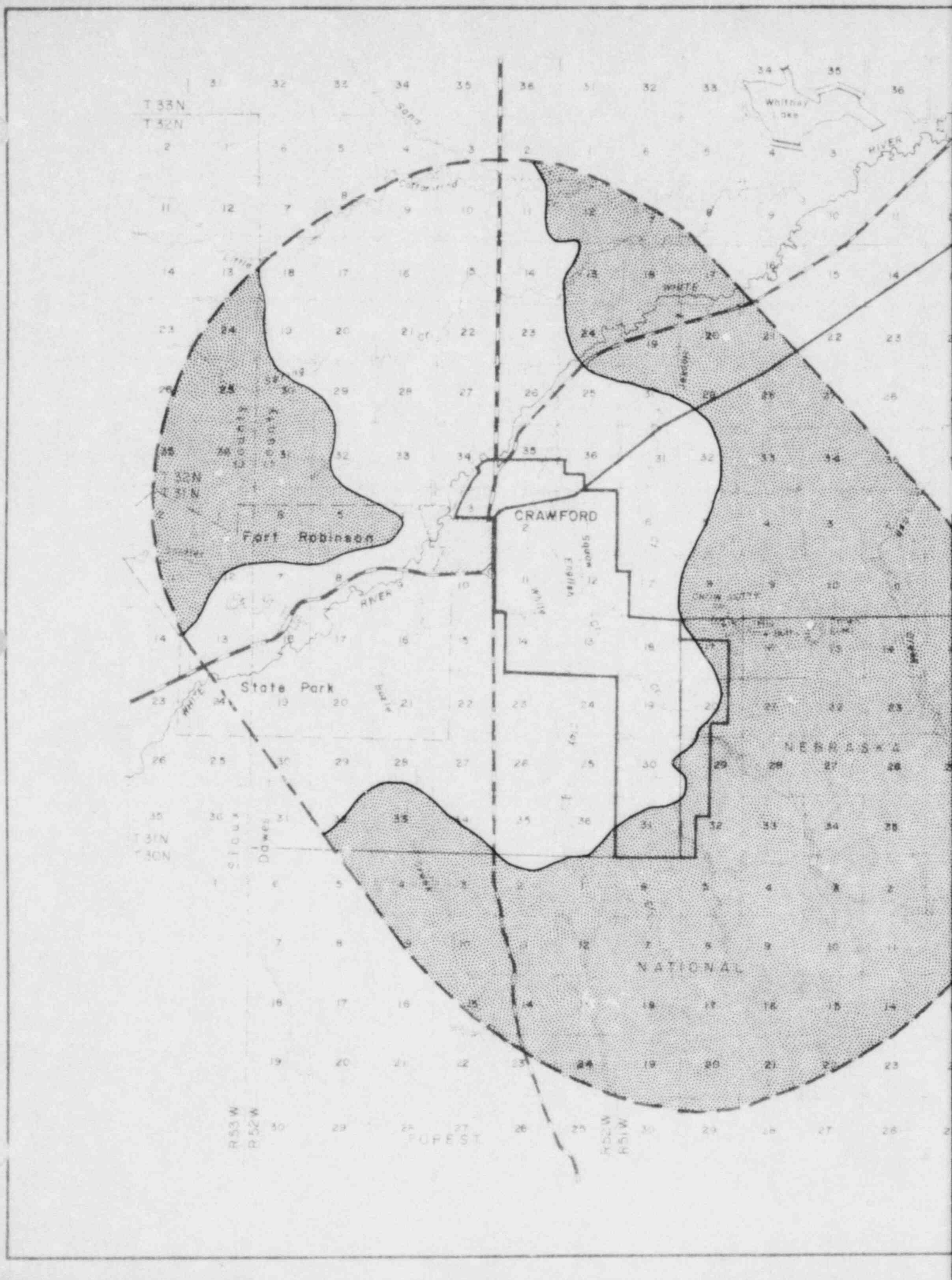
wv - winter visitor

m - migrant

Column 7,8 - Breeding Status (Birds Only)

* - confirmed breeder

** - suspected breeder



T33N
T32N
T32N
T31N
T31N
T30N
Whitney Lake
RIVER
WHITE
Cottonwood
Little
Fort Robinson
CRAWFORD
RIVER
State Park
NEBRASKA
NATIONAL
FOREST
Dawes
Sioux
R53W
R52W
R52W
R51W

LEGEND

PRIMARY MULE DEER RANGE

REV	BY	DATE	
			WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			MULE DEER DISTRIBUTION
			PREPARED BY F. Harrington & Assoc.
			DWN. BY D&D Graphics DATE 8-1-82 FIG. 2.9-4

TABLE 2.9-6

BIG GAME MAMMAL HABITAT AFFINITIES

Species	Deciduous Woodlands Obs	(%)	Coniferous Woodlands Obs	(%)	Mesophytic Shrublands Obs	(%)	Shortgrass Prairie Obs	(%)	Mixed Grass Prairie Obs	(%)	Range Rehab. Obs	(%)	Cultivated Obs	(%)	Structure Biotopes Obs	(%)	Totals Obs	(%)
Mule Deer																		
CSA*	18	(75.0)							2	(8.3)			4	(16.7)			24	(100.0)
Total Area	132	(15.4)	53	(6.2)					106	(12.4)	57	(6.7)	492	(57.7)	13	(1.5)	853	(100.0)
White-tailed Deer																		
CSA*	39	(37.9)							4	(3.8)	6	(5.8)	54	(52.4)			103	(100.0)
Total Area	480	(55.8)	23	(2.6)	14	(1.6)			160	(18.6)	31	(3.6)	141	(16.3)	10	(1.1)	860	(100.0)
Pronghorn																		
CSA*	(NOT PRESENT ON COMMERCIAL STUDY AREA)																0	(0.0)
Total Area							109	(22.1)	242	(49.1)	126	(25.6)	13	(2.6)	3	(0.6)	493	(100.0)

*CSA (Commercial Study Area)

Distribution of mule deer within the Commercial Study Area was slight, with only 3 percent of observations recorded there. In contrast to the Study Area proper, most mule deer on the Commercial Study Area (75%) were documented in Deciduous Streambank habitat - primarily along Squaw Creek in the southeast portion of the Commercial Study Area and adjacent to the Ponderosa Wildlife Area.

Only two Mule deer (0.2%) were observed within Section 19, adjacent to the RAB - a female and yearling in May. The site does not afford high quality habitat for this species.

White-tailed deer were distributed more widely than mule deer (Fig. 2.9-5), and were recorded in a greater range of habitat types (Table 2.9-6). Most commonly utilized habitats, however, were the Deciduous Woodland types.

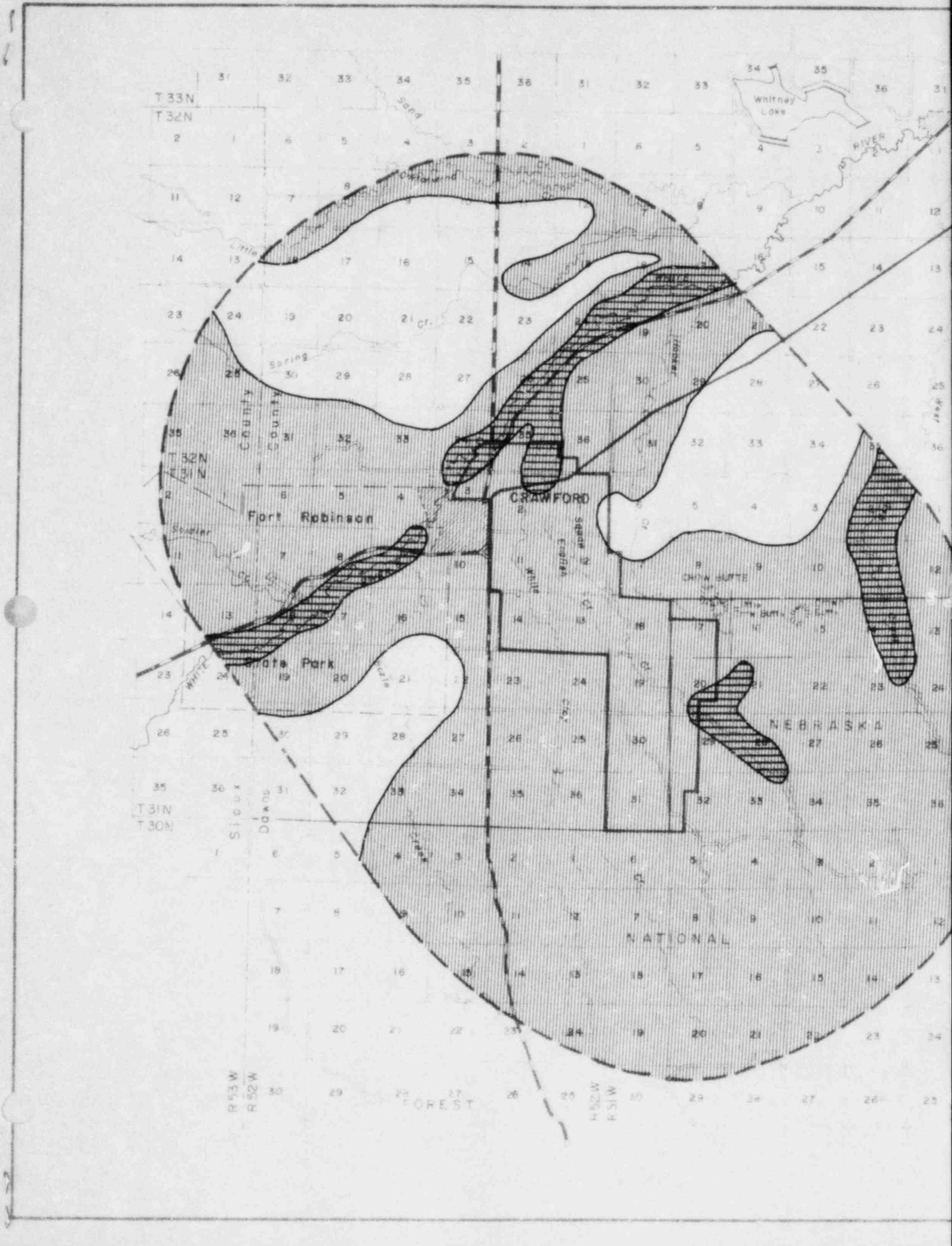
Herd size ranged from 1-42, with largest aggregations seen in February. During the late winter months, the deer displayed a "yarding" tendency, typical for the species, with concentrations occurring in wooded bottomlands. Like mule deer, whitetails made considerable use of winter wheat fields, but about equal use was made of winter annual forbs within the Deciduous Streambank Forest type and adjoining meadows.

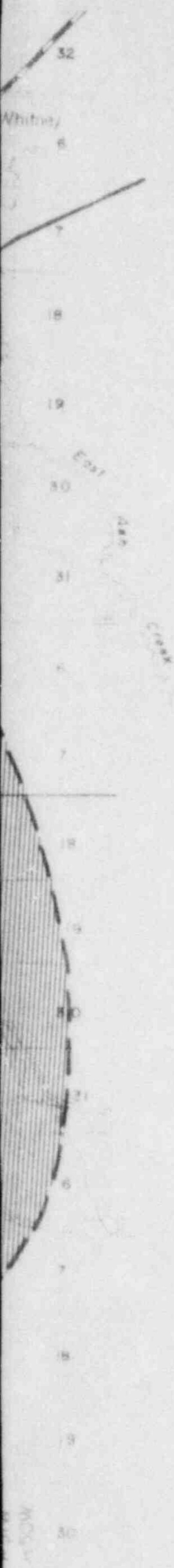
In May a general dispersal was observed, with deer moving into upland drainages, although a large percentage remained along the lower watercourses. First fawns were seen in late June.

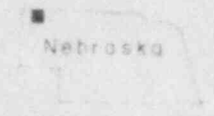
Compared to mule deer, whitetails were more commonly observed on the Commercial Study Area, with 12 percent of observations recorded there. Greatest use of the Commercial Study Area was observed in Woodland and Cultivated types along the lower portions of English, Squaw, and White Clay Creeks, in the northern portion of the Commercial Study Area.

Only one (0.1%) white-tailed deer, a female, was observed within the Research and Development Restricted Area Boundary, in May. Habitat on the site is marginal for the species.

Pronghorn were distributed in three separate populations on the Study Area (Fig. 2.9-6). During the study period, the "Fort Robinson" population, consisting of 12 animals, ranged in and out of the Park, northward to the outskirts of the town of Crawford. This population was restricted primarily to the Mixed Grass Type (Table 2.9-6).


T33N
T32N
Whitney Lake
RIVER
Sand
Little
Spring
Cr.
County
County
T32N
T31N
Fort Robinson
CRAWFORD
Soldier
State Park
White
White
English
Squaw
China Butte
Hooker
NEBRASKA
Sioux
Dawes
T31N
T30N
NATIONAL
FOREST
R53W
R52W
R52W
R51W





LOCATION MAP
N.T.S.

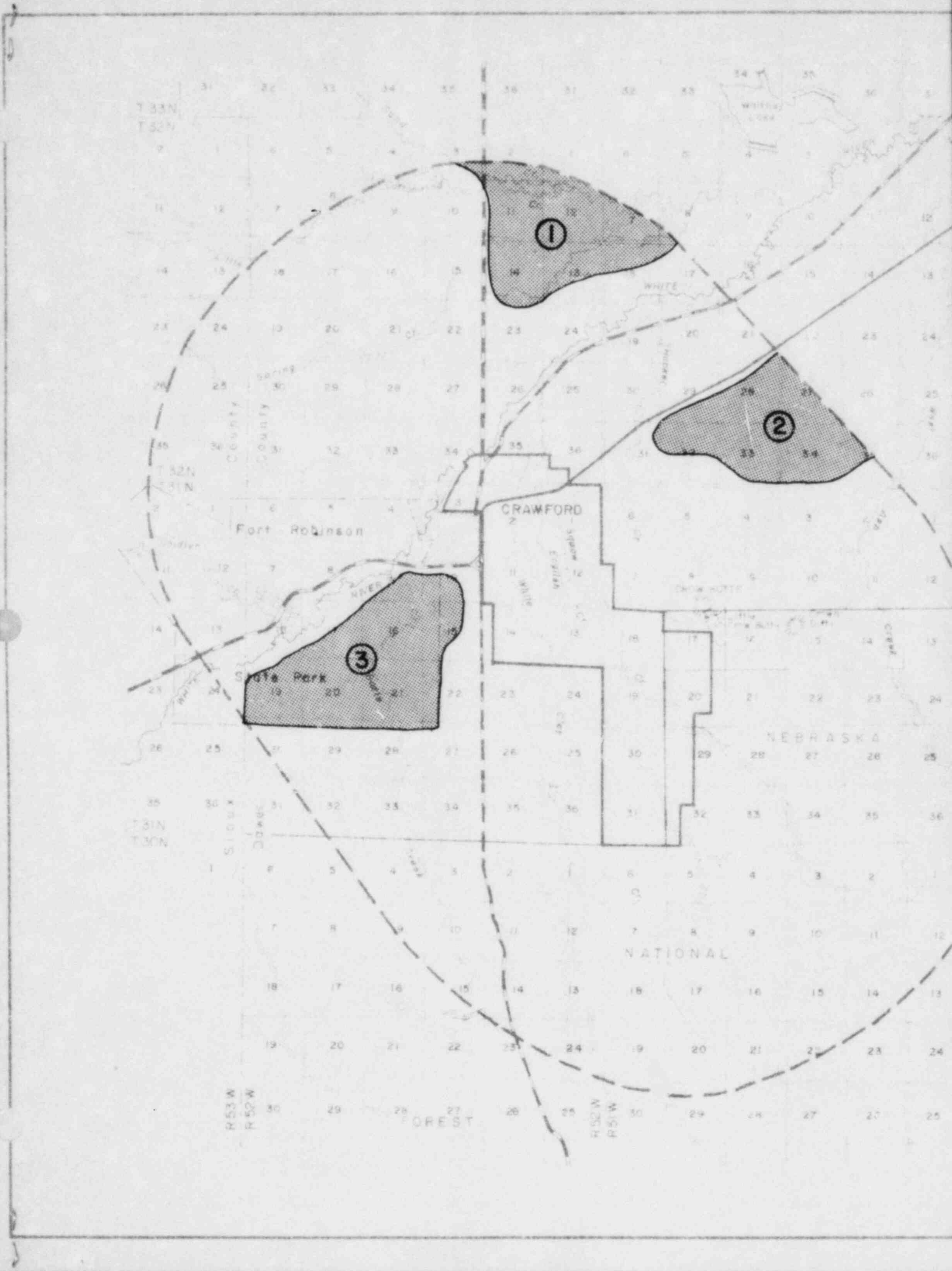
SCALE: 1/2" = 1 Mile

LEGEND

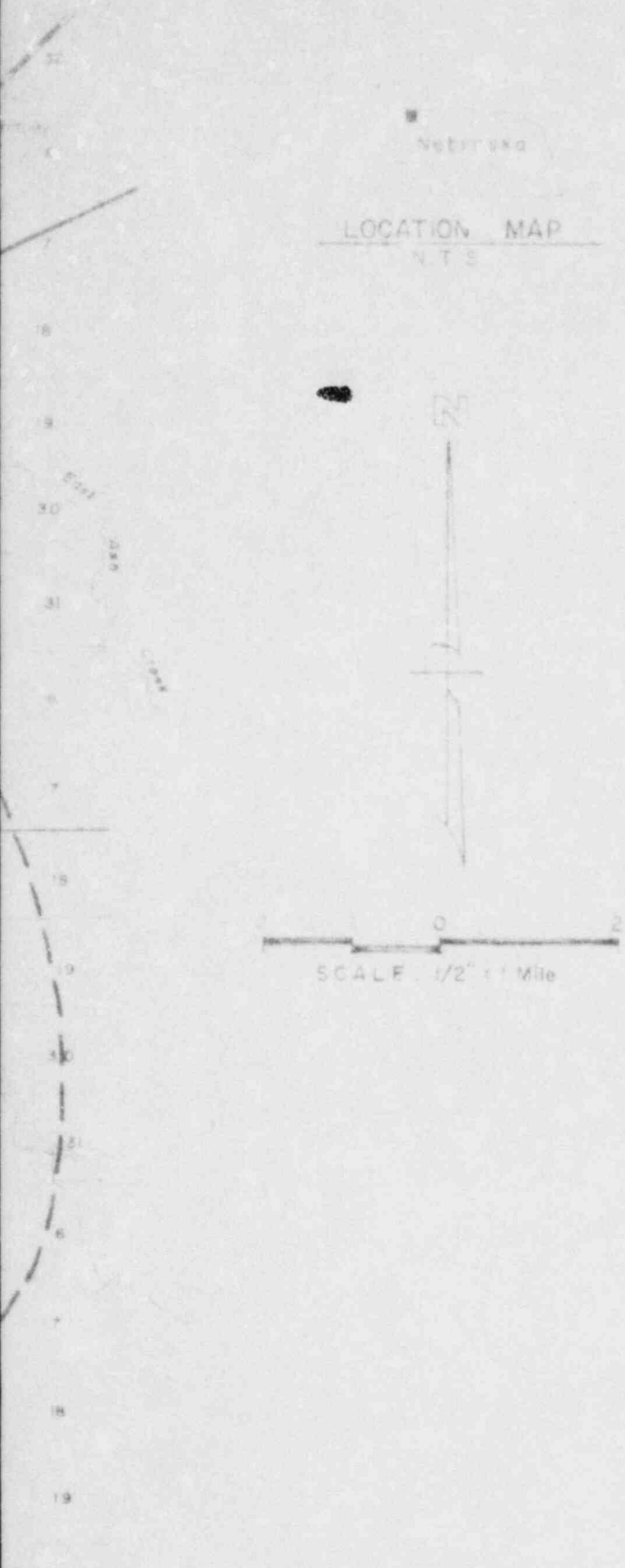
PRIMARY DISTRIBUTION

WINTER CONCENTRATION AREAS

REV	BY	DATE	
			WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			WHITE-TAILED DEER DISTRIBUTION
			PREPARED BY F. Harrington & Assoc.
			DWN BY D&D Graphics DATE 8-1-82 FIG. 2.9-5



T33N
T32N
T32N
T31N
T31N
T30N
R53W
R52W
R52W
R51W
CRAWFORD
Fort Robinson
State Park
NEBRASKA
NATIONAL
FOREST
WHITE
Sioux
Dawes
County
County
1
2
3



LEGEND

LIMITS OF PRONGHORN DISTRIBUTION

① "NORTHERN" POPULATION

② "EASTERN" POPULATION

③ "FORT ROBINSON" POPULATION

REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			PRONGHORN DISTRIBUTION
			PREPARED BY: F. Harrington & Assoc.
			DWN BY: D&D Graphics DATE: 8-1-82 FIG. 2.9-6

The "eastern" population ranged along the plains and foothills south of the White River, in Mixed Grass and Shortgrass habitat, eastward to perhaps the city of Chadron. A maximum number of 7 was recorded on the Adjacent Area during the study period.

A large population of pronghorn ("northern" population), ranges over the Shortgrass prairie from the edge of the Adjacent Area northward to the foothills of the Black Hills. Preferred winter habitat of the species would appear to be sagebrush communities, more commonly found outside the Study Area to the north. During the winter months, however, herds of up to 70 ranged along the northern edge of the Study Area. In spring, there was a northward dispersal, with fewer than 10 animals remaining on the Study Area. Within the Study Area, about 96 percent of observations were recorded in the Grassland Types - Shortgrass, Mixed Grass, and Range Rehabilitation.

Pronghorn were not recorded on the Commercial Study Area or Research and Development Restricted Boundary Area, owing to the absence of expansive plains habitat.

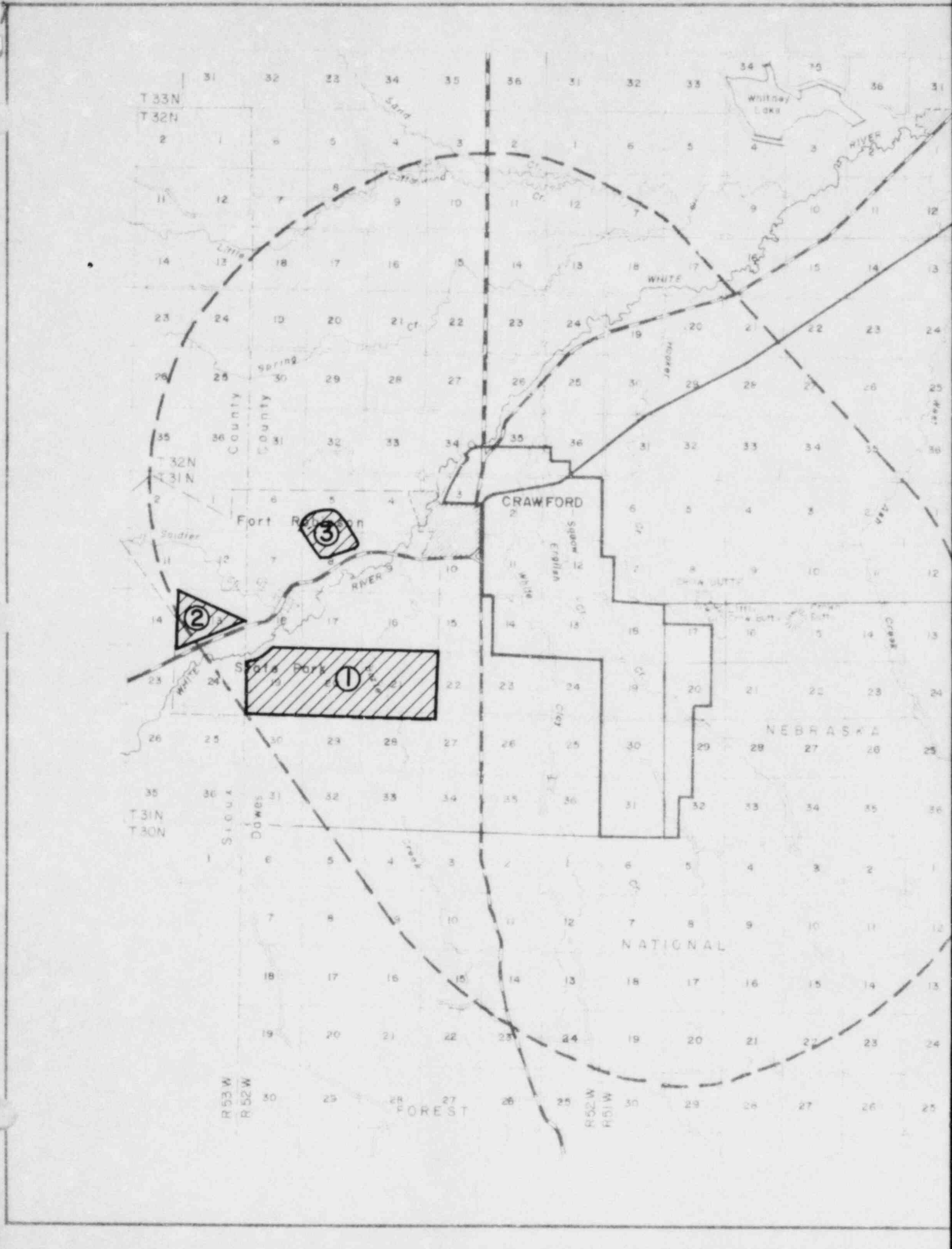
Captive Ungulates. About 200 bison are impounded at Fort Robinson State Park in two seasonal compounds encompassing Mixed Grass habitat (Fig. 2.9-7). The animals are maintained as a tourist attraction, but are also cropped and offered as fare in the Park dining room and evening "buffalo cook-outs".

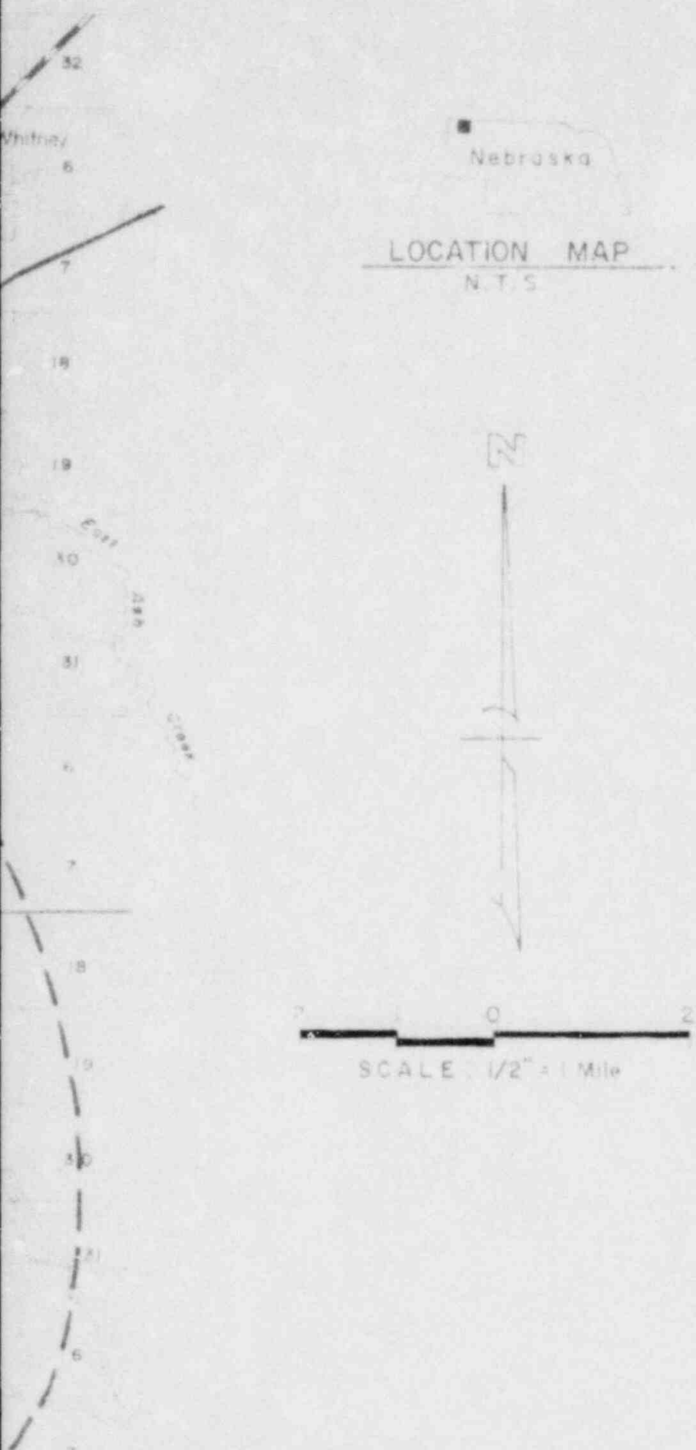
Wapiti (8) and bighorn sheep (22) are maintained in a separate compound (Fig. 2.9-7), consisting of Cliff, Ponderosa-Grassland, and Mixed Grass Habitat types. In the course of the study, one female wapiti was observed outside the compound to the north - either an escapee or a free-ranging animal attracted to the captive population. Free ranging wapiti occur in the Black Hills to the north, and have been reported just east of the Study Area along the Pine Ridge escarpment.

One bighorn ram was reported west of the compound, and another found dead (shot) two years previously (J. Murphy, pres. comm.).

One cow moose, evidently a migrant from Wyoming, was observed for a number of years west of Fort Robinson, but the species does not occur regularly in the Pine Ridge area.

Neither bison, wapiti, bighorn sheep, nor moose occur on the Commercial Study Area, nor are they expected to occur there.


T 33N
T 32N
Whitney Lake
Sand
Cottonwood
Cr.
RIVER
Little
WHITE
Spring
Cr.
Hooker
Sioux County
Dawes County
T 32N
T 31N
CRAWFORD
Fort Robinson
Soldier
RIVER
White
English
Squaw
Cr.
Crow Butte
Little Crow Butte
Pelican Butte
Creek
State Park
WHITE
Clay
NEBRASKA
T 31N
T 30N
Sioux
Dawes
Creek
Cr.
NATIONAL
R53W
R52W
FOREST
R52W
R51W
1
2
3



LEGEND

1. BISON WINTER COMPOUND
2. BISON SUMMER COMPOUND
3. BIGHORN SHEEP, WAPITI COMPOUND

REV	BY	DATE	WYOMING FUEL COMPANY	
			CROW BUTTE PROJECT Dawes County, Nebraska	
			CAPTIVE UNGULATES Bison, Bighorn Sheep, Wapiti (Fort Robinson)	
			PREPARED BY: F. Harrington & Assoc.	
			DWN BY: D&D Graphics DATE: 8-1-82	FIG. 2.9-7

Carnivores

Populations of carnivores on the Study Area are conspicuously low, compared to studies using similar methods elsewhere in the region. A number of factors is believed to contribute to the relatively low numbers - 1) a federal predator control agent has been operating in the area, 2) trapping by area residents is conducted intensively throughout the area, 3) landowners routinely kill all carnivores encountered, 4) state officials trap on state lands as a matter of routine.

The most commonly observed carnivore on the Study Area was the feral house cat, occurring widely and in a ratio of 5 cats per wild conivore observed (estimated ratio - records for this species were not kept until well into the study).

Coyotes range widely throughout the Study Area in low numbers, with most observations in the western portion of the Study Area. Preferred habitats were grasslands (Table 2.9-7). An individual, believed to be a young male, was observed regularly in the central portion of the Commercial Study Area. The species was not recorded on the Research and Development Restricted Area Boundary, but can be expected to range over the site in search of suitable prey - jackrabbits and rodents.

Red foxes were observed primarily in cultivated habitat (Table 2.9-7). Tracks of the species, however, suggested that they ranged to some degree throughout the Study Area. Two dens were located north of the Commercial Study Area, with 5 and 3 pups, resp. The former den, and presumably its occupants, were destroyed by the landowner. Red foxes were not observed on the Restricted Area Boundary side, but tracks suggested that the species regularly ranges over the site, primarily in association with stands of Yucca, which affords plentiful denning opportunities for rodents.

Tracks of bobcats were observed at widely spaced locations in Deciduous and Coniferous Woodland types within the Adjacent Area. An individual was documented dead on the highway in the southern portion of the AA. The species is relatively uncommon in the area and was not documented on or adjacent to the RAB.

Striped skunks were seen primarily in roadside situations, but judging from tracks the species occurs throughout the Study Area, including the RAB, in low numbers.

Long-tailed weasels are widely distributed in a variety of habitats, judging from tracks presumably of this species. An individual was found dead on the highway in the southern portion of the Adjacent Area. The species was not documented on the Restricted Area Boundary, but can be expected to occur there in proportion to the seasonal populations of small mammals.

Evidence of badgers was recorded on the edge of the Study Area, north of Little Cottonwood Creek. The species can be reasonably expected to occur on the RAB, in low numbers.

Tracks of the single mink were observed along the White River within Fort Robinson State Park. The species is relatively rare in the area and probably restricted to the larger streams.

Threatened and Endangered Carnivores which may occur in the region include swift fox (state-designated) and black-footed ferret (federally-designated). The most recent record of a swift fox on the Study Area was an unconfirmed sighting by a highway patrolman about 6 km northeast of the Commercial Study Area in 1980. That would place the record, if valid, in Shortgrass habitat, typical habitat for the species. The former area conservation officer, who has trapped in the area for 40 years, reported seeing only one swift fox specimen - an individual taken near Horn (about 10 km northwest of the CSA) about 30 years previously. The species was not confirmed in the course of the study. Swift foxes, however, might be expected to occur in low numbers anywhere within the grassland habitat within the region. Protection of the species would appear to be problematic in the local area, however, given the intensity of trapping and poisoning, including that conducted by state and federal officials.

The black-footed ferret was last observed in the state north of the Study Area in 1959 (USFS 1978). Its principal prey, prairie dogs, are uncommon on the Study Area. The two colonies, and a single observation on the CSA (Fig 2.9-8) are probably insufficient to sustain a viable ferret population. The Research and Development Restricted Area Boundary site does not contain typical habitat for the species.

Other Mammals

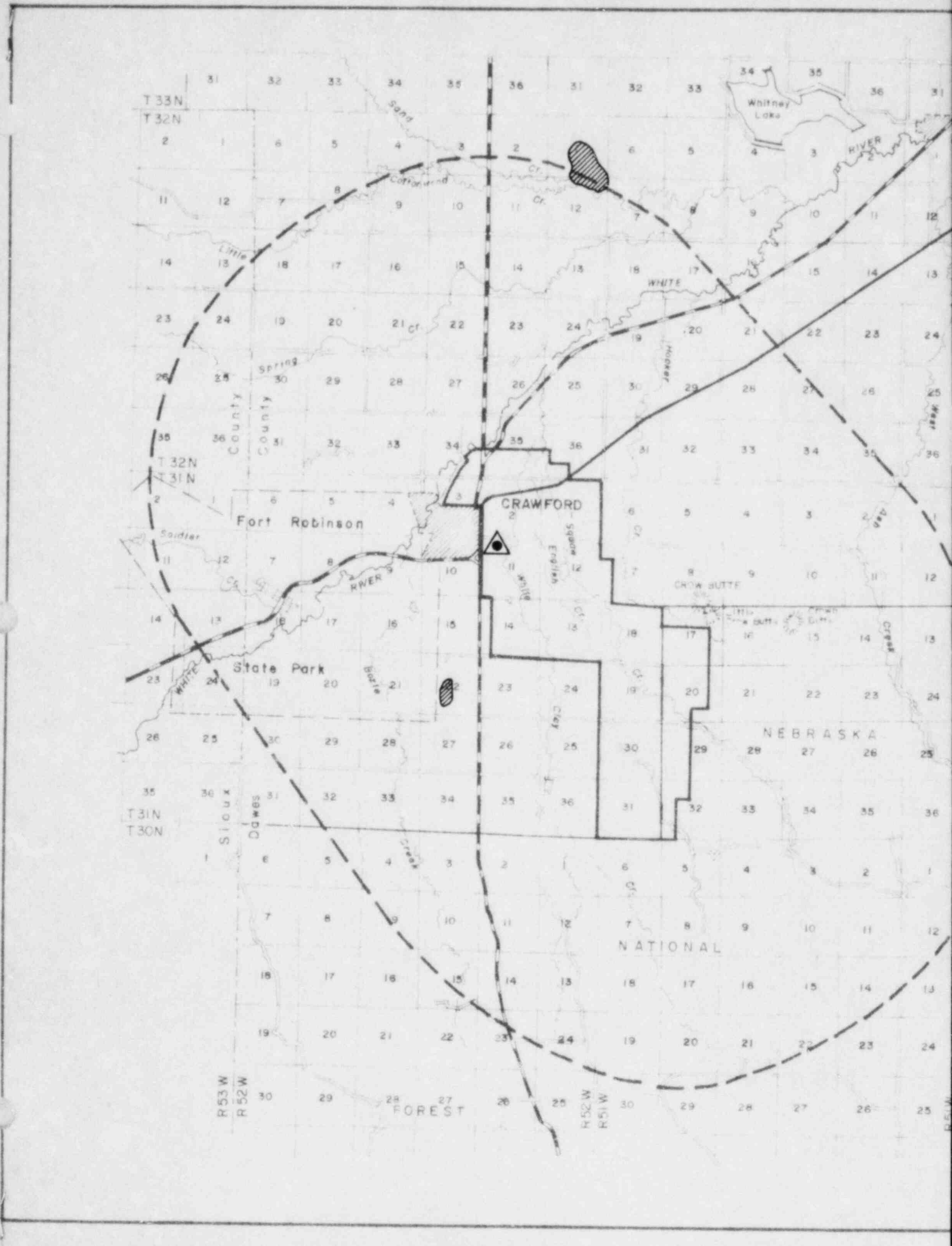
Small mammal live-trapping was conducted during the spring season (Table 2.9-8). The most ubiquitous species, and the most abundant, was the deer mouse, occurring at every sampling site. Other species captured included white-footed mouse, thirteen-lined ground squirrel, and meadow mole. Greatest densities (0.16 per trap-night) were recorded in the Lower Wooded Riparian transect, and lowest (0.01 per trap-night) in the Non-wooded

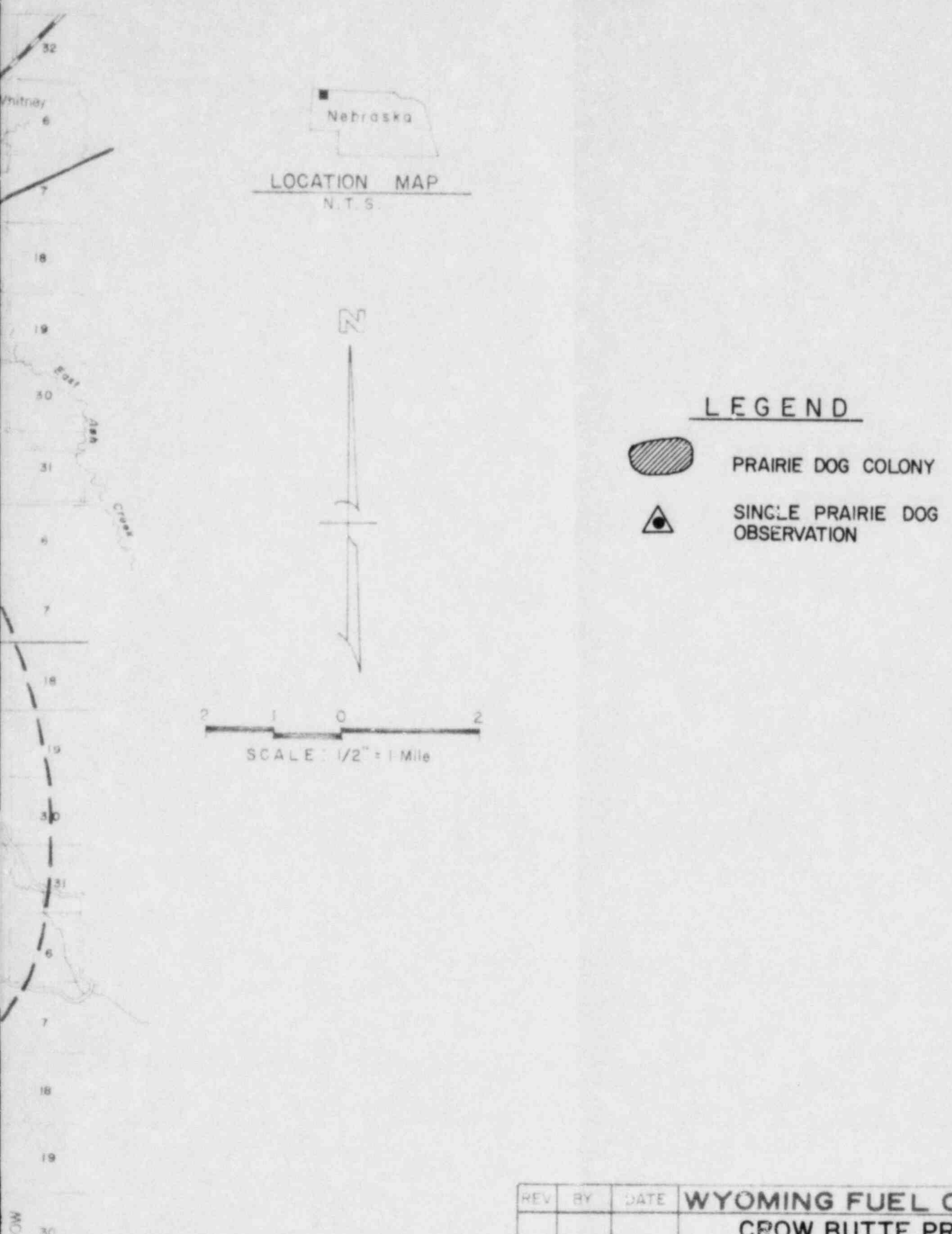
TABLE 2.9-7

CARNIVORE HABITAT AFFINITIES

Species	Aquatic Habitats Obs	(%)	Deciduous Woodlands Obs	(%)	Coniferous Woodlands Obs	(%)	Shortgrass Prairie Obs	(%)	Mixed Grass Prairie Obs	(%)	Range Rehab. Obs	(%)	Cultivated Obs	(%)	Structure Biotopes Obs	(%)	Totals Obs	(%)
Coyote			2	(8.0)	4	(16.0)	2	(8.0)	17	(68.0)							25	(100)
Red Fox	1	(6.2)							1	(6.2)	1	(6.2)	12	(75.2)	1	(6.2)	16	(100)
Striped Skunk									2	(28.6)					5	(71.4)	7	(100)
Long-tailed Weasel															1*	(100)	1	(100)
Bobcat															1*	(100)	1	(100)
Raccoon	3	(13.6)	9	(40.9)	1	(4.5)					1	(4.5)	3	(13.6	5	(22.9)	22	(100)

* Dead on Road


T33N
T32N
T31N
T30N
Whitney Lake
WHITE RIVER
Sand
Cottonwood Cr.
Little
Spring
Sioux County
Dawes County
Fort Robinson
State Park
CRAWFORD
CROW BUTTE
Soldier
English
Squaw
Clay
Hooker
Creek
NEBRASKA
NATIONAL
FOREST
R53W
R52W
R52W
R51W



REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			Location Of PRAIRIE DOG COLONIES
			PREPARED BY: F. Harrington & Assoc.
			DWN BY: D&D Graphics · DATE 8-1-82 · FIG 2.9-8

TABLE 2.9-8

SMALL MAMMAL TRAPPING RESULTS - SPRING

Species	Night	Ad♂	Ad♀	Juv♂	Juv♀	Total	Recapture	Juv: Ad	♂:♀	#/Trap-Night	Composition (%)
						SHORTGRASS (150 Trap-Nights)					
Deer	1	2				2	-	-	-	.04	
Mouse	2			1		1	0	-	-	.02	
	3			1		1	1	-	-	.02	
	T	2		2		4	1	1.0: 1	-	.03	21%
Thirteen-lined	1	2	2			4	-	-	1.0: 1	.08	
Ground Squirrel	2	1	3			4	2	-	0.3: 1	.08	
	3		2			2	2	-	-	.04	
	T	3	7			10	4	-	0.4: 1	.06	53%
White-footed	1					0	-	-	-	.00	
Mouse	2	3		2		5	-	0.7: 1	-	.10	
	3					0	0	-	-	.00	
	T	3		2		5	0	0.7: 1	-	.03	26%
Totals						19	6			.13	100%

Diversity Index = 1.014

TABLE 2.9-8
(Continued)

SMALL MAMMAL TRAPPING RESULTS - SPRING

Species	Night	Ad♂	Ad♀	Juv♂	Juv♀	Total	Recapture	Juv: Ad	♂:♀	#/Trap-Night	Composition (%)
						PONDEROSA PINE (150 Trap-Nights)					
White-footed Mouse	1	1				1	-	-	-	.02	
	2	1				1	0	-	-	.02	
	3			1		1	0	-	-	.02	
	T	2		1		3	0	0.5: 1	-	.02	33%
Deer Mouse	1					0	-	-	-	.00	
	2					0	-	-	-	.00	
	3	3		1	1	5	-	0.7: 1	4.0: 1	.10	
	T	3		1	1	5	-	0.7: 1	4.0: 1	.03	55%
Meadow Vole	1					0	-	-	-	.00	
	2					0	-	-	-	.00	
	3	1				1	-	-	-	.02	
	T	1				1	-	-	-	.01	12%
Totals						9	0			.06	100%

Diversity Index = 0.949

TABLE 2.9-8
(Continued)

SMALL MAMMAL TRAPPING RESULTS - SPRING

Species	Night	Ad♂	Ad♀	Juv♂	Juv♀	Total	Recapture	Juv: Ad	♂:♀	#/Trap-Night	Composition (%)
						MIXED GRASS (150 Trap-Nights)					
Deer Mouse	1	1				1	-	-	-	.02	
	2	2				2	1	-	-	.04	
	3	1				1	1	-	-	.02	
	T	4				4	2	-	-	.03	40%
Thirteen-lined	1	1	2			3	-	-	0.5: 1	.06	
Ground Squirrel	2	1	2			3	2	-	0.5: 1	.06	
	3					0	0	-	-	.00	
	T	2	4			6	2	-	0.5: 1	.04	
Totals						10	4			.06	100%
Diversity Index = 0.673											
						LOWER WOODED RIPARIAN (100 Trap-Nights)					
Deer Mouse	1	5	1	2		8	-	0.3: 1	7.0: 1	.16	
	2	6		1	1	8	5	0.3: 1	7.0: 1	.16	
	3					(Flood - Traps Inundated)				-	
	T	11	1	3	1	16	5	0.3: 1	7.0: 1	.16	100%
Totals						16	5			.16	100%
Diversity Index = 0.000											

TABLE 2.9-8
(Continued)

SMALL MAMMAL TRAPPING RESULTS - SPRING

Species	Night	Ad♂	Ad♀	Juv♂	Juv♀	Total	Recapture	Juv: Ad	♂:♀	#/ Trap-Night	Composition (%)
UPPER WOODED RIPARIAN (150 Trap-Nights)											
Deer Mouse	1	1				1	-	-	-	.02	
	2	1	1			2	1	-	1.0: 1	.04	
	3	1				1	1	-	-	.02	
	T	3	1			4	2	-	3.0: 1	.03	67%
White-footed Mouse	1	1				1	-	-	-	.02	
	2	1				1	1	-	-	.02	
	3					0	0	-	-	.00	
	T	2				2	1	-	-	.01	33%
Totals						6	3			.04	100%
Diversity Index = 0.634											
NON-WOODED RIPARIAN (150 Trap-Nights)											
Deer Mouse	1					0	-	-	-	.00	
	2				1	1	-	-	-	.02	
	3					0	-	-	-	.00	
	T				1	1	0	-	-	.01	100%
Totals						1	0			.01	100%
Diversity Index = 0.000											

TABLE 2.9-8
(Continued)

SMALL MAMMAL TRAPPING RESULTS - SPRING

Species	Night	Ad♂	Ad♀	Juv♂	Juv♀	Total	Recapture	Juv: Ad	♂:♀	#/Trap-Night	Composition (%)
						CULTIVATED (150 Trap-Nights)					
Deer Mouse	1			1		1	-	-	-	.02	
	2	1				1	0	-	-	.02	
	3	1				1	1	-	-	.02	
	T	2		1		3	1	0.5: 1	-	.02	60%
Thirteen-lined	1		1			1	-	-	-	.02	
Ground Squirrel	2		1			1	1	-	-	.02	
	3					0	0	-	-	.00	
	T		2			2	1	-	-	.01	40%
Totals						5	2			.03	100%

Diversity Index = 0.673

Riparian. Greatest diversity (1.04 - Shannon and Weaver 1949) was detected in the Shortgrass type, and lowest diversity (0.00) in the Non-wooded Riparian and Lower Wooded Riparian types.

Other small mammals observed or captured during extensive trapping exercises included eastern mole (uncommon along stream banks and in Mixed Grass habitats), spotted ground squirrel (uncommon in Shortgrass habitat), northern pocket gopher (common throughout), house mouse (common in structure biotopes), and meadow jumping mouse (uncommon along streambanks).

Muskrats were recorded commonly along water courses and occur in all permanent impoundments. Beavers are relatively uncommon - ranging along the White River from Crawford westward onto Fort Robinson State Park. Porcupines are common, ranging throughout the woodland areas. Fox squirrels are abundant in woodlands, farmyards and towns.

Two species of jackrabbits range over the Study Area. White-tailed jackrabbits are common in grassland and cultivated areas, whereas the black-tailed jackrabbits are relatively scarce in the same habitats. This would appear to be a reflection of the relatively cold winter climate. Eastern cottontails are common on the Study Area in upland as well as woodland and cultivated types. Cottontails observed in the northern portion of the Adjacent Area, in Shortgrass and Sand-Sagebrush habitats, are believed to be desert cottontails, judging from the smaller size and pale coloration, but the taxonomic distinction has not yet been verified.

2.9.1.5 Birds

According to published sources (Johnsgard 1979, USFS 1981), 302 species of birds have been reported within 80 km of the Study Area. In the course of the present study, 201 species have been documented within the Study Area (Table 2.9-9).

Upland Game Birds

The Turkey is the most popular game bird in the region. The species is not native to the Pine Ridge area. After the introduction of 28 Merriam's Turkeys in 1959 about 29 km northwest of the Commercial Study Area, the population increased to an estimated 1500-2000 birds in three breeding seasons (USFS 1978).

The turkey is widely distributed on the Study Area, primarily along the foothills and plateaus, within Ponderosa habitat, and along drainages in the northern portion of the Study Area. Of 701 observations of the species from January to mid-July, most (38%) were observed in structure biotopes, mainly farmyards, with 24 percent in Deciduous Woodlands, 21 percent in Coniferous Woodlands, and the remainder in Cultivated, Mixed Grass, and Range Rehabilitation types (Table 2.9-10).

In winter, nearly all observations of the species were in four concentration areas, inside the Study Area and outside, where the birds were being fed or were feeding among livestock in farmyard situations: 1) Lux Ranch (Adjacent Area) - 55, 2) Ponderosa Wildlife Area (Adjacent Area) - 20, 3) Ostermeyer Ranch (10 km northwest of the Adjacent Area) - 200, and 4) Johnson Ranch (2 km southwest of the Adjacent Area) - 150. The total winter population was estimated at 450 birds, including 350 outside the Study Area. Additional concentrations in the Outer Area were recorded between Whitney and Chadron, along the White River in farmyard situations (about 500).

Only about 75 birds winter in the Study Area proper, and none within the Commercial Study Area.

In spring there was a broad disposal of birds away from the winter concentration areas. Courtship was first observed 30 March, and shortly thereafter males with harems were observed primarily in woodland habitats at widely separated locations.

In May, tracks of a single turkey were documented along Squaw Creek within Section 19 - the only record of the species on the Commercial Study Area. The first brood (5 young) was observed east of the Commercial Study Area 27 June.

TABLE 2.9-9

BIRD SPECIES LIST

Common Name	Scientific Name	Status
GAVIIFORMES		
Common Loon	*Gavia immer*	R-OA-O-m
Arctic Loon	*Gavia arctica*	R-OA-O-m
PODICIPEDIFORMES		
Red-necked Grebe	*Podiceps grisegena*	R-OA-O-m
Horned Grebe	*Podiceps auritus*	D-AA-U-m
Eared Grebe	*Podiceps caspicus*	D-CA-U-sv
Western Grebe	*Aechmophorus occidentalis*	D-CA-U-sv
Pied-billed Grebe	*Podilymbus podiceps*	D-CA-C-sr**
PELECANIFORMES		
White Pelican	*Pelecanus erythrorhynchos*	D-AA-U-sr**
Double-crested Cormorant	*Phalacrocorax auritus*	D-CA-U-sr**
CICONIFORMES		
Great Blue Heron	*Ardea herodias*	D-CA-U-sr
Green Heron	*Butorides virescens*	R-OA-O-m
Cattle Egret	*Bubulcus ibis*	R-OA-O-m
Great Egret	*Casmerodius albus*	R-OA-O-m
Snowy Egret	*Leucophoyx thula*	R-OA-O-m
Black-crowned Night Heron	*Nycticorax nycticorax*	D-CA-U-sr**
Yellow-crowned Night Heron	*Nyctanassa violacea*	R-OA-O-m
American Bittern	*Botaurus lentiginosus*	D-AA-U-sr**
White-faced Ibis	*Plegadis chihi*	R-OA-O-m
ANSERIFORMES		
Whistling Swan	*Olor columbianus*	R-OA-O-m
Trumpeter Swan	*Olor buccinator*	D-AA-O-m
Canada Goose	*Branta canadensis*	D-CA-U-pr
Brant	*Branta bernicla*	R-OA-U-m
White-fronted Goose	*Anser albifrons*	D-AA-U-m
Snow Goose	*Chen hyperborea*	D-CA-U-m
Mallard	*Anas plantyrhynchos*	D-CA-C-pr*
Black Duck	*Anas rubripes*	R-OA-O-m
Gadwall	*Anas strepera*	D-CA-C-sr**
Pintail	*Anas acuta*	D-CA-C-sr**
Green-winged Teal	*Anas carolinensis*	D-CA-U-sr**
Blue-winged Teal	*Anas discors*	D-CA-C-sr**
Cinnamon Teal	*Anas cyanoptera*	D-CA-U-sr**
American Wigeon	*Mareca americana*	D-CA-U-sr**
Northern Shoveler	*Spatula clypeata*	D-CA-C-sr**

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
ANSERIFORMES		
Wood Duck	*Aix sponsa*	D-CA-U-sr**
Redhead	*Aythya americana*	D-CA-U-sv
Ring-necked Duck	*Aythya collaris*	D-CA-U-sv
Canvasback	*Aythya valisineria*	D-AA-U-m
Lesser Scaup	*Aythya affinis*	D-CA-C-m
Common Goldeneye	*Bucephala clangula*	D-CA-U-m
Barrow's Goldeneye	*Bucephala islandica*	R-OA-O-wv
Bufflehead	*Bucephala albeola*	D-CA-C-m
Oldsquaw	*Clangula hyemalis*	R-OA-U-m
White-winged Scoter	*Melanitta deglandi*	R-OA-U-m
Surf Scoter	*Melanitta perspicillata*	R-OA-U-m
Black Scoter	*Oidemia nigra*	R-OA-U-m
Ruddy Duck	*Oxyura jamaicensis*	D-CA-C-sr**
Hooded Merganser	*Lophodytes cucullatus*	D-CA-U-m
Common Merganser	*Mergus merganser*	D-CA-U-m
Red-breasted Merganser	*Mergus serrator*	R-OA-O-m
FALCONIFORMES		
Turkey Vulture	*Cathartes aura*	D-CA-U-sr**
Goshawk	*Accipiter gentilis*	D-CA-U-wv
Sharp-shinned Hawk	*Accipiter striatis*	D-AA-U-pr**
Cooper's Hawk	*Accipiter cooperi*	D-AA-U-pr*
Red-tailed Hawk	*Buteo jamaicensis*	
(Light Phase)	"	D-CA-C-sr*
(Dark Phase)	"	D-AA-U-m
Red-shouldered Hawk	*Buteo lineatus*	R-OA-O-m
Broad-winged Hawk	*Buteo platypterus*	R-OA-O-m
Swainson's Hawk	*Buteo swainsoni*	R-OA-U-sr**
Rough-legged Hawk	*Buteo lagopus*	D-CA-C-wv
Ferruginous Hawk	*Buteo regalis*	D-AA-U-sr*
Golden Eagle	*Aquila chrysaetos*	D-RA-C-pr*
Bald Eagle	*Haliaeetus leucocephalus*	D-CA-F-wv
Northern Harrier	*Circus cyaneus*	D-RA-C-pr**
Osprey	*Pandion haliaetus*	R-AA-O-sv
Gyrfalcon	*Falco rusticolus*	D-AA-U-m
Prairie Falcon	*Falco mexicanus*	D-RA-C-pr*
Peregrine Falcon	*Falco peregrinus*	R-OA-F-m
Merlin	*Falco columbarius*	D-AA-U-pr**
American Kestrel	*Falco sparverius*	D-RA-A-pr*

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
GALLIFORMES		
Sharp-tailed Grouse	*Pedioecetes phasianellus*	D-CA-C-pr*
Bobwhite	*Colinus virginianus*	R-OA-O-pr
Ring-necked Pheasant	*Phasianus colchicus*	D-CA-C-pr*
Turkey	*Meleagris gallopavo*	D-AA-C-pr*
Gray Partridge	*Perdix perdix*	D-AA-O-pr**
GRUIFORMES		
Sandhill Crane	*Grus canadensis*	D-OA-U-m
Virginia Rail	*Rallus limicola*	D-AA-U-sr**
Sora Rail	*Porzana carolina*	D-CA-U-sr**
American Coot	*Fulica americana*	D-CA-C-sr**
CHARADRIIFORMES		
Semipalmated Plover	*Charadrius semipalmatus*	R-OA-U-m
Piping Plover	*Charadrius melodus*	R-OA-U-m
Snowy Plover	*Charadrius alexandrinus*	R-OA-O-m
Killdeer	*Charadrius vociferus*	D-CA-C-sr*
American Golden Plover	*Pluvialis dominica*	R-OA-U-m
Black-bellied Plover	*Squatarola squatarola*	D-AA-U-m
Marbled Godwit	*Lemosa fedoa*	D-AA-U-m
Whimbrel	*Numenius phaeopus*	R-OA-O-m
Long-billed Curlew	*Numenius americanus*	D-AA-U-sr**
Upland Sandpiper	*Bartramia longicauda*	D-AA-U-sr**
Greater Yellowlegs	*Totanus melanoleucus*	D-CA-C-m
Lesser Yellowlegs	*Totanus flavipes*	D-CA-C-m
Solitary Sandpiper	*Tringa solitaria*	D-CA-U-m
Willet	*Catoptrophorus semipalmatus*	D-CA-U-sr**
Spotted Sandpiper	*Actitis macularia*	D-CA-C-sr**
Common Snipe	*Capella gallinago*	D-CA-C-pr*
Short-billed Dowitcher	*Limnodromus griseus*	R-OA-U-m
Long-billed Dowitcher	*Limnodromus scolopaceus*	D-AA-C-m
Red Knot	*Calidris canutus*	R-OA-O-m
Sanderling	*Calidris alba*	D-AA-U-m
Semipalmated Sandpiper	*Ereunetes pusillus*	D-AA-U-m
Western Sandpiper	*Ereunetes mauri*	R-OA-U-m
Least Sandpiper	*Eriola minutilla*	D-CA-U-m
White-rumped Sandpiper	*Eriola fuscicollis*	R-OA-U-m
Baird's Sandpiper	*Eriola bairdii*	D-AA-C-m
Pectoral Sandpiper	*Eriola melanotos*	R-OA-U-m
Stilt Sandpiper	*Micropalama himantopus*	D-AA-C-m
Buff-breasted Sandpiper	*Tryngites subrufficollis*	R-OA-U-m

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
CHARADRIIFORMES		
American Avocet	*Recurvirostra americana*	D-AA-C-sr**
Wilson's Phalarope	*Steganopus tricolor*	D-CA-C-sr**
Northern Phalarope	*Lobipes lobatus*	D-AA-U-m
Parasitic Jaeger	*Stercorarius parasiticus*	R-OA-O-m
Herring Gull	*Larus argentatus*	R-OA-U-m
California Gull	*Larus californicus*	R-OA-U-m
Ring-billed Gull	*Larus delawarensis*	D-CA-C-sv
Black-headed Gull	*Larus ridibundus*	R-OA-O-m
Franklin's Gull	*Larus pipixcan*	D-AA-C-sv
Bonaparte's Gull	*Larus philadelphia*	R-OA-U-m
Forster's Tern	*Sterna forsteri*	D-AA-U-sv
Common Tern	*Sterna hirundo*	R-OA-O-m
Little (Least Interior) Tern	*Sterna albifrons*	R-OA-S-m
Black Tern	*Chlidonias niger*	D-AA-U-sr**
COLUMBIFORMES		
Mourning Dove	*Zenaidura macroura*	D-RA-A-sr*
Rock Dove	*Columba livia*	D-CA-C-pr*
CUCULIFORMES		
Yellow-billed Cuckoo	*Coccyzus americanus*	D-RA-U-sr**
Black-billed Cuckoo	*Coccyzus erythropthalmus*	D-CA-U-sr**
STRIGIFORMES		
Barn Owl	*Tyto alba*	D-AA-U-pr**
Screech Owl	*Otus asio*	D-AA-U-pr**
Great Horned Owl	*Bubo virginianus*	D-RA-C-pr*
Snowy Owl	*Nyctea scandiaca*	R-OA-U-wv
Burrowing Owl	*Speotyto cunicularia*	D-AA-U-sr*
Barred Owl	*Strix varia*	R-OA-O-pr
Long-eared Owl	*Asio otus*	R-OA-U-pr
Short-eared Owl	*Asio flammeus*	D-CA-U-pr**
Saw-whet Owl	*Aegolius acadicus*	D-AA-U-pr**
CAPRIMULGIFORMES		
Common Poor-will	*Phalaenoptilus nuttallii*	D-AA-U-sr**
Common Nighthawk	*Chordeiles minor*	D-RA-C-sr**
APODIFORMES		
Chimney Swift	*Chaetura pelagica*	D-AA-U-sr**
White-throated Swift	*Aeronautes saxatalis*	D-AA-U-sr**

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
APODIFORMES		
Broad-tailed Hummingbird	*Selasphorus platycercus*	R-OA-O-m
Rufous Hummingbird	*Selasphorus rufus*	R-OA-O-m
CORACIIFORMES		
Belted Kingfisher	*Megaceryle alcyon*	D-CA-U-sr**
PICIFORMES		
Common Flicker	*Colaptes auratus*	D-RA-C-pr*
Red-bellied Woodpecker	*Centurus carolinus*	R-OA-O-sr
Red-headed Woodpecker	*Melanerpes erythrocephalus*	D-CA-C-sr*
Lewis' Woodpecker	*Asyndesmus lewis*	D-AA-U-sr**
Yellow-bellied Sapsucker	*Sphyrapicus varius*	R-OA-U-m
Hairy Woodpecker	*Dendrocopos villosus*	D-CA-C-pr**
Downy Woodpecker	*Dendrocopos pubescens*	D-CA-C-pr**
PASSERIFORMES		
Tyrannidae		
Eastern Kingbird	*Tyrannus tyrannus*	D-RA-C-sr*
Western Kingbird	*Tyrannus verticalis*	D-RA-C-sr*
Cassin's Kingbird	*Tyrannus vociferans*	R-OA-U-sv
Scissor-tailed Flycatcher	*Muscivora forfic*	R-OA-O-m
Great Crested Flycatcher	*Myiarchus crinitus*	D-RA-U-sr**
Eastern Phoebe	*Sayornis phoebe*	D-AA-U-sr**
Say's Phoebe	*Sayornis saya*	D-RA-U-sr**
Black Phoebe	*Sayornis nigricans*	D-AA-O-m
Willow Flycatcher	*Empidonax traillii*	D-AA-U-sr**
Least Flycatcher	*Empidonax minimus*	D-AA-U-m
Hammond's Flycatcher	*Empidonax hammondii*	R-OA-O-m
Western Flycatcher	*Empidonax difficilis*	R-OA-O-m
Eastern Pewee	*Contopus virens*	D-AA-U-sr**
Western Pewee	*Contopus sordidulus*	D-RA-C-sr**
Olive-sided Flycatcher	*Nuttalornis borealis*	R-OA-U-m
Alaudidae		
Horned Lark	*Eremophila alpestris*	D-RA-C-pr*
Hirundinidae		
Violet-green Swallow	*Tachycineta thallassina*	D-CA-U-sr**
Tree Swallow	*Iridoprocne bicolor*	D-CA-U-sr**
Bank Swallow	*Riparia riparia*	D-RA-C-sr*

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
Hirundinidae		
Rough-winged Swallow	*Stelgidopteryx ruficollis*	D-CA-U-sr**
Barn Swallow	*Hirundo rustica*	D-CA-C-sr*
Cliff Swallow	*Petrochelidon pyrrhonota*	D-CA-C-sr*
Purple Martin	*Progne subis*	R-OA-O-m
Corvidae		
Gray Jay	*Perisoreus canadensis*	R-OA-O-wv
Blue Jay	*Cyanocitta cristata*	R-CA-C-pr**
Steller's Jay	*Cyanocitta stelleri*	R-OA-O-wv
Black-billed Magpie	*Pica pica*	D-RA-C-pr*
American Crow	*Corvus brachyrhynchos*	D-RA-C-pr*
Pinyon Jay	*Gymnorhinus cyanocephalus*	D-CA-C-pr**
Clark's Nutcracker	*Nucifraga columbiana*	R-OA-O-wv
Paridae		
Black-capped Chickadee	*Parus atricapillus*	D-RA-C-pr**
Tufted Titmouse	*Parus bicolor*	R-OA-O-m
Sittidae		
White-breasted Nuthatch	*Sitta carolinensis*	D-CA-C-pr**
Red-breasted Nuthatch	*Sitta canadensis*	D-CA-C-pr**
Pygmy Nuthatch	*Sitta pygmaea*	D-AA-C-pr**
Certhiidae		
Brown Creeper	*Certha familiaris*	D-AA-U-pr**
Cinclidae		
Dipper	*Cinclus mexicanus*	R-OA-U-wv
Troglodytidae		
Northern House Wren	*Troglodytes aedon*	D-CA-C-sr**
Winter Wren	*Troglodytes troglodytes*	R-OA-U-wv
Bewick's Wren	*Thryomanes bewickii*	R-OA-O-m
Carolina Wren	*Thryothorus ludovicianus*	R-OA-O-m
Marsh Wren	*Telmatodytes palustris*	D-AA-U-sr**
Canyon Wren	*Catherpes mexicanus*	R-OA-O-wv
Rock Wren	*Salpinctes obsoletus*	D-AA-U-sr**
Mimidae		
Mockingbird	*Mimus polyglottos*	R-OA-U-sv
Gray Catbird	*Dumetella carolinensis*	D-CA-C-sr**

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
Mimidae		
Brown Thrasher	*Toxostoma rufum*	D-RA-C-sr**
Sage Thrasher	*Orescoptes montanus*	R-OA-U-sv
Turdidae		
American Robin	*Turdus migratorius*	D-RA-C-sr*
Wood Thrush	*Hylocichla mustelina*	D-AA-U-m
Hermit Thrush	*Hylocichla guttata*	D-AA-U-m
Swainson's Thrush	*Hylocichla ustulata*	D-CA-C-m
Gray-cheeked Thrush	*Hylocichla minima*	D-CA-U-m
Veery	*Hylocichla fuscenscens*	D-CA-U-m
Eastern Bluebird	*Sialia sialis*	R-OA-U-sv
Mountain Bluebird	*Sialia currucoides*	D-RA-C-sr**
Townsend's Solitaire	*Myadestes townsendi*	D-AA-U-pr**
Sylviidae		
Blue-gray Gnatcatcher	*Polioptila caerulea*	R-OA-O-m
Golden-crowned Kinglet	*Regulus satrapa*	R-OA-U-m
Ruby-crowned Kinglet	*Regulus calendula*	D-AA-U-m
Motacillidae		
Water Pipit	*Anthus spinoletta*	D-AA-C-m
Bombycillidae		
Bohemian Waxwing	*Bombycilla garrulus*	D-CA-C-wv
Cedar Waxwing	*Bombycilla cedrorum*	D-PA-C-sr**
Laniidae		
Northern Shrike	*Lanius excubitor*	D-RA-U-wv
Loggerhead Shrike	*Lanius ludovicianus*	D-RA-U-sr**
Sturnidae		
European Starling	*Sturnus vulgaris*	D-RA-C-pr*
Vireonidae		
White-eyed Vireo	*Vireo griseus*	R-OA-O-m
Bell's Vireo	*Vireo bellii*	D-AA-U-sr**
Yellow-throated Vireo	*Vireo flavifrons*	R-OA-O-m
Solitary Vireo	*Vireo solitarius*	R-OA-U-sv
Red-eyed Vireo	*Vireo olivaceus*	D-CA-C-sr**
Philadelphia Vireo	*Vireo philadelphicus*	R-OA-O-m
Warbling Vireo	*Vireo gilvus*	D-RA-C-sr**

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
Parulidae		
Black and White Warbler	*Mniotilta varia*	D-AA-U-m
Prothonotary Warbler	*Protonotaria citrea*	R-OA-O-m
Tennessee Warbler	*Vermivora peregrina*	D-AA-U-m
Orange-crowned Warbler	*Vermivora celata*	D-CA-U-m
Nashville Warbler	*Vermivora ruficapilla*	D-AA-U-m
Northern Parula	*Parula americana*	R-OA-U-m
Yellow Warbler	*Dendroica petechia*	D-RA-C-sr**
Magnolia Warbler	*Dendroica magnolia*	R-OA-U-m
Cape May Warbler	*Dendroica tigrina*	R-OA-U-m
Yellow-rumped Warbler	*Dendroica coronata*	
(Audubon Race)	"	D-CA-C-sr**
(Myrtle Race)	"	D-CA-U-m
Townsend's Warbler	*Dendroica townsendi*	R-OA-U-m
Black-throated Green Warbler	*Dendroica virens*	R-OA-U-m
Cerulean Warbler	*Dendroica cerulea*	R-OA-O-m
Blackburnian Warbler	*Dendroica fusca*	R-OA-O-m
Chestnut-sided Warbler	*Dendroica pensylvanica*	R-OA-U-m
Blackpoll Warbler	*Dendroica striata*	D-AA-U-m
Palm Warbler	*Dendroica palmarum*	R-OA-U-m
Ovenbird	*Seiurus aurocapillus*	D-AA-U-sr**
Northern Waterthrush	*Seiurus noveboracensis*	D-CA-U-m
Mourning Warbler	*Oporornis philadelphia*	R-OA-O-m
MacGillivray's Warbler	*Oporornis tolmiei*	R-OA-U-m
Common Yellowthroat	*Geothlypis trichas*	D-CA-C-sr**
Yellow-breasted Chat	*Icteria virens*	D-CA-C-sr**
Hooded Warbler	*Wilsonia citrina*	R-OA-O-m
Wilson's Warbler	*Wilsonia pusilla*	D-AA-C-m
American Redstart	*Setophaga ruticilla*	D-RA-C-sr**
Ploceidae		
House Sparrow	*Passer domesticus*	D-RA-C-pr*
Icteridae		
Bobolink	*Dolichonyx oryzivorus*	D-CA-U-sr**
Eastern Meadowlark	*Sturnella magna*	D-AA-U-sr**
Western Meadowlark	*Sturnella neglecta*	D-RA-C-sr*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	D-CA-U-sr**
Red-winged Blackbird	*Agelaius phoeniceus*	D-CA-C-sr*
Orchard Oriole	*Icterus spurius*	D-CA-C-sr**
Northern (Bullock) Oriole	*Icterus galbula*	D-RA-U-sr**
Rusty Blackbird	*Euphagus carolinus*	R-OA-U-m

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
Icteridae		
Brewer's Blackbird	*Euphagus cyanocephalus*	D-RA-U-sr**
Common Grackle	*Quiscalus quiscula*	D-RA-C-sr**
Brown-headed Cowbird	*Molothrus ater*	D-CA-C-sr**
Thraupidae		
Western Tanager	*Piranga ludoviciana*	D-CA-U-sr**
Scarlet Tanager	*Piranga olivacea*	R-OA-O-m
Fringillidae		
Cardinal	*Richmondena cardinalis*	R-OA-O-pr
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	R-OA-U-m
Blue Grosbeak	*Guiraca caerulea*	D-CA-U-sr**
Indigo Bunting	*Passerina cyanea*	D-CA-U-sr**
Lazuli Bunting	*Passerina amoena*	D-CA-C-sr**
Indigo x Lazuli Hybrid	*P. cyanea x amoena*	D-CA-U-sr**
Dickcissel	*Spiza americana*	R-OA-U-sv
Evening Grosbeak	*Herperiphona vespertina*	D-AA-C-wv
Purple Finch	*Carpodacus purpureus*	R-OA-U-m
Cassin's Finch	*Carpodacus cassinii*	R-OA-U-m
House Finch	*Carpodacus mexicanus*	D-PA-U-m
Pine Grosbeak	*Pinicola enucleator*	R-OA-O-wv
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*	R-OA-U-wv
Common Redpoll	*Acanthis flammea*	R-OA-U-wv
Pine Siskin	*Spinus pinus*	D-CA-C-pr**
American Goldfinch	*Spinus tristis*	D-RA-C-pr**
Red Crossbill	*Loxia curvirostra*	D-AA-A-pr**
White-winged Crossbill	*Loxia leucoptera*	R-OA-O-wv
Green-tailed Towhee	*Chlorura chlorura*	R-OA-O-m
Rufous-sided Towhee	*Pipilo erythrophthalmus*	D-RA-C-sr**
Lark Bunting	*Calamospiza melanocoryx*	D-RA-C-sr**
Savannah Sparrow	*Passerculus sandwichensis*	D-RA-C-m
Grasshopper Sparrow	*Ammodramus savannarum*	D-AA-U-m
Vesper Sparrow	*Pooecetes gramineus*	D-RA-U-sr**
Lark Sparrow	*Chondestes grammacus*	D-RA-C-sr*
Black-throated Sparrow	*Amphispiza bilineata*	R-OA-O-m
Dark-eyed Junco	*Junco hyemalis*	
(White-winged Race)	"	D-CA-C-pr**
(Slate-colored Race)	"	D-RA-C-wv
(Oregon Race)	"	D-RA-C-wv
(Gray-headed Race)	"	D-AA-U-m

TABLE 2.9-9
(Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
Fringillidae		
Tree Sparrow	*Spizella arborea*	D-RA-C-wv
Chipping Sparrow	*Spizella passerina*	D-CA-C-sr**
Clay-colored Sparrow	*Spizella pallida*	D-RA-C-sr**
Brewer's Sparrow	*Spizella breweri*	D-AA-U-sr**
Field Sparrow	*Spizella pusilla*	R-OA-U-m
Harris' Sparrow	*Zonotrichia querula*	R-OA-U-m
White-crowned Sparrow	*Zonotrichia leucophrys*	D-CA-C-m
White-throated Sparrow	*Zonotrichia albicollis*	R-OA-U-m
Fox Sparrow	*Passerella iliaca*	R-OA-O-m
Lincoln's Sparrow	*Melospiza lincolnii*	D-AA-U-m
Swamp Sparrow	*Melospiza georgiana*	R-OA-O-m
Song Sparrow	*Melospiza melodia*	D-CA-C-wv
McCown's Longspur	*Rhynchophanes mccownii*	D-AA-U-sr**
Lapland Longspur	*Calcarius lapponicus*	D-AA-C-m
Chestnut-collared Longspur	*Calcarius ornatus*	D-AA-U-sr**
Snow Bunting	*Plectrophenax nivalis*	D-AA-C-wv

SEE TABLE 2.9-5A FOR STATUS CODES

TABLE 2.9-10

GAME BIRD HABITAT AFFINITIES

Species	Riverine Habitats Obs	(%)	Deciduous Woodlands Obs	(%)	Coniferous Woodlands Obs	(%)	Mixed Grass Prairie Obs	(%)	Range Rehab. Obs	(%)	Cultivated Obs	(%)	Structure Biotopes Obs	(%)	Totals Obs	(%)
Sharp-tailed Grouse																
Commercial Study Area			10	(58.8)			5	(29.4)	2	(11.8)					17	(100)
Total Area			10	(8.1)	2	(1.6)	80	(65.0)	4	(3.2)	10	(8.1)	17	(14.0)	123*	(100)
Pheasant																
Commercial Study Area	2	(2.3)	9	(10.7)			2	(2.3)	16	(19.0)	4	(4.8)	51	(60.9)	84	(100)
Total Area	5	(2.9)	24	(13.9)			10	(5.8)	18	(10.4)	12	(6.9)	104	(60.1)	173	(100)
Turkey																
Commercial Study Area	(Not Observed on Commercial Study Area)															
Total Area			167	(23.8)	148	(21.1)	12	(1.7)	29	(4.1)	80	(11.4)	265	(37.9)	701	(100)
Gray Partridge																
Commercial Study Area	(Not Observed on Commercial Study Area)															
Total Area													2	(100)	2	(100)

* Excludes 568 Observations on Leks

In summary the turkey constitutes a semi-domesticated bird in this area. There are no historical records of turkeys in the region, probably because there is inadequate winter habitat - an absence of mast-producing trees. Birds, therefore are required to rely on supplemental feeding in winter. Although the species does not regularly occur on the Commercial Study Area, it could be expected to occur in proportion to the amount of supplemental winter feeding offered by local landowners. At the present time they offer none.

Pheasants are common on the Study Area, with about half the observations recorded on the Commercial Study Area. Preferred habitats (Table 2.9-10) were structure biotopes and cultivated types, with most pheasants observed in roadside situations.

Pheasant crowing counts were conducted along a route lying largely within the Commercial Study Area (Table 2.9-11; Fig 2.9-9). Number of calls for the route (20 listening stations, 2 minutes each) ranged from 15 in April to 106 in late May, with courtship activity declining sharply thereafter. Based on the above counts and taking into consideration the sex ratio observed during the same period (0.68 females/male), the total Commercial Study Area population was estimated at 180 birds in spring. Most of those were distributed from the central portion of the Commercial Study Area northward. Pheasants were not recorded on the proposed Restricted Area Boundary, which contains habitat unsuitable to marginal for the species. The first pheasant brood was observed 27 June (5 young).

Sharp-tailed grouse are common on the Study Area, distributed primarily in the foothills areas and plains. During the study period the preferred habitat was Mixed Grass Prairie (Table 2.9-10).

In spring an intensive search revealed the presence of 6 sharptail leks within the Study Area, and 2 additional leks on the perimeter (Table 2.9-12; Fig 2.9-9). Peak male attendance ranged from 4-33 ($\bar{x}$ = 15.6). Activity on the leks was evident from mid-April into late May, with the peak of attendance from late April into early May.

No lek was found on the Commercial Study Area, and only about 10% of birds recorded there. The absence of leks may be due to 1) the higher level of disturbance which exists on the Commercial Study Area (roads, railroads, farming activities), 2) unfavorable climatic conditions - much of the Commercial Study Area lies within a wind-lane in the eastern part of the valley. Sharptails typically display reduced activity on windy days, 3) the high level of raptor activity and abundance of raptor perching sites on the

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TABLE 2.9-11

PHEASANT AND DOVE CALLING COUNTS*

Station	Pheasant 22 April 82	Pheasant 17 May 82	Pheasant 25 May 82	Dove 25 May 82
1	0	2	2	41
2	2	4	2	46
3	0	0	0	2
4	3	0	2	54
5	0	1	1	30
6	0	0	0	0
7	0	0	0	15
8	0	2	0	5
9	0	1	0	0
10	0	5	5	28
11	1	3	6	30
12	1	2	5	41
13	0	0	1	7
14	2	1	12	37
15	0	1	5	11
16	1	1	5	31
17	2	3	5	25
18	1	1	6	13
19	2	2	9	6
20	0	2	4	21
Total Calls	15	31	106	443
Males Observed	0	2	2	-
Females Observed	0	0	0	-
Total Birds Observed	0	2	2	87

* Calls per Two-Minute Interval

TABLE 2.9-12

SHARP-TAILED GROUSE LEK COUNTS

Lek Name	Date Located	No. Counts	Peak ♂ Attendance	Highest Count (♂♂ & ♀♀)
Bison 1	11 March	11	18 (14 April)	18 (14 April)
Bison 2	22 April	6	11 (24 April)	11 (24 April)
Bison 3	24 April	5	16 (17 May)	18 (28 April)
James	18 April	6	19 (18 April)	19 (18 April)
Spring Creek	22 April	6	33 (22 April)	34 (22 April)
Little Cottonwood	22 April	5	4 (22 April)	5 (22 April)
Hartman	21 April	5	13 (17 May)	13 (17 May)
Ash	23 April	4	11 (24 April)	11 (24 April)
Totals, 1982			125	128
$\bar{X}$, 1982			15.6	16.0

Commercial Study Area - telephone and power transmission poles, including two, 500 kv (?) lines. Sharptails were not recorded on the Research and Development Restricted Area Boundary.

One pair of Gray Partridge was observed on 26 June in the Adjacent Area, in a roadside situation adjacent to a Range Rehabilitation area about 4 km northeast of the Commercial Study Area. This is the first record of the species in the area.

Mourning Doves are abundant throughout the Study Area during the summer residence period. Count data (Table 2.9-11) compare favorably with other areas in the region. The species is common on the Commercial Study Area and Restricted Boundary Area.

Bobwhite Quail were reported by local residents as common in the past, but were evidently extirpated. The species was not recorded on the Study Area. If present, the distinctive calls of the species would most certainly have been heard. The demise of the species in the local area would appear to reflect the on-going degradation of riparian areas due to over-grazing and deleterious land practices - practices which have doubtlessly led to the decline of other species as well.

Raptors

A large number of raptor species was documented on the Study Area - a reflection of the diversity in habitat types and the existence of a large number of suitable nesting sites - trees and cliff sites.

Golden eagles are permanent residents of the area, ranging over most of the Study Area in a variety of habitats. Most eagles (55%) were observed perched on cliffs and escarpments (Table 2.9-13). Indeed, eagles, perched on escarpments, could be observed at any time within the Study Area, if one chose to scan the area with a spotting scope. The presence of 5 active golden eagle nesting territories on the Study Area (Table 2.9-14; Fig. 2.9-10) would suggest that the species is at saturation density in the area. The presence of another territory along Sand Creek in the northern Adjacent Area was deemed possible, but only red-tailed hawks (below) were found there. All golden eagle nests were located on northeast cliff exposures, perhaps a reflection of temperatures during the late nesting period, and all appeared to have been used for several years, if not decades.

The eagle distribution pattern suggested that the Commercial Study Area and the Research and Development Restricted Area Boundary fall chiefly within the territory of the pair occupying GE-1, about 200 m south of the Commercial Study Area boundary. The nest was reported by the landowner (Lux) as active for the past several years. Nesting was unsuccessful in the current year. Incubation was first observed on 28 March. The female assumed a brooding position on 25 April, but abandoned the nest on 7 May. She attended an alternate nest (GE-1A1) for several days and then departed. We are not certain to what the abandonment may be attributed - infertility, young mortality, or nest predation. It is probable that nesting attempts will take place every year, however. The remaining nests were successful, production 1, 1, 2, and 2 fledglings respectively.

Bald eagles (protected under federal act) were observed at several locations on the Study Area in winter and early spring. An individual was observed perched in the center of the Commercial Study Area in March. Evidently the species is an uncommon winter resident and migrant, with its primary winter distribution lying along rivers 100+ km to the east (Lock 1974). The species does not nest on the area, and neither critical habitat nor regular roosting sites are present on the Commercial Study Area.

Two races of red-tailed hawks occur on the Study Area. The dark phase (Harlan's) was recorded in spring migration in the Adjacent Area (Table 2.9-13). The pale phase (paler than Harlan's but darker than birds of the Rocky Mountain region to the west) is a regular summer resident and breeder. The first spring arrivals appeared on territories 1 March 1982.

Nine nesting territories were located on the Study Area, and believed to represent the entire summer population. Seven of the 9 nests were successful, producing a total of 12 fledglings ($\bar{x}$ = 1.3/nesting territory). The female which was unsuccessful at RT-1 was believed to have re-nested at RT-4 and was unsuccessful there also. The eggs were probably infertile on both attempts. No male was present during the second attempt.

The Research & Development Restricted Area Boundary lies, in part, within the observed nesting territory of RT-8, which produced 2 young. The nest is located about 700 m north of the site, and the pair was regularly observed hunting over the Research and Development Restricted Area Boundary Mixed Grass habitat.

Rough-legged hawks are common winter residents, occurring on the Study Area until early April. They occur in a variety of habitats but typically perch in tall cottonwoods and feed over grassland habitat. The species was observed regularly on the Commercial Study Area in winter.

Ferruginous hawks are migrants, moving through the Study Area in small numbers in mid- to late March. Nesting of the species in the Shortgrass Prairie about 30 km north of the Commercial Study Area was confirmed during an aerial reconnaissance of the northern plains area in April. The species would appear to be plentiful within its preferred range.

Swainson's hawks are reported as "common summer residents" in the Crawford area (USFS 1981). But we observed none in the course of the 6-month study period. Either the species is more common to the east, outside the realm of the red-tailed hawk, or errors in identification were made by the responsible agency officials. It is possible, as is often the case, the species was confused with juvenile red-tailed hawks.

The prairie falcon is a common permanent resident and breeder, perching on cliffs and ranging over a variety of habitats (Table 2.9-13). Four active nests of the species were located on the Study Area, all in cliff cavities. A fifth nest was believed to exist in the extreme eastern portion of the Adjacent Area (Barrel

TABLE 2.9-13

RAPTOR HABITAT AFFINITIES*

Species	Cliff Sites		Riverine Habitats		Deciduous Woodlands		Coniferous Woodlands		Shortgrass Prairie		Mixed Grass Prairie		Range Rehab.		Cultivated		Structure Biotopes		Totals	
	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)
Golden Eagle**	44	(55.0)			9	(11.3)	5	(6.3)			8	(10.0)	4	(5.0)	6	(7.6)	3	(3.8)	80	(100)
Bald Eagle**					3	(60.0)	2	(40.0)											5	(100)
Red-tailed Hawk																				
Light Phase**	3	(1.7)			97	(57.4)	4	(2.4)	7	(4.1)	27	(16.0)	5	(3.0)	20	(11.6)	6	(3.6)	169	(100)
Dark Phase					4	(80.0)									1	(20.0)			5	(100)
Rough-legged Hawk**			1	(3.6)	5	(17.9)					7	(25.0)	6	(21.4)	9	(32.1)			28	(100)
Ferruginous Hawk									1	(16.7)	3	(50.0)			2	(33.3)			6	(100)
Prairie Falcon**	14	(56.0)			1	(4.0)			1	(4.0)	5	(20.0)	1	(4.0)	2	(8.0)	1	(4.0)	25	(100)
Gyrfalcon, Dark Phase											1	(100)							1	(100)
Merlin											2	(40.0)			1	(20.0)	2	(40.0)	5	(100)
Kestrel**	+		+		+		+		+		+		+		+		+		ABUNDANT	
Goshawk**					3	(75.0)	1	(25.0)											4	(100)
Cooper's Hawk**					2	(50.0)	1	(25.0)									1	(25.0)	4	(100)
Sharp-shinned Hawk					4	(80.0)			1	(20.0)									5	(100)
Northern Harrier**					14	(20.9)			2	(3.0)	18	(16.9)	17	(25.4)	25	(37.3)	1	(1.6)	67	(100)
Turkey Vulture	4	(20.0)			11	(55.0)	3	(15.0)	1	(5.0)	1	(5.0)							20	(100)
Great Horned Owl**					74	(80.4)	3	(3.3)			4	(4.3)			1	(1.1)	10	(10.9)	92	(100)
Screech Owl					1	(50.0)					1	(50.0)							2	(100)
Barn Owl																	1	(100)	1	(100)
Short-eared Owl**											2	(100)							2	(100)
Saw-whet Owl					1	(100)													1	(100)
Burrowing Owl											4	(100)							4	(100)

* Commercial Study Area and Adjacent Area Data Combined

** Observed on Commercial Study Area

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TABLE 2.9-14

RAPTOR NESTING DATA

Species Nest Number	UTM Location	Nest Site	Nesting Status, 1982
Golden Eagle			
GE-1	471862,063577	Cliff	Incubating 28 Mar, Abandoned 7 May
GE-1A1*	471970,063666	Cliff	Unoccupied
GE-1A2	471962,063667	Cliff	Unoccupied
GE-2	471908,062995	Cliff	2 Young Fledged ~ 1 July
GE-3	472439,063911	Cliff	1 Young Fledged ~ 5 July
GE-3A	472433,063760	Cliff	Unoccupied
GE-4	472838,064378	Cliff	1 Young Fledged ~ 1 July
GE-5	472745,062645	Cliff	2 Young Fledged ~ 1 July
Red-tailed Hawk			
RT-1	472248,063278	Cottonwood	Incubating 30 Mar, Abandoned 7 May
RT-2	473600,063090	Cottonwood	1 Young Fledged ~ 1 July
RT-3	472386,062561	Cottonwood	2 Young Fledged ~ 10 July
RT-4	472780,063276	Cottonwood	Incubating 12 May, Abandoned 10 July
RT-4A	472780,063276	Cottonwood	Unoccupied
RT-5	473340,063560	Cottonwood	2 Young Fledged ~ 1 July
RT-6	472548,062765	Cottonwood	1 Young Fledged ~ 30 June
RT-6A	472552,062768	Cottonwood	Unoccupied
RT-7	473429,062544	Cottonwood	2 Young Fledged ~ 1 July
RT-8	472401,063466	Willow	2 Young Fledged ~ 30 June
RT-9	472475,062952	Cottonwood	2 Young Fledged ~ 5 July
Cooper's Hawk			
CH-1	472651,062735	Ponderosa	Nest Occupied 1 July, Incubation

TABLE 2.9-14
(Continued)

RAPTOR NESTING DATA

Species Nest Number	UTM Location	Nest Site	Nesting Status, 1982
<u>Prairie Falcon</u>			
PF-1	472450,063745	Cliff Cavity	Courtship May, Unoccupied 1 July
PF-1A	472456,063908	Cliff Cavity	Courtship May, Unoccupied 1 July
PF-2	472720,062503	Cliff Cavity	Occupied 1 July, 1+ Young
PF-3	472728,062518	Cliff Cavity	Occupied 1 July, 1+ Young
PF-4	472692,062710	Cliff Cavity	Occupied 1 July, 1+ Young
PF-5	(Barrel Butte)	Cliff?	Nest Not Located 1 July, Pair in Vicinity
<u>Great Horned Owl</u>			
GH-1 (RT-3A?)	472378,062567	Cottonwood	2 Young Fledged ~ 25 May
GH-2 (RT-4A?)	472769,062379	Cottonwood	1 Young Present 20 April Nest Destroyed 4 May
GH-3 (RT-10?)	473205,063303	Cottonwood	1+ Young Fledged ~ 25 May
GH-4 (RT-8A)	472271,063512	Cottonwood	2 Young Fledged ~ 5 June
GH-5	472691,062982	Cottonwood	2 Young Fledged ~ 28 May
<u>Burrowing Owl</u>			
BU-1	473023,062744	Burrow	Occupied 1 July, Status Uncertain
BU-2	472250,063105	Burrow	Occupied 1 July, Status Uncertain

Butte), but had not been located at the end of the reporting period. The species was observed hunting over the Research and Development Restricted Area Boundary site on two occasions.

A single gyrfalcon, probably in migration, was observed in the northeast portion of the Adjacent Area.

Merlins are uncommon, with 5 observations recorded on the Adjacent Area. The species is probably a resident and may nest in the Pire Ridge area, but no nest was found.

Kestrels are abundant summer residents, recorded in all habitat types, including those of the Restricted Area Boundary. The species may number in the hundreds on the Study Area in migration, and breeding territories were deemed too numerous to address within the terms of reference of the current study.

Goshawks are uncommon winter residents, evidently ranging over large areas. Four were observed at widely separated locations, including one in the northern portion of the Commercial Study Area in March.

Cooper's hawks, formerly reported as winter residents in the area, were determined in the course of the study to be permanent residents and breeders. One nest was found in the Adjacent Area, on Fort Robinson State Park. The species was not observed on the Commercial Study Area, but probably forages over the entire area from time to time.

Sharp-shinned hawks were seen on several occasions on the Study Area. A pair was observed in courtship on Fort Robinson, but no nest was found.

Northern harriers are permanent residents on the Study Area, ranging primarily over grassland habitats, and more common in summer. The species was frequently observed on the Commercial Study Area and may nest there, but no nest was found. Courtship was seen on Fort Robinson, and it is likely that the species (a ground-nester) more regularly nests in the taller grasses found there.

Turkey vultures are common migrants and uncommon summer residents, occasionally seen soaring above cliffs. The species was recorded on the Commercial Study Area only during migration.

Great horned owls are common permanent residents. A large population was documented, primarily within Deciduous Streambank Forest habitat. During February, when courtship was evident and the owls were vocalizing a great deal, it was estimated that a pair of owls existed every 4 km along the White River. Five nests were found, two of which were located on the Commercial Study Area. One nest, located in the northern portion of the Commercial Study Area, along Squaw Creek, was destroyed, evidently by area residents. Another nest, located in the center of Section 19 and roughly 50 m north of the Research and Development Restricted Area Boundary, in a cottonwood on Squaw Creek, produced 2 young. Of raptor species, great horned owls are most apt to be tolerant of disturbance. Nest GH-5, for example, was located at the corner of 1st and Elm streets in the city of Crawford, and 2 young were successfully fledged 28 May.

The burrowing owl is a summer resident. Two dens were found in the Adjacent Area. The species is relatively uncommon on the Study Area and probably does not nest on the Commercial Study Area.

One barn owl was found dead on the highway on the northeast perimeter of the Adjacent Area. The species is evidently uncommon in the area, and was not found in a search of abandoned buildings and barns of the Commercial Study Area.

Two short-eared owls were observed in May, probably in migration - in Mixed Grass habitat in the center of the Commercial Study Area.

Two screech owls were documented - one on Fort Robinson and another on the Ponderosa Wildlife Area east of the Commercial Study Area. The species is probably more common than observations would suggest.

One saw-whet owl was recorded in the West Ash Creek drainage of the eastern Adjacent Area. The status of the species is unclear, but is probably relatively common though infrequently observed.

WATERFOWL

Ground surveys for waterfowl were initiated in March and were conducted weekly until the end of June. Procedures established by Duzbin (1969) for assessing breeding populations of ducks were utilized. Data collected during surveys included the following: date, time, weather conditions, habitat type, species, numbers sex and locations.

A total of 24 species was observed in 9 habitat types (Table 2.9-15). The mallard (see species list for scientific names) was the most commonly observed species on waterfowl while the snow goose and hooded merganser were the least commonly observed. Impoundments were important to the largest number of species and the greatest numbers of waterfowl. Class III, V and II Wetlands were also important habitats for dabblers. These wetlands were concentrated in an area 1 to 2 km north and northwest of impoundment M-1 (see Fig. 2.9-11 in the Aquatics Section) in the 8 km Adjacent Area.

Habitat utilization shifted from riverine in early March, when these were the only open water areas, to impoundments and natural wetlands after mid-March, when these areas became ice-free. The Class II, III, and V wetlands became increasingly important in May as spring rains filled them.

Two areas of waterfowl concentration were identified, one on the Commercial Study Area and one on the Adjacent Area. The area of waterfowl concentration on the Commercial Study Area included impoundment M-1 and the Class II, III, and V Wetlands north and northwest of this impoundment.

Nineteen species were observed on the Commercial Study Area, with 18 of the 19 species reported for I-6 (Table 2.9-16). I-1 was the only impoundment where no species of waterfowl were observed. This is a small stockwater pond which had little water in March and April. Heavy livestock use, lack of aquatic vegetation and a low water level during early spring probably precluded use of this impoundment by waterfowl.

Estimates of breeding pairs of waterfowl on the Commercial Study Area and Adjacent Areas are presented in Table 2.9-17. The mallard was the most common species of nesting waterfowl on both the Commercial Study Area and Adjacent Areas. Although several thousand ducks stopped on the Study Area during migration, very

TABLE 2.9-15

WATERFOWL HABITAT AFFINITIES

Species	Class II Wetland		Class III Wetland		Class V Wetland		Riverine		Impoundment		Range Rehab.		Cultivated		Roadside		Total	
	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)
Trumpeter Swan									4	(100)							4	(100)
Canada Goose			7	(47)							8	(53)					15	(100)
White-fronted Goose			1	(100)													1	(100)
Snow Goose	1	(20)							4	(80)							5	(100)
Mallard	74	(6)	249	(19)	16	(1.1)	59	(4.3)	907	(69)			4	(.3)	4	(.3)	1313	(100)
Pintail	28	(3.6)	603	(77)	8	(1)	1	(.1)	137	(17.6)			3	(.4)	2	(.3)	782	(100)
Gadwall	7	(2)	58	(12)	115	(25)			286	(61)							466	(100)
American Wigeon	24	(6)	97	(23)	148	(34)			161	(37)							430	(100)
Northern Shoveler	34	(6)	67	(11.9)	10	(1.8)	2	(.3)	455	(80)							568	(100)
Blue-winged Teal	34	(14)	51	(21)	16	(7)	4	(2)	133	(56)							238	(100)
Green-winged Teal	23	(5.1)	105	(24)	13	(3)	6	(1.3)	295	(66)					3	(.6)	445	(100)
Cinnamon Teal					1	(12)			7	(88)							8	(100)
Wood Duck	2	(67)			1	(33)											3	(100)
Redhead	8	(5)	12	(8)					128	(87)							148	(100)
Canvasback									40	(100)							40	(100)
Ring-necked Duck					13	(3)			434	(97)							477	(100)
Hooded Merganser									1	(100)							1	(100)
Common Merganser									46	(100)							46	(100)
Lesser Scaup			2	(.4)	10	(20			549	(97.6)							561	(100)
Common Goldeneye									14	(100)							14	(100)
Bufflehead									65	(100)							65	(100)
Ruddy Duck									64	(100)							64	(100)
American Coot			7	(25)					21	(75)							28	(100)
Double-crested Cormorant									45	(100)							45	(100)

TABLE 2.9-16
WATERFOWL OCCURRENCE ON COMMERCIAL STUDY AREA IMPOUNDMENTS

	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8
Snow Goose					X	X		
Mallard		X	X	X	X	X	X	X
Pintail					X	X		X
Gadwall		X		X	X	X		X
American Wigeon		X	X	X	X	X		X
Northern Shoveler			X	X	X	X		
Blue-winged Teal		X	X	X	X	X	X	
Greed-winged Teal			X	X	X	X	X	X
Cinnamon Teal							X	
Redhead				X	X	X		X
Canvasback						X		X
Ring-necked Duck			X	X	X	X	X	X
Hooded Merganser						X		
Common Merganser				X	X	X		
Lesser Scaup				X	X	X	X	X
Bufflehead				X	X	X	X	
Ruddy Duck						X	X	
Double-crested Cormorant				X	X	X	X	X
Coot						X		X

TABLE 2.9-17

WATERFOWL BREEDING PAIR ESTIMATES

	Assigned Breeding Pairs	
	Commercial Study Area	Adjacent Area
Mallard	14	21
Pintail	1	7
Gadwall		10
American Wigeon		1
Northern Shoveler	1	3
Blue-winged Teal	3	8
Green-winged Teal		3
Wood Duck	1	
Redhead		
Lesser Scaup		1
Ruddy Duck	2	
Coot	1	4

few remained to nest. The greatest number of ducks thought to be nesting on the Study Area utilized the Class III and V Wetlands and impoundment M-1 on the Adjacent Area. Heavy grazing by livestock and cultivation limit the quantity and quality of upland nesting cover for dabblers, and the limited amount of emergent vegetation in the impoundments provides few nesting areas for species which nest over water.

Two broods of mallards were the only waterfowl broods observed during May and June. The first hen with three young was on I-6 in the Commercial Study Area and the second hen with eight young was on the White River in the Adjacent Area. The few observations of broods is due in part to poor visibility caused by the presence of tall vegetation on the Class III and V Wetlands and the tall perimeter vegetation on many of the impoundments.

Eared grebes, pied-billed grebes and western grebes were observed on the Commercial Study Area. The pied-billed grebe is the only species of the grebe thought to nest on the Commercial Study Area. Horned grebes were observed during migration on the Adjacent Area.

During early April a migrating flock of 45 lesser sandhill cranes was observed flying over the Adjacent Area. No sandhill cranes were observed to stop on the Study Area.

Whooping cranes were not observed on the Study Area. The nearest confirmed report for the period 1950 to 1980 was about 100 km southeast of the Study Area (USFWS 1981). Whooping cranes would not be expected on the Study Area, since the western boundary of the regular migration corridor is over 200 km east of the Study Area (USFWS 1981).

The interior least tern (little tern) a State-listed threatened species, which nests on islands of the Platte River, was not observed on the Study Area.

No mountain plovers (State-listed threatened species) were observed on the Study Area. This species is relatively common on the short grass prairie 250 km south of the Study Area.

White pelicans were seen during April on Lake Whitney and a lake near Toadstool Park, located northeast and north of the Adjacent Area, respectively. They evidently do not breed in the vicinity of the Study Area.

Twenty species of shorebirds were seen during spring, with the killdeer being the most common. Due to the dry weather in April and early May, during the period of peak shorebird migration, there was little suitable habitat available. The largest number of species and individuals were seen on the Class III and V Wetlands and the impoundment M-1 on the Adjacent Area. No waterfowl or shorebird species was recorded on the Research and Development Restricted Area Boundary in the course of the study.

Other Bird Species

Seven, 1-km flush transects were located within the Adjacent Area, Commercial Study Area and Research and Development Restricted Area Boundary in order to sample bird populations (Fig. 2.9-9). Transect sites were selected in a fashion judged representative of the diversity of bird habitats and feeding niches within the Study Area - Lower Wooded Riparian (Deciduous Streambank Forest within grassland and cultivation), Ponderosa (Ponderosa Pine - Grassland, Shrubland), Upper Wooded Riparian (Deciduous Streambank Forest - Ponderosa Pine Interspersion), Non-wooded Riparian (Deep Marsh, Shallow Marsh, Wet Meadow Riparian Complex), Cultivated (primarily alfalfa), Mixed Grass Prairie (within the Research and Development Restricted Area Boundary site), and Shortgrass Prairie.

Greatest bird densities in spring were observed in the Upper Wooded Riparian area (18.50 birds/ha), and lowest in the Cultivated area (0.43 birds/ha). The most abundant bird was the red crossbill, with densities of 12.50/ha in the Upper Wooded Type and 5.90/ha in Ponderosa Pine. This reflects the high ponderosa pine seed production in the current year. Numbers of red crossbills fluctuate widely in the region, and in years of poor seed production the species is expected to be scarce or absent entirely.

Other common birds, with densities of more than 1/ha in suitable habitat in spring were the redwing blackbird, black-capped chickadee, mourning dove, rufous-sided towhee, yellow warbler, house wren, violet-green swallow, and pine siskin.

Greatest diversities (Shannon and Weaver 1949) were observed in the Lower Wooded Riparian and Upper Wooded Riparian Types (2.924 and 2.080, resp.; 31 and 26 species, resp.). Lowest diversity was recorded in the Cultivated Type (0.325, 2 species).

TABLE 2.9-18

SPRING BIRD DENSITIES - TRANSECT DATA

Species	No. Obs.	Mean Dist. (m)	Density Birds/ha	Percent
SHORTGRASS				
Horned Lark	8	18.1	0.44	34.8
Western Meadowlark	14	40.6	0.34	60.9
Upland Sandpiper	1	6.0	0.17	4.3
Totals	23	32.0	0.72	100.0
Diversity Index = 0.797				
MIXED GRASS				
Western Meadowlark	13	35.2	0.36	81.2
Bank Swallow	3	5.0	0.60	18.8
Totals	16	29.6	0.64	100.0
Diversity Index = 0.468				
NON-WOODED RIPARIAN				
Common Snipe	12	12.4	0.96	3.8
Western Meadowlark	29	46.4	0.62	9.3
Redwing Blackbird	222	47.0	4.72	70.7
Killdeer	23	32.7	0.70	7.4
Common Flicker	2	47.5	0.04	0.6
Starling	5	50.0	0.10	1.6
Bobolink	2	15.0	0.13	0.6
Common Grackle	8	80.0	0.10	2.5
Mourning Dove	1	60.0	0.02	0.3
Blue-winged Teal	5	33.0	0.15	1.6
Mallard	3	31.0	0.10	1.0
Lark Bunting	2	41.0	0.05	0.6
Totals	314	44.9	6.99	100.0
Diversity Index = 1.200				
CULTIVATED				
Western Meadowlark	19	42.9	0.44	90.5
Robin	2	100.0	0.02	9.5
Totals	21	48.3	0.43	100.0
Diversity Index = 0.325				

TABLE 2.9-18
(Continued)

SPRING BIRD DENSITIES - TRANSECT DATA

Species	No. Obs.	Mean Dist. (m)	Density Birds/ha	Percent
LOWER WOODED RIPARIAN				
Black-capped Chickadee	18	15.3	1.18	7.6
Great Horned Owl	5	23.0	0.21	2.0
Common Crow	7	30.0	0.23	2.9
Pine Siskin	25	32.0	0.78	10.6
Starling	24	27.8	0.86	9.9
American Robin	26	15.1	1.85	11.7
Common Flicker	4	21.0	0.19	1.6
Redwing Blackbird	4	20.0	0.10	0.8
Mourning Dove	33	18.4	1.79	13.6
Yellow-rumped Warbler	12	21.5	0.55	4.9
Common Grackle	6	25.8	0.23	2.6
Pheasant	5	80.0	0.06	2.0
Hairy Woodpecker	1	40.0	0.02	0.4
Tree Sparrow	3	15.0	0.20	1.2
Slate-colored Junco	4	18.7	0.21	1.7
Western Meadowlark	4	15.0	0.27	1.7
Brown Thrasher	3	6.7	0.45	1.2
Chipping Sparrow	2	20.0	0.10	0.8
Clay-colored Sparrow	2	20.0	0.10	0.8
Orange-crowned Warbler	1	20.0	0.05	0.4
Lark Sparrow	5	15.0	0.33	2.0
Yellow Warbler	11	7.7	1.42	4.5
Eastern Kingbird	2	5.5	0.36	0.8
Rufous-sided Towhee	8	7.5	1.06	3.3
House Wren	14	9.6	1.45	5.8
Downy Woodpecker	5	8.0	0.62	2.0
Violet-Green Swallow	1	1.0	1.00	0.4
American Redstart	2	9.0	0.22	0.8
Northern Waterthrush	1	10.0	0.10	0.4
American Goldfinch	2	15.0	0.13	0.8
Mallard	2	5.0	0.40	0.8
Totals	242	20.2	11.90	100.0

Diversity Index = 2.924

TABLE 2.9-18
(Continued)

SPRING BIRD DENSITIES - TRANSECT DATA

Species	No. Obs.	Mean Dist. (m)	Density Birds/ha	Percent
		UPPER WOODED RIPARIAN		
Common Flicker	1	10.0	0.10	0.2
Red Crossbill	172	13.8	12.50	46.6
B.-c. Chickadee	30	24.3	1.23	8.2
Black-billed Magpie	2	30.0	0.06	0.5
Starling	19	37.9	0.50	5.2
Downy Woodpecker	8	39.6	0.20	2.3
Blue Jay	1	20.0	0.05	0.2
Evening Grosbeak	49	9.6	5.10	13.3
Slate-colored Junco	6	26.7	0.22	1.6
Hairy Woodpecker	1	20.0	0.05	0.2
American Robin	8	11.6	0.68	2.2
Pinyon Jay	10	40.0	0.25	2.8
Pygmy Nuthatch	2	1.0	2.00	0.5
Red-breasted Nuthatch	12	13.8	0.87	3.3
Oregon Junco	4	40.0	0.10	1.1
Great Horned Owl	1	20.0	0.05	0.2
Kestrel	4	43.7	0.09	1.1
House Wren	18	32.7	0.55	4.9
Mourning Dove	5	37.0	0.13	1.3
Rufous-sided Towhee	5	40.0	0.12	1.3
Black-headed Grosbeak	3	18.3	0.16	0.8
Blackpoll Warbler	1	20.0	0.05	0.2
Hermit Thrush	1	60.0	0.02	0.2
Brewer's Blackbird	4	52.5	0.01	1.1
Ruby-crowned Kinglet	1	100.0	0.01	0.2
Chipping Sparrow	2	40.0	0.05	0.5
Totals	370	19.9	18.50	100.0

Diversity Index = 2.080

TABLE 2.9-18
(Continued)

SPRING BIRD DENSITIES - TRANSECT DATA

Species	No. Obs.	Mean Dist. (m)	Density Birds/ha	Percent
		PONDEROSA PINE		
Red C·ossbill	227	38.5	5.90	86.5
Red-b . Nuthatch	14	28.2	0.50	5.5
Downy Woodpecker	2	32.5	0.06	0.7
Pine Siskin	1	1.0	1.00	0.3
B.-c. Chickadee	3	50.0	0.06	1.1
Slate-colored Junco	2	30.0	0.06	0.7
Ruby-crowned Kinglet	3	41.7	0.07	1.1
Mourning Dove	6	25.0	0.24	2.3
Rufous-sided Towhee	4	47.5	0.08	1.5
House Wren	1	10.0	0.10	0.3
Totals	263	42.4	6.20	100.0

Diversity Index = 0.551

The data may underestimate the overall importance of the Mixed Grass Prairie type. The transect was located on and adjacent to the Research and Development Restricted Area Boundary, since the Mixed Grass type best represents the site. But the site is relatively impoverished due to abusive land practices, and therefore does not properly represent the full capability of the Mixed Grass type. Only 2 species were observed during 5 transect exercises in spring, yielding a computed density of 0.64 birds/ha, and a diversity index of 0.468.

2.9.1.6. Reptiles and Amphibians

Of 25 species of reptiles and amphibians recorded for the region, 13 were documented on the Study Area during the period of investigation.

Toads which were observed, and distributions determined primarily by their calls, were Woodhouse's toad (not numerous, but occurring on all the larger impoundments and watercourses), Great Plains toad (not numerous, but widely distributed in a variety of habitats), and plains spadefoot (abundant at selected locations - permanent and seasonal wetlands within the prairie areas).

Documented frogs included the boreal chorus frog (common and widely distributed in a variety of habitats), leopard frog (common in areas of perennial water), and bullfrogs (abundant in impoundments where they have been stocked, in the central and northern portions of the Commercial Study Area and uncommon elsewhere).

The two species of turtles observed were the snapping turtle (common in all streams and permanent impoundments) and painted turtle (common at selected locations - larger impoundments and rivers).

No lizard was recorded during the study period.

Bullsnakes and the plains garter snake were commonly seen. The common garter snake and racer were each observed on only one occasion each. Surprisingly, in view of reports, no rattlesnake was observed, and none found dead on roads.

The Restricted Area Boundary has a relatively sparse herpetofauna, with only bullsnakes confirmed and rattlesnakes reported.

TABLE 2.9-19

REPTILE AND AMPHIBIAN SPECIES LIST

Common Name	Scientific Name	Status
Tiger Salamander	*Ambystoma tigrinum*	E-CA-C
Plains Spadefoot	*Scaphiopus bombifrons*	D-AA-C
Woodhouse's Toad	*Bufo woodhousei*	D-CA-C
Great Plains Toad	*Bufo cognatus*	D-CA-C
Boreal Chorus Frog	*Pseudacris triseriata*	D-CA-C
Leopard Frog	*Rana pipiens*	D-CA-C
Bullfrog	*Rana catesbeiana*	D-CA-C
Snapping Turtle	*Chelydra serpentina*	D-CA-C
Western Box Turtle	*Terrepene ornata*	E-CA-U
Painted Turtle	*Chrysemys picta*	D-CA-U
Spiny Softshell	*Trionyx spiniferus*	E-AA-U
Lesser Earless Lizard	*Holbrookia maculata*	E-AA-U
Eastern Fence Lizard	*Sceloporus undulatus*	E-AA-U
Short-horned Lizard	*Phrynosoma douglassi*	E-CA-U
Great Plains Skink	*Eumeces obsoletus*	E-CA-U
Many-lined Skink	*Eumeces multivirgatus*	E-CA-U
Six-lined Racerunner	*Cnemidophorus sexlineatus*	E-CA-U
Western Hognose Snake	*Heterodon nasicus*	E-CA-U
Racer	*Coluber constrictor*	D-AA-U
Bullsnake	*Pituophis melanoleucas*	D-RA-C
Milk Snake	*Lampropeltis triangulum*	E-CA-U
Common Water Snake	*Natrix sipedon*	E-OA-U
Common Garter Snake	*Thamnophis sirtalis*	D-CA-U
Plains Garter Snake	*Thamnophis radix*	D-RA-C
Prairie Rattlesnake	*Crotalus viridis*	R-RA-U

(SEE TABLE 2.9-5A FOR STATUS CODES)

2.9.2 AQUATIC ECOLOGY

2.9.2.1 Introduction

Aquatic habitats on the Commercial Study Area consist of three streams and eight impoundments. English Creek, Squaw Creek, and White Clay Creek are first-order streams (smallest perennial streams marked on a 1:24,000-scale map) that form the drainage basin for the Commercial Study Area (Fig. 2.9-11). English Creek is entirely within the confines of the Commercial Study Area originating from springs on the eastern edge of Section 13 and flowing northerly for about 5.6 km (3.5 mi.) where it empties into Squaw Creek in Sec. 35. Squaw Creek orginates in the Nebraska National Forest and the Ponderosa State Wildlife Area to the southeast and flows through the Commercial Study Area to its confluence with White Clay Creek. White Clay Creek drains from the national forest to the south and flows northerly through the Commercial Study Area and empties into the White River. Seven of the eight impoundments are on-stream with four on English Creek, two on White Clay Creek and one on Squaw Creek. The remaining impoundment is a stock pond created by a dam on a small drainage area.

In addition, a spring fed impoundment just off the Commercial Study Area in Section 7 and the White River north of the Commercial Study Area were included for sampling.

The objectives of this study were designed to provide the information necessary to assess the aquatic resources of streams and impoundments on the Commercial Study Area. Specifically, the objectives of the study were as follows:

1. To determine water quality parameters.

2. To inventory and compile species lists of aquatic vertebrates, invertebrates and plants (macrophytes, algae and diatoms).

3. To determine the relative abundance and habitat utilization of aquatic vertebrates, invertebrates and plants.

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2.9.2.2 Methods

Surface Water Quality for Biological Studies. Streams and impoundments were selected for physical and biological sampling based on the following rules:

1. All streams and impoundments within the Commercial Study Area were chosen for collection of biological and water quality data (Fig. 2.9-11). Small diversion structures which are used primarily for irrigation were not considered as impoundments.

2. Within the 8 km Adjacent Area impoundments with permanent water, which could possibly support fish populations, and selected streams were chosen for collection of water quality data.

Information concerning water quality parameters in this section is not intended to replace that collected for studies of surface water hydrology, but to provide on-site information for biological studies. More comprehensive information on the various parameters of water quality are presented in Section 2.7.2 (Surface Water Hydrology).

Samples of surface water were taken from streams, springs and impoundments during February and April of 1982. The sampling time was made as uniform as possible with all field samples and physico-chemical determinations being made between 08:00 and 16:00 hours.

Nine physico-chemical determinations - air temperature, water temperature, dissolved oxygen, total alkalinity, carbon dioxide, pH, conductivity, turbidity and hydrogen sulfide - were made on each stream, spring or impoundment within or on the boundary of the Commercial Study Area. Impoundments within the Adjacent Area had six parameters - air temperature, water temperature, dissolved oxygen, pH, conductivity and hydrogen sulfide - checked during the February sampling session, and all parameters were checked during April.

Physico-chemical determinations were made with a portable Hach Direct - Reading Engineer's Laboratory (Model DR-EL/4). The following methods were used:

Temperature (Degrees C) Probe Method - Dissolved Oxygen Meter

Dissolved Oxygen (mg/l) Hach Portable Dissolved Oxygen Meter, Model 16046

Total Alkalinity (mg/l $CaCO_3$) Titration Method APHA Standard Methods, 14th ed., 278 (1975)

Carbon Dioxide (mg/l) Titration Method APHA Standard Methods, 14th ed. 298 (1975)

pH (pH Units) Electrode Method APHA Standard Methods, 14th ed., 460 (1975)

Conductivity (mhos/cm) Direct Measurement Method

Turbidity (Formazin Turbidity Units) Absorptometric Method FWPCA Methods for Chemical Analysis of Water and Wastes, 275 (1969)

Hydrogen Sulfide (mg/l) Lead Sulfide Method to determine if levels greater than 0.1 mg/l were present, in which case, an Orion Sulfide Ion Electrode (Model 94-16) was used for more accurate determinations.

Fish. A variety of sampling gear and methods was employed to collect fish from the Study Area streams and impoundments. Choice of equipment was dictated by the type of habitat being sampled, the effectiveness of the equipment, and by prior knowledge of the presence of important species. Methods used to collect fish included electrofishing, gill-netting, hoop-netting, minnow-trapping and angling with rod and reel.

The sampling effort expended in collecting fish was not standardized due to differences in the 1) amount of suitable habitat present, 2) types of habitats sampled, 3) sampling equipment used, and 4) abundance of fish present at each location. As such, fish were collected at each location to document their occurrence and to determine their relative abundance but no attempt was made to determine absolute densities.

At each sampling location all fish collected were identified, counted, measured for total length, and whenever possible returned unharmed to the water.

Benthic Macroinvertebrates. Quantitative samples of Benthic Macroinvertebrates were collected from soft substrates in streams and impoundments with a Ponar Dredge (0.022 m^2) and from gravel riffle substrates with a Surber Sampler (0.0093 m^2). All dredge and surber samples were collected in triplicate at each location. Samples were preserved in 70% ethanol.

Invertebrates were hand-picked from substrate material and identified to the lowest practical level with the aid of stereoscopic and standard taxonomic references (Ward and Whipple 1959; Pennak 1953). Data from Ponar and Surber samples were reported as number of individuals per square meter of bottom by multiplying by 45.93 and 10.76, respectively. Qualitative samples collected by sweep netting were used to augment the species list. Shannon-Weaver (1949) diversity indices were calculated for all Ponar and Surber samples.

Periphyton (Algae & Diatoms). Single qualitative samples of periphyton were collected at each sampling location by scraping the surface of several rocks, sticks, plants or other substrate material with a pocket knife and were preserved in 5% formalin. Preserved samples were identified under a compound microscope using appropriate taxonomic references (Ward and Whipple 1959; Prescott 1962; Weber 1966). Diatom proportional counts were performed at the generic level after counting a minimum of [illegible]50 valves. Green and blue-green algae were identified and their occurrence noted for each sampling location.

2.9.2.3 Results and Discussion

Water Quality. The sampling sites were grouped into two categories: streams, which included two springs (E-1 and E-2) at the upper end of English Creek, and impoundments (Fig. 2.9-11). The streams had flows ranging from .75 cms on the White River to less than 0.1 cms on lower Squaw Creek during the two sampling periods. Impoundments ranged in size from .2 ha to 7.7 ha for FR-3 and I-6 respectively.

Comparison of constituents at stream and spring sample sites for February and April are presented in Table 2.9-20. Dissolved oxygen was above 10 mg/l at all stream stations, with the exception of S-4 during February. The reduced dissolved oxygen at S-4 was probably due to ice coverage extending several hundred meters upstream from the sampling site. The spring, E-1, had dissolved oxygen levels below 10 mg/l during both sampling periods. While E-2 was below 10 mg/l only during February. Lower dissolved oxygen levels would be expected from springs, as groundwater generally has lower levels of dissolved oxygen than surface water.

Total alkalinity fluctuated little between February and April for the stream and spring sample sites, with the exception of E-3 (Table 2.9-20). Flow at E-3 in April was about 30% of that in February. The decreased flow would maintain the concentration of constituents picked up from the alluvial aquifer, and the four impoundments on English Creek were ice-free in April. Thus evaporation and the concentration of ions was greater in April than February. Total alkalinity increased between stations on a stream as distance increased between stations and the number of impoundments on a stream became greater.

The greatest concentrations of carbon dioxide (20 mg/l) was recorded at E-3. E-3 is a spring and groundwater often exceeds surface water concentrations of carbon dioxide. Lower concentrations of carbon dioxide were found in April than in February within stream stations. This may have been due to increased algae and the initiation of aquatic plant growth.

Hydrogen-ion concentration expressed as pH varied from 6.60 for spring station E-1 to 8.05 for stream station WC-1.

Conductivity, like alkalinity, increased with greater distance between stations on a stream and with a greater number of impoundments between the upstream and downstream stations. The highest

TABLE 2.9-20

SURFACE WATER QUALITY RESULTS FOR CROW BUTTE, 1982

SAMPLED STREAMS AND SPRINGS

	Stream Station											
	S-1		S-2		S-3		S-4		WA-1		SO-1	
Constituent	02/25	04/19	02/25	04/19	02/25	04/19	02/25	04/19	02/22	04/21	02/22	04/21
Air Temperature (Degrees C)	-3	4	-3	6	-1	7	1	8	16	13	21	13
Water Temperature (Degrees C)	1	5	1	7	1	8	1	10	5	12	8	10
Dissolved Oxygen (mg/l)	12.0	11.9	12.1	12.4	12.1	11.2	7.8	12.3	11.2	10.2	10.2	11.1
Total Alkalinity (mg/l $CaCO_3$)	206	195	213	195	215	198	286	257	165	193	160	180
Carbon Dioxide (mg/l)	12.0	4.0	11.0	5.0	11.0	5.5	15.0	9.0	11.5	9.0	10.5	9.0
pH	7.71	7.30	7.78	7.73	7.83	7.80	7.58	7.91	7.70	7.23	7.60	7.20
Conductivity (mhos/cm)	420	380	430	390	430	390	560	530	380	380	310	350
Turbidity (FTU)	3	6	3	4	8	8	10	9	3	4	7	4
Hydrogen Sulfide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

TABLE 2.9-20 (Cont)

SURFACE WATER QUALITY RESULTS FOR CROW BUTTE, 1982
SAMPLED STREAMS AND SPRINGS

Constituent	Stream Station													
	W-1		W-2		E-1*		E-2*		E-3		WC-1		WC-2	
	02/24	04/21	02/24	04/21	02/22	04/22	02/22	04/22	02/24	04/20	02/24	04/22	02/24	04/22
Air Temperature (Degrees C)	0	8	-1	9	18	15	18	15	3	3	3	16	4	19
Water Temperature (Degrees C)	3	4	3	6	11	9.5	10	12	4	4	3	8	2	9
Dissolved Oxygen (mg/l)	11.2	12.3	12.1	13.9	9.8	8.2	5.1	11.2	10.8	11.9	11.4	12.9	11.0	10.6
Total Alkalinity (mg/l $CaCO_3$)	187	178	191	186	230	213	226	205	209	375	192	182	244	233
Carbon Dioxide (mg/l)	15.0	10.0	17.0	11.0	13.5	15.0	20.0	10.0	17.5	8.0	8.0	9.0	18.0	11.0
pH	7.74	7.05	7.50	7.72	7.37	6.60	7.50	6.90	7.38	7.70	8.05	7.63	7.52	7.75
Conductivity (mhos/cm)	350	340	390	350	460	450	400	440	420	770	380	380	520	520
Turbidity (FTU)	28	12	31	3	7	7	12	5	12	6	9	10	12	15
Hydrogen Sulfide (mg/l)	<0.01	<0.01	<0.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Sample stations E-1 and E-2 are springs at the top of English Creek

conductivity reading (770 mhos/cm was recorded at E-3 in April. As was mentioned in the section on total alkalinity the flow at this station in April was very low and there are four impoundments upstream from it, thus limiting flow and increasing concentrations of salts from greater evaporation.

Turbidity values were low for all streams and springs. The highest value recorded was 28 FTU (formazin turbidity units) at W-1 in February. The streams in the project area have a sand and gravel substrate with little clay, silt or fine organic matter which are the major causes of higher turbidity values.

The high oxygen levels in the streams and springs precluded detectable levels of hydrogen sulfide (H_2S). These levels of oxygen would oxidize sulfides to sulfates.

Impoundments, with the exceptions of I-1, FR-8 and FR-9, had high levels of dissolved oxygen during February (Table 2.9-21). All impoundments were ice covered at this time. The average thickness was 25 cm and ranged from 10 to 50 cm. Impoundment I-1 is a small stock pond with little aquatic vegetation to produce oxygen. While FR-8 had a large amount of dead emergent vegetation at its upper end. This large amount of oxidizable material probably caused the low concentration of dissolved oxygen (1.9 mg/l). The water from FR-8 drains directly into FR-9 and combined with the dead emergent vegetation in FR-9 probably caused this impoundment to have a dissolved oxygen concentration of 2.6 mg/l. Impoundment L-1, however, had a supersaturation of 20 mg/l. This was probably due to the clearness of the ice and the amount of green plants beneath the ice.

Total alkalinity content of the impoundments within or on the boundary of the Commercial Study Area generally had the highest levels in April. This was probably due to low precipitation during early spring. More precipitation would have diluted ion concentrations in the impoundments. The lowest recorded total alkalinity was during February in I-1 (50 mg/l $CaCO_3$) during April. Total alkalinity values for the streams and impoundments fell within the range which are considered to have little direct affect on fish. However fish may be indirectly affected by total alkalinity, as waters with values below 40 mg/l are biologically less productive than those with higher values (Lagler, 1956).

The pH values for all impoundments, with the exception of L-1 which had a supersaturation of oxygen in February, were lowest in winter. Dissolved oxygen and carbon dioxide, both of which affect pH

TABLE 2.9-21

SURFACE WATER QUALTY RESULTS FOR CROW BUTTE, 1982
SAMPLED IMPOUNDMENTS

Constituent	I-1		I-2		I-3		I-4		I-5		I-6		I-7		I-8	
	02/17	04/21	02/17	04/22	02/17	04/20	02/17	04/20	02/17	04/20	02/16	04/19	02/16	04/20	02/16	04/21
Air Temperature (Degrees C)	9	12	11	17	14	3	13	3	11	2	12	8	12	3	14	11
Water Temperature (Degrees C)	1	8.5	4	7	1	3	1	5	1	6	1	9	1	6	1	8
Dissolved Oxygen (mg/l)	4.8	11.8	10.1	11.8	7.8	11.0	9.9	10.7	7.8	10.8	10.4	10.6	6.2	9.2	9.8	11.6
Total Alkalinity (mg/l $CaCO_3$)	50	88	201	211	182	228	149	230	213	248	141	190	298	237	184	217
Carbon Dioxide (mg/l)	8.0	7.0	9.0	10.0	10.0	11.0	10.0	11.0	9.0	10.0	9.0	11.0	14.0	12.0	8.0	9.0
pH	6.07	7.70	7.40	7.64	7.20	8.13	7.26	7.81	7.10	7.83	7.14	7.88	6.78	7.52	7.56	7.81
Conductivity (mhos/cm)	110	190	410	450	380	490	310	480	430	530	280	400	580	570	330	490
Turbidity (FTU)	47	26	28	16	8	28	11	20	6	48	58	115	34	10	55	26
Hydrogen Sulfide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

TABLE 2.9-21 (Cont)

SURFACE WATER QUALTY RESULTS FOR CROW BUTTE, 1982

SAMPLED IMPOUNDMENTS

Constituent	I-9		FR-1		FR-2		FR-3		FR-4		FR-5		FR-6	
	02/16	04/21	02/14	04/18	02/14	04/18	02/14	04/18	02/14	04/18	02/14	04/17	02/14	04/17
Air Temperature (Degrees C)	12	12	18	4	16	4	12	5	10	5	9	17	10	17
Water Temperature (Degrees C)	3	7	1	9	1	11	1	9	1	11	4	10	1	10.5
Dissolved Oxygen (Mg/L)	13.2	12.5	7.8	10.4	11.8	10.4	8.8	14.8	10.2	14.0	14.2	12.1	11.0	11.8
Total Alkalinity (Mg/L $CaCO_3$)	65	152		142		185		166		113		147		136
Carbon Dioxide (Mg/L)	5.0	12.0		10.5		10.0		10.0		4.5		10.0		9.0
pH	7.40	7.85	6.82	7.90	7.79	7.82	6.91	7.52	6.42	8.48	7.[illegible]0	7.55	7.15	7.89
Conductivity (mhos/cm)	150	340	310	250	380	390	120	280	120	240	420	350	400	310
Turbidity (FTU)	24	9		2		1		1		4		2		3
Hydrogen Sulfide (Mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

TABLE 2.9-21 (Cont)

SURFACE WATER QUALITY RESULTS FOR CROW BUTTE, 1982

SAMPLED IMPOUNDMENTS

	Impoundment													
	FR-7		FR-8		FR-9		B-1		M-1		M-2		L-1	
Constituent	02/14	04/17	02/14	04/17	02/14	04/17	02/15	04/18	02/15	04/18	02/15	04/18	02/15	04/18
Air Temperature (Degrees C)	10	17	7	17	5	17	12	17	10	17	9	17	4	14
Water Temperature (Degrees C)	1	11	1	12	1	13	1	9	1	11	1	11	1	12
Dissolved Oxygen (mg/l)	11.2	11.3	1.9	8.8	2.6	10.7	12.5	10.0	12.1	11.6	12.6	13.1	20.0	11.2
Total Alkalinity (mg/l $CaCO_3$)		121		136		166		334		220		161		162
Carbon Dioxide (mg/l)		9.0		11.0		12.5		5.0		3.5		3.0		7.0
pH	7.40	8.00	7.06	7.45	6.95	7.67	8.02	8.71	7.04	8.39	7.55	8.70	8.50	7.92
Conductivity (mhos/cm)	450	290	480	320	520	350	960	920	340	550	500	380	380	350
Turbidity (FTU)		4		4		4		155	42	42		22		10
Hydrogen Sulfide (mg/l)	<0.01	<0.01	2.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

values, are readily influenced by the processes of plants and animals. No extremely low or high pH values were recorded, as the lowest and highest values were 6.05 and 8.7 respectively.

The conductivity of the impoundments ranged from 110 to 960 mhos/cm. As with alkalinity there was generally a trend of higher conductivity readings for the downstream impoundments on a stream system.

The highest turbidity value for impoundments was greater than the highest for streams, 155 FTU and 28 FTU respectively. The greater amount of silt and especially fine organic matter provided by aquatic plants in the impoundments would cause this difference.

The only impoundment with a detectable level of hydrogen sulfide during February was FR-8 (2.0 mg/l). The large amount of dead emergent vegetation at the upper end of this impoundment, the ice covering and the low level of dissolved oxygen were responsible for this condition.

Habitat Characteristics. In general, all aquatic habitats on the Commercial Study Area suffer from ongoing environmental stresses. Naturally occurring stresses include: unstable substrates and banks, low flows, and periodic flooding. Overgrazing on adjacent rangelands and in riparian areas and farming practices along the stream courses further compound these problems. Commercial baitfish practices such as poisoning, dewatering and introducing bait minnows has affected many of the impoundments. Livestock grazing and watering add to impoundment problems. The end result to these environmental stresses is reflected in a fisheries mostly consisting of non-game, tolerant species. Periodic stocking by the Nebraska Game and Parks Commission has created some put-and-take sport fisheries in the area but these are not self-sustaining due to environmental factors.

English Creek. English Creek flows through rangeland on the Commercial Study Area. The riparian zone consists mostly of grasses and aquatic plants including cattails (*Typha* spp.), bulrushes (*Seirpus* spp.) and sedges (*Carex* spp.). Low flow and vegetation choked stream channel does not provide for much in the way of habitat for fish. On-stream impoundments and pools created by washouts below culverts provide about the only suitable fish habitat.

Squaw Creek. Squaw Creek changes dramatically from the upstream areas to the lower reaches. At the upper sampling station

(S-1) the pine and grass covered slopes, and the thick, undisturbed riparian zone provides for much more stable watershed. The substrates in this area consist of hardpan, gravel riffle areas, and some silted-in pools. The stream banks are relatively stable with overhanging trees and vegetation with some undercutting. The creek is generally less than 2 m wide. Log jams, undercut tree roots and banks and pools to 1.5 m deep provide cover and probably overwintering areas for fish.

From station S-2 downstream to I-6 Squaw Creek looks entirely different. Although cottonwoods continue to provide the overstory as in the upper reaches, the understory in this lower section has virtually been eliminated by livestock grazing. The stream banks are degraded and unstable and the substrate is mostly sand. The stream is generally less than 2 m wide. Few gravel riffle areas are present and most of the pools are heavily silted. Pools to 1.5 m deep, undercut tree roots and log jams provide cover for fish. Aquatic vegetation is rather sparse in this section of stream with some *Cladophora* growing in shallow fast-flowing areas.

The watershed in this lower area is unstable and, as evidenced by high-water debris, is subjected to periodic severe flooding. During the evening of 19 May 1982, about 2 inches of rain fell in one hour on the middle and lower Squaw Creek watershed. Considerable damage to roads and riparian areas on and below the Commercial Study Area was caused by this event. Squaw Creek flowed over the road one-half mile above I-6 causing gullies across the road. English Creek went over the road northwest of I-6, over U.S. Highway 20 and washed out the culvert at E-3. Squaw Creek was diverted into English Creek at I-6 which was the cause of the overflow on Highway 20 and the washing out of the culvert E-3. Bridges have been built on Squaw Creek to accommodate floods, whereas only culverts exist on English Creek which were designed to carry the flow of a much smaller watershed.

Sand and silt deposits up to 24 inches and log jams up to 4 feet above the channel were observed the following day on Squaw Creek above I-6. The damage to riparian areas on the Commercial Study Area aggravated by a flood of similar or greater proportions during the previous summer and the heavy use of these areas by livestock. Very little ground cover existed in riparian areas prior to the event, which could have reduced water velocity and the resultant damage.

Measurements of maximum depth and extent of flooding were taken the day following the event in an effort to estimate water volumes. These measurements were used to provide streamflow estimates for Squaw Creek stations S-1 and S-3 using an HP 67 Trapezoidal Channel Program. The estimated streamflow at S-1 was .18 cms while at S-2 it was 3.09 cms. The very high increase from S-1 to S-3, a distance of two miles, was probably due in part to less precipitation on the upper watershed, but mainly to differences of vegetation cover. Much of the upper watershed is forested and the area immediately above S-1 is the Ponderosa Wildlife Area where livestock grazing and cultivation is prohibited. Whereas, the middle and lower watershed is comprised of heavily grazed rangeland, cultivated small grains or summer fallow.

Estimates of streamflow below S-3 are much less accurate as water overflowed the stream channel, thus making it impossible to use the Trapezoidal Channel method. Based on highwater marks and other evidence, it would appear that flow in English Creek at E-3 was close to 5 cms.

The problem of flooding on English Creek could be greatly reduced or eliminated if more water could be released from I-6 or an emergency spillway constructed to prevent the water from Squaw Creek from flowing into English Creek. But most importantly, watershed management of Squaw Creek could be improved by reducing grazing pressure on rangelands, reducing or eliminating grazing in riparian zones and improving soil conservation practices for cultivated lands.

White Clay Creek. White Clay Creek flows through a riparian grass area at station WC-1. The stream channel is generally less than a meter wide with relatively stable stream banks provided by grasses. The substrate in this section is mud and sand. Depths range from 25 to 75 cm with no well defined pools or riffles. At station WC-2 the creek flows through pastureland. In this section the substrate consists of sand, gravel and rubble with some silting in pools. Riffle areas are present as well as pools to 75 cm deep. Although this area is grazed by livestock, the stream banks appear to be relatively stable.

White River. The White River has a shifting sand and silt substrate and appears turbid most of the time due to suspended materials. Very few riffle areas exist and pools are not well defined. Some shallow sand bars are present along the edges but for the most part depths range from 0.5 to probably 2 m. Eroding stream banks are present along most sections. Stream width varies from about

3 to 5 m. Cover for fish is provided by deep water, log jams and undercut tree roots. Some good riparian areas exist along the river especially around Fort Robinson State Park. Other riparian areas are heavily grazed and lack understory vegetation. The White River is subject to fluctuating water levels and flooding.

Impoundments. Impoundments range in size from .4 ha (I-1) to 7.7 ha (I-6). I-1 is a small stockwater pond created by an earthen dam on a small drainage basin. Heavy livestock use and lack of water during some periods have prevented the growth of aquatic vegetation. Other impoundments on the Commercial Study Area have extensive aquatic vegetation growth including: cattails, bulrushes, horned pondweed (*Zanichella* sp), aquatic buttercup (*Ranunculus* sp), smartweed (*Polygonum* spp), hornwort (*Ceratophyllum* sp) and stonewort (*Chara* sp). Impoundments I-4, 5, 6, 7, and 8 have been or are now being, managed for raising baitfish. In addition, some of these also serve as stock watering ponds. Impoundment I-9 has been stocked with brook trout for recreational fishing and also serves for stock watering.

Fish. The status and distribution of fish species for the Study Area are presented in Table 2.9-22. Fourteen species of fish were collected from the Commercial Study Area streams and impoundments (Table 2.9-23). Game fish collected included: black bullheads, rainbow trout, brown trout, and brook trout. Black bullheads were collected from White Clay Creek but were not present in sufficient numbers or of sufficient size to contribute to a sport fishery.

Brook trout were collected from Squaw Creek at several locations. Six brook trout were captured at station S-1 in approximately 500 m of stream. In over 1 km of stream sampled between station S-2 and I-6, two brook trout were collected. Trout ranged in size from 184 to 245 mm (7¼ to 9½ inches). Periodic stocking by the Nebraska Game and Parks Commission provides a limited put-and-take fishery of local importance in the Ponderosa State Wildlife area. The most recent stocking was done in 1981 when 500 5-inch and 9,611 2-inch brook trout were released. Previous stocking was done in 1977 and 1976.

Periodic severe flooding is probably the most important factor limiting the effectiveness of stocking and reducing the trout population in Squaw Creek.

Brown trout and rainbow trout were collected in the White River at station W-1 and brown trout were collected at W-2. Eight brown trout were captured in approximately 350 m of stream and ranged in size from 184 to 390 mm (7¼ to 15½ inches). Only one

TABLE 2.9-22

FISH SPECIES LIST

Family/Common Name	Scientific Name	Status
Hiodontidae		
Goldeye	*Hiodon alosoides*	R-OA
Salmonidae		
Brook trout	*Salvelinus fontinalis*	D-PP-O
Brown trout	*Salmo trutta*	D-AA-C
Rainbow trout	*Salmo gairdneri*	D-AA-C
Esocidae		
Northern pike	*Esox Lucius*	R-OA
Cyprinidae		
Fathead minnow	*Pimephales promelas*	D-PP-C
Creek chub	*Semotilus atromaculatus*	D-PA-C
Longnose dace	*Phinichthys cataractae*	D-PP-C
Golden shiner	*Notemigonus crysoleucas*	D-PA-C
Sand shiner	*Notropis stramineus*	D-PA-U
Common shiner	*Notropis cornutus*	R-OA
Red shiner	*Notropis lutrensis*	R-OA
Flathead chub	*Hybopsis gracilis*	R-OA
Plains minnow	*Hybognathus placitus*	D-PA-O
Carp	*Cyprinus carpio*	D-OA-C
Catostomidae		
White sucker	*Catostomus commersoni*	D-PA-C
Longnose sucker	*Catostomus catostomus*	R-OA
River carpsucker	*Carpiodes carpio*	R-OA
Ictoluridae		
Black bullhead	*Ictalurus melas*	D-PA-U
Channel Catfish	*Ictalurus punctatus*	D-OA-U
Stonecat	*Noturus flavus*	D-AA-O
Cyprinodontidae		
Plains topminnow	*Fundulus sciadicus*	D-PA-O
Percichthyidae		
White bass	*Morone chrysops*	D-OA-C

TABLE 2.9-22 (Cont)

FISH SPECIES LIST

Family/Common Name	Scientific Name	Status
Centrarchidae		
Smallmouth bass	*Micropterus dolomieui*	R-OA
Largemouth bass	*Micropterus salmoides*	D-OA-C
Green sunfish	*Lepomis cyanellus*	D-PA-C
Bluegill	*Lepouis macrochirus*	D-OA-C
Black crappie	*Pomoxis nigromaculatus*	D-OA-C
Peridae		
Walleye	*Stizostedion vitreum*	D-OA-C

TABLE 2.9-23
OCCURRENCE OF FISH SPECIES BY HABITAT

FISH SPECIES	English Cr.	Squaw Cr.	White Clay Cr.	White River	IMPOUNDMENTS 1	2	3	4	5	6	7	8	9
SALMONIDAE													
Brook Trout		X											X
Brown Trout				X									
Rainbow Trout				X									
CYPRINIDAE													
Creek Chub	X		X	X		X							
Fathead Minnow	X	X	X	X					X	X	X		
Longnose Dace		X	X	X									
Plains Minnow			X										
Sand Shiner				X		X							
Golden Shiner	X		X						X	X			
CATOSTOMIDAE													
White Sucker			X	X		X							
ICTALURIDAE													
Black Bullhead			X										
Stone Cat				X									
CYPRINODONTIDAE													
Plains Topminnow	X		X										
CENTRARCHIDAE													
Green Sunfish	X		X	X		X			X				
Number of Species	5	3	9	9		4			3	2			1
Sampling Method													
Electrofishing	o	o	o	o		o			o				o
Gill Netting													
Pond Netting													
Minnow Trapping	o	o	o	o		o			o				
Rod & Reel Angling													o

rainbow trout was caught and it measured 218 mm (8½ inches). A regionally important put-and-take fishery exists in the White River around the Fort Robinson State Park area. The most recent stocking was done in May, 1982, when 700-9 inch rainbow trout were released. In 1981 stocks of 800-9 inch rainbow trout and 700-9 inch brown trout were planted. In 1980 stocks of 1,400-9 inch brown trout and 2,000-9 inch rainbow trout were released and in 1979 a stock of 194-14 inch brook trout was also made.

Fluctuating flows, periodic flooding, sand and silt substrates, and warm water temperatures are probably the most important factors limiting natural trout production in the White River.

Longnose dace were the most abundant fish species captures at the White River stations and they appear to be an important forage fish for trout (Table 2.9-24). Several brown trout stomachs were examined and were found to contain from one to three longnose dace. Good benthic macroinvertebrate production areas in the White River are generally lacking and as a result aquatic insects are probably not as important in the diet as longnose dace.

Impoundment I-9 has been stocked with brook trout but it is not a public area and therefore provides only a limited amount of recreational fishing. The other impoundments have been, or are now, managed for baitfish production which includes fathead minnows and golden shiners. The presence of golden shiners in White Clay Creek and English Creek undoubtably results from these operations.

Benthic Macroinvertebrates. Aquatic insects accounted for 33 of the taxa identified and non-insect invertebrates made up the 18 remaining taxa (Table 2.9-25). Distribution of taxa within the insect orders was as follows: Diptera (true flies) 13; Coleopetra (beetles) 7; Ephemeroptera (mayflies) 4; Trichoptera (caddis flies) 4; Odonata (dragon flies and damsel flies) 3; Plecoptera (stoneflies) 1; and Hemiptera (true bugs) 1.

Non-insect invertebrates included snails (Gastropoda), leeches (Hirudinea), aquatic worms (Oligochaeta), Crustacea (crayfish, scuds, seed shrimp), clams (Pelecypoda), planaria (Turbellaria), and round worms (Nematoda).

Of approximately 6,500 macroinvertebrates counted and identified 33.6% were midges (Tendipedidae), 20.0% black flies (Simulidae), 19.1% aquatic worms (Obligochaeta), 14.5% biting midges (Ceratopogonidae), 7.0% mayflies, and 1.4% caddis flies. Together these six taxa accounted for over 95% of the total number of inverte-

TABLE 2.9-24

RELATIVE ABUNDANCE (PERCENT OCCURRENCE) OF FISH COLLECTED AT EACH SAMPLING LOCATION

	Streams								Impoundments								
Fish Species	E-3	S-1	S-2 S-3	S-4	WC-1	WC-2	W-1	W-2	1	2	3	4	5	6	7	8	9
Salmonidae																	
Brook trout		5.7	1.2														100
Brown trout							15.4	3.2									
Rainbow trout							3.9										
Cyprinidae																	
Creek Chub	1.8				73.2	0.6											
Fathead minnow	67.3	11.3	65.5	100	6.3	65.4							86.0	100	100		
Longnose dace		83.0	33.3		8.9	11.6	61.5	76.3									
Plains minnow						0.3											
Sand Shiner																	
Golden Shiner	12.7					0.6							3.1				
Catostonmidae																	
White Sucker					3.6	1.2	19.2	20.4									
Ictaluridae																	
Black bullhead						0.9											
Stone cat																	
Cyprinodontidae																	
Plains topminnoe						0.3											
Centrarchidae																	
Green sunfish	18.2				8.0	20.0				100		100	10.9				
Total Number in Sample	55	100	174	18	112	335	26	93		3		21	193	126	5		6

TABLE 2.9-25

OCCURRENCE OF BENTHIC MACROINVERTEBRATES IN STUDY AREA STREAMS AND IMPOUNDMENTS FOR SAMPLES COLLECTED IN APRIL 1982.

TAXON	English Cr.	Squaw Cr.	White Clay Cr.	White River	IMPOUNDMENTS 1	2	3	4	5	6	7	8	9
Class: Insecta (Insects)													
Order: Coleoptera (Beetles)													
Family: Dryopidae													
Helichus		X											
Family: Dytischidae													
Agabinus		X											
Hydrovatus		X											
Family: Elmiade													
Dubiraphia		X											
Neoelmis		X											
Optioservus		X											
Family: Hydrophilidae													
Berosus									X				
Order: Diptera (True Flies)													
Family: Anthomyiidae													
Limnophora	X	X											
Family: Ceratopogonidae													
Palpomyia	X	X	X	X	X		X						X
Family: Dolichopodidae	X												
Family: Ptychopteridae													
Bittacomorpha	X												
Family: Simulidae		X											
Family: Stratiomyiidae	X												
Euparyphus	X												
Odontomyia	X												
Family: Tendipedidae	X	X	X	X	X	X	X	X	X		X	X	X
Family: Tipulidae													
Hexatoma		X											
Limnophila		X											
Limonia		X											
Tipula		X											

TABLE 2.9-25 (Cont)

OCCURRENCE OF BENTHIC MACROINVERTEBRATES IN STUDY AREA STREAMS AND IMPOUNDMENTS FOR SAMPLES COLLECTED IN APRIL 1982.

TAXON	English Cr.	Squaw Cr.	White Clay Cr.	White River	IMPOUNDMENTS 1	2	3	4	5	6	7	8	9
Order: Ephemeroptera (Mayflies)													
Family: Baetidae													
Baetia		x		x									
Caenis								x			x		x
Callibaetis								x					
Tricorythodes		x		x									
Order: Hemiptera (True Bugs)													
Family: Gerridae													
Gerris		x											
Order: Odonata													
Suborder: Anisoptera (Dragon Flies)													
Family: Libellulidae													
Libellula							x						x
Suborder: Zygoptera (Damsel Flies)													
Family: Agrionidae													
Amphiagrion							x						
Family: Coenagrionidae								x					
Argia													x
Order: Plecoptera (Stoneflies)													
Family: Perlodidae													
Isoperla		x											
Order: Trichoptera (Caddisflies)													
Family: Hydropsychidae													
Cheumatopsyche		x											
Hydropsyche		x		x									

TABLE 2.9-25 (Cont)

OCCURRENCE OF BENTHIC MACROINVERTEBRATES IN STUDY AREA STREAMS AND IMPOUNDMENTS FOR SAMPLES COLLECTED IN APRIL 1982.

TAXON	English Cr.	Squaw Cr.	White Clay Cr.	White River	IMPOUNDMENTS 1	2	3	4	5	6	7	8	9
Family: Limnephilidae													
Hesperophylax		X											
Limnephilus	X												
OTHER INVERTEBRATES													
Class: Crustacea													
Subclass: Malacostraca													
Order: Amphipoda (Scuds)													
Family Gammaridae													
Gammarus	X												
Family: Talitridae													
Hyallela Axteca	X	X						X	X				X
Subclass: Malacostraca													
Order: Decopoda (Crayfish)													
Family Astacidae													
Orconectes Immunis	X	X	X	X									
Subclass: Ostracoda (Seed Schrimp)		X						X					
Class: Gastropoda (Snails)													
Order: Pulmonata													
Family: Ancylidae													
Ferrissia													X
Family: Lymnaeidae													
Lymnaea	X						X						
Family: Physidae													
Physa	X	X							X		X		X
Family: Planorbidae													
Gyraulus									X				

TABLE 2.9-25 (Cont)

OCCURRENCE OF BENTHIC MACROINVERTEBRATES IN STUDY AREA STREAMS AND IMPOUNDMENTS FOR SAMPLES COLLECTED IN APRIL 1982.

TAXON	English Cr.	Squaw Cr.	White Clay Cr.	White River	IMPOUNDMENTS 1	2	3	4	5	6	7	8	9
Class: Hirudinea (Leeches)													
Order: Arhynchobdellida													
Family: Erpobdellidae	X	X	X		X		X				X		X
Order: Rhynchobdellida													
Family: Glossiphonidae													
Glossiphonia Complanata	X	X											
Helobdella Stagnalis	X						X						X
Placobdella Rugosa					X								
Phylum: Nematoda (Round Worms)	X	X						X			X		
Class: Obligochaeta (Worms)													
Order: Opisthopora		X	X	X	X	X		X			X		
Order: Plesiopora	X	X	X	X	X	X	X	X	X	X	X		X
Order: Prosopora													X
Class: Pelecypoda (Clams)													
Order: Heterodonta													
Family: Sphaeridae													
Musculium					X								
Psidium	X	X	X		X								
Class: Turbellaria													
Order Tricladia (Planaria)		X											X
Number of Taxa	18	33	8	7	8	3	8	9	6	1	7	1	13

brates collected. Percent contribution of these taxa to the total number of benthic macroinvertebrates collected at each station is presented in Table 2.9-26. In general, midges or aquatic worms were numerically dominant of most sampling stations. Exceptions occurred at sampling stations E-1 and E-2 where biting midges were most abundant; station S-2 where caddis flies dominated; station S-2 where mayflies dominated; and at station S-3 where black flies were dominant. Aquatic worms occur widely in all types of habitats, but the greatest abundance is usually associated with organically rich substrates and such is the case in most of the impoundments.

Table 2.9-26 also presents data on other benthic macroinvertebrates community values. Although densities were high at most sampling stations, diversity values were low. The use of diversity indices is based on the generally observed phenomenon that relatively undisturbed environments support communities having large numbers of species with no individual species present in overwhelming abundance. Healthy streams usually have diversity values between 3.0 and 4.0, but many forms of stress tend to reduce diversity by making the environment unsuitable for some species or by giving other species a competitive advantage. Squaw Creek at S-1 was the only stream sampling station that had diversity values within this range indicating a higher quality and a more stable habitat.

The density and diversity of benthic macroinvertebrates in the impoundments also reflects the quality of habitat. Impoundment E-1 is a mud bottom stockpond with little aquatic vegetation that supports an impoverished benthic community. Impoundment I-9, on the other hand, is spring fed, cool, productive, has a rich organic substrate and supports a diverse and abundant benthic community.

<u>Periphyton</u>. The Periphyton community of the aquatic habitats on the Study Area was composed largely of diatoms (21 genera) with a few green algae (8 genera) and one blue-green algae (Table 2.9-27). In general, only minor differences were found between communities in the streams and those in impoundments.

A good diversity of diatoms was present at each sampling location with the number of genera ranging from 8 to 15 and averaging 11. *Cymbella, Nauicula, Nitzschia, Surirella,* and *Synedra* were the most common genera and were found in every sample. In addition,

TABLE 2.9-26

BENTHIC MACROINVERTEBRATE COMMUNITY VALUES FOR STUDY AREA STREAMS
AND IMPOUNDMENTS DERIVED FROM SAMPLES TAKEN IN APRIL, 1982.

SAMPLING LOCATIONS

Streams

Parameter/sample	E-1	E-2	E-3	S-1	S-2	S-2	S-3	S-4	WC-1	WC-2	W-1	W-2
Sampling Method*	D	D	D	S	D	S	S	D	D	D	D	D
Density (Org./m^2)												
1	5695	3766	3674	549	8451	377	8468	4777	322	[illegible]	505	3261
2	15387	1378	2251	785	6071	1754	3325	1883	9186	367	276	5741
3	18188	92	4271	785	2664	560	5[illegible]96	2526	6798	459	276	8451
$\bar{x}$	13090	1745	3399	706	5729	897	5896	3062	5435	428	352	5818
Diversity ($\bar{d}$)												
1	0.75	1.40	0.71	3.07	0.10	1.59	1.09	1.44	1.38	0.72	1.24	1.28
2	0.48	1.60	1.33	3.07	0.13	1.22	1.24	2.00	1.95	1.41	0.92	1.37
3	0.24	0	1.01	3.41	0.34	1.20	1.13	2.09	0.65	1.36	0.92	0.78
$\bar{x}$	0.49	1.0	1.02	3.18	0.19	1.34	1.15	1.84	1.33	1.16	1.03	1.14
No. of Taxa	11	9	7	22	5	8	16	9	8	4	3	7
Community Structure (% Occurrence)												
Taxon												
Tendipedidae	0.9	17.5	82.0	10.7	98.1	18.0	14.1	45.5	71.8	42.9	47.8	72.4
Oligochaeta		1.8	5.0	3.6	0.8	3.2	0.2	36.0	14.4	50.0	47.8	19.7
Ephemeroptera				20.3		65.2	6.8					7.9
Trichoptera			0.5	37.1	0.5	0.4	0.5				4.3	0.5
Ceratopogonidae	94.5	56.1		0.5		0.4	0.2	1.0	8.7	7.1		0.3
Simulidae				8.6		11.6	76.8					

Impoundments

Parameter/sample	1	2	3	4	5	6	7	8	9
Sampling Method*	D	D	D	D	D	D	D	D	D
Density (Org./m^2)									
1	0	6992	6155	4731	5190	138	965	505	12998
2	0	1288	6063	7165	8543		1010	138	10,151
3	46	13432	14698	2480	459		965	184	7578
$\bar{x}$	15	7237	8972	4792	4731	138	980	276	10242
Diversity ($\bar{d}$)									
1		1.07	0.96	0.85	1.06	0	1.37	0	1.48
2		1.09	1.17	1.31	0.17		1.37	0	2.10
3	0	0.64	0.66	1.47	1.96		2.07	0	1.49
$\bar{x}$	0	0.93	0.93	1.21	1.06	0	1.60	0	1.69
No. of Taxa	1	8	8	9	6	1	7	1	13
Community Structure (% Occurrence)									
Taxon									
Tendipedidae		3.8	19.2	12.3	87.7	48.4	100	37.4	33.6
Oligochaeta	100	89.8	78.3	81.3	3.6	39.1		39.5	19.1
Ephemeroptera				0.9		4.7		16.6	7.0
Trichoptera									1.4
Ceratopogonidae		1.7	0.6					4.2	14.5
Simulidae									20.0

* D = Ponar Dredge Sample; S = Surber Sample

TABLE 2.9-27

DIATOM PROPORTIONAL COUNTS (PERCENT OCCURRENCE) AND OCCURRENCE OF OTHER ALGAE BY SAMPLING LOCATION. DATA ARE FROM SAMPLES COLLECTED IN APRIL, 1982.

	Streams											Impoundments							
Diatoms	E-1	E-2	E-3	S-1	S-2	S-3	S-4	WC-1	WC-2	W-1	W-2	1	2	3	4	5	7	8	9
Acnanthes	17.9	1.2	0.3	76.7		14.3	19.7	22.3	2.0	40.3			2.8				4.3	2.6	2.1
Amphora	0.5			0.5				0.3									0.3	1.8	
Cocconeis			0.3	2.4	0.7	4.8	1.7	1.2	11.3	1.9	0.3	1.1			0.4	0.6	0.3	1.4	0.7
Cyclotella			2.1		2.2	1.0	8.2	7.6		0.6				0.3		6.6	6.0	1.0	0.9
Cymatopleura							0.4												
Cymbella	6.3	0.3	0.3	1.9	6.1	2.9	8.2	25.9	7.0	7.8	1.8		7.1	1.3	11.8	3.9	1.4	8.[illegible]	13.7
Diatoma		0.6		1.9				6.4	1.0	0.9	21.6		0.7						17.9
Epithemia	1.1						1.3		0.4					12.6	2.1	1.7	2.6	4.4	
Fragilaria	3.3	66.5	0.3	0.5	2.9			0.3					0.7		9.3		0.6		0.2
Gomphonema	14.4	0.3	80.5	3.4	4.3			0.3			7.5		17.3	0.3	1.7	5.8	2.3	9.9	0.7
Gyrosigma									0.4							0.3			
Hantzschia													0.4	0.5	0.4		0.[illegible]		
Melosira													[illegible]				0.6		
Meridion	0.8		0.3				2.1												
Nauicula	3.8	2.6	8.2	5.3	15.8	16.2	13.7	9.8	58.6	33.4	47.7		3.2	6.2	5.5	2.5	18.2	21.0	1.2
Nedium	0.3																		
Nitzschia	13.0	6.6	3.8	5.3	65.9	58.1	13.7	15.2	10.6	11.3	19.1		6.0	12.9	7.6	3.6	30.4	12.1	34.4
Rhopalodia									0.4					3.2		0.3	1.4	0.2	
Stauroneia	0.3													0.3				0.4	
Surirella	0.5	0.3	1.0	0.5	0.4	1.9	3.9	1.2	6.6	3.4	0.5		0.7	0.3	2.5	5.8	12.5	1.0	0.2
Syneura	37.8	22.0	2.7	1.5	1.8	1.0	27.0	9.5	2.0	0.3	1.5		60.1	62.2	58.6	69.1	19.0	35.6	27.9
Green Algae																			
Ceratophylum															X				
Chara															X	X			
Cladophora			X	X	X	X	X	X	X	X	X								
Mougeotia	X	X												X					
Oedigonium															X		X		
Rhizoclonium							X												
Spirogyra	X	X					X		X						X		X		
Zygnema	X	X					X								X		X		
Blue-green Algae																			
Anabaena																	X		

2.9(106) (12/15/82)

Synedra was numerically dominant in seven of 18 samples, *Nitzschia* 4/18, *Nauicula* 2/18, and *Cymbella* 1/18. Although *Surirella* was found in all samples, its percent occurrence was low and in only one sample did it occur in excess of 10%.

Green algae were found at all sampling locations, with the greatest development occurring in the impoundments. *Clodophora* was the most common and abundant green algae found in the streams and at some locations formed thick mats with tassels approaching a meter in length.

2.9.3 Potential Impacts

In the assessment of potential impacts of the proposed development, particular attention was paid to "Important Species" (USNRC 1980). These include (1) commercially or recreationally valuable species, (2) threatened or endangered species, (3) species affecting the well-being of species within criteria (1) or (2), (4) species which are critical to the structure and function of the ecological system or biological indicators of chemical pollutants or radionuclides in the environment.

Anticipated impacts of the proposed project, with particular reference to conditions presently existing within the Research and Development Restricted Area Boundary, are outlined below.

Short-term Impacts

Economic Considerations. Although the Pine Ridge area is among the most popular hunting and fishing areas in the state of Nebraska, most activities take place on public lands adjacent to the Commercial Study Area - Fort Robinson State Park, Fort Robinson Wildlife Area, Ponderosa Wildlife Area, the Nebraska National Forest, and the Oglalla National Grassland. The proposed project is not expected to diminish in any way the hunting and fishing opportunities on those areas.

The entire Commercial Study Area, including the Research and Development Restricted Area, is privately owned, and hunting and fishing opportunities are the prerogative of individual land-owners. Harvestable wildlife populations are relatively low, compared to the aforementioned public hunting areas, and a sport fishery is practically non-existent. Estimates of total annual harvest on the Commercial Study Area, based on observed phenomena and discussions with landowners, are: mule deer (fewer than 5); white-tailed deer (fewer than 5); other big game species (0); turkeys (fewer than 5); pheasants (fewer than 20); sharp-tailed grouse (fewer than 10); quail and partridges (0); doves and pigeons (fewer than 10); ducks and geese (fewer than 30); rabbits, all species (fewer than 10); squirrels (fewer than 10); game fish (0).

In the average year, there is probably no game mammal, bird or fish harvested from the Research and Development Restricted Area site. Of game species, only cottontail rabbits occur commonly on the site, and these are not normally hunted by area residents.

Flora. No threatened or endangered plant species was documented on the Commercial Study Area or Restricted Area. The Research and Development Restricted Area is dominated by disclimax flora, with a low productivity. Considerable opportunity for floristic enhancement exists.

Mammals, General. No threatened or endangered species was documented on the Commercial Study Area or Restricted Area.

Big Game Mammals. The Research and Development Restricted Area site affords marginal to unsuitable habitat for white-tailed deer and mule deer. Other big game species are absent.

Carnivores. Red foxes, coyotes, raccoons, long-tailed weasels, and striped skunks are expected to occur regularly but in low numbers on the Research and Development Restricted Area site. Impacts are expected to be in direct proportion to the reduction in suitable prey species, including small mammals, birds and insects. If reasonable attention is given to protection of vegetation during the operational phase, there is no reason to anticipate a significant reduction in the prey base.

Birds, General. No federal- or state-designated threatened or endangered species was documented on the Research and Development Restricted Area site. Bald Eagles, protected under federal act, were recorded on the Adjacent Area, including one on the Commercial Study Area, but were not observed on or adjacent to the Restricted Area site. The species is an uncommon winter resident and migrant. Critical habitat does not exist for the species within or near the study area.

Game Birds. Of game birds, only a single turkey was recorded on the Research and Development Restricted Area site. No significant impacts are anticipated.

Raptors. The Research and Development Restricted Area site lies within the nesting territories of a pair of golden eagles and a pair of red-tailed hawks. A pair of great horned owls nests on the perimeter of the site. The Restricted Area is also utilized by rough-legged hawks, northern harriers, prairie falcons, and kestrels. Impacts are expected to be in direct proportion to any reduction in suitable prey, including small mammals, birds, reptiles and insects. In view of the degraded range conditions on the site (see text), it is probable that habitat conditions for rodents, lagomorphs, and other suitable prey species can be enhanced during the operational and reclamation stages of development, if attention is paid to vegetation protection and rehabilitation.

Reptiles, Amphibians and Fish. No threatened or endangered species were recorded, and none is expected to occur on the Commercial Study Area or Research and Development Restricted Area. Owing to the unstable nature of Squaw Creek on the northern edge of the Restricted Area, it is likely that aquatic conditions can be enhanced during the operational phase, if attention is paid to vegetation protection and rehabilitation.

Disturbances, General. Disturbances from construction and operational activities are not expected to greatly exceed those which already exist on and adjacent to the Research and Development Restricted Area - roads, the Burlington-Northern railroad, a high-tension power line, telephone lines, residential, farming and ranching activities.

Long-term Impacts

No long-term impacts from the project are anticipated, and no impairment of ecological stability, or diminishment of biological diversity.

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SECTION 2.10

BACKGROUND RADIOLOGICAL CHARACTERISTICS

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2.10 BACKGROUND RADIOLOGICAL CHARACTERISTICS

2.10.1 Introduction

This section contains a description of the environmental sampling program that Wyoming Fuel Company used to assess radiological background conditions of the area in the vicinity of the Crow Butte R&D Project. The results of this program in conjunction with an operational monitoring program will be used to determine the effects on the environment, if any, of the Crow Butte R&D Project. Over a period in excess of one year, samples have been collected and analyzed for the concentration of radionuclides in premining environment. This program will be concluded in April 1983. The program included samples of the air, ground water, surface water, soils, sediments, vegetation, and fish. The results of the program indicate the existing concentrations of the radionuclides are in the range reported in similar studies. The only anomalies reported were elevated radium-226 levels in some ground water samples. This increase in radium-226 is to be expected in ground water that has migrated through mineralized strata containing uranium.

In order to determine background radiological conditions in the immediate area of the Crow Butte R&D Project, Wyoming Fuel Company initiated an environmental sampling program in the fourth quarter of 1981. This program was designed to meet the criteria outlined in the USNRC Regulatory Guide 4.14, Radiological Effluent and Environmental Monitoring at Uranium Mills(1980). Lower limits of detection for the program described below are equivalent to those specified in USNRC Regulatory Guide 4.14. An air sampling program was initiated in April 1982. This program evaluated the background concentration of various airborne radionuclides including ambient radon-222 levels. Gamma dosimeters were also distributed through the area in April 1982. Sampling of private water wells began in October 1981 and by April 1982 selected area wells were sampled on a quarterly basis.

Soils in the region have been sampled for the concentration of natural uranium and radium-226. Soils in the immediate area of the proposed plant, ponds and wellfield have also been sampled. Surface water in Squaw Creek was collected at two locations on a quarterly basis. Samples of sediments from the creek were also obtained at these locations. Water and sediment samples were taken from several area impoundments. Samples of fish were obtained from Squaw Creek and selected impoundments. Vegetation samples have been collected near the air monitoring stations. In June 1983 samples of area crops will be collected.

Table 2.10-1 summarizes the preoperational radiological monitoring program currently being concluded at the Crow Butte R&D Project. Figure 2.10-1 included in a map pocket is a topographic map of the region surrounding the proposed R&D in-situ uranium project showing the locations of the various sample sites.

2.10.2 Air Sampling Program

Four locations were chosen for air monitoring stations. The placement of these stations was based on wind data obtained at Scottsbluff, Nebraska located approximately 98 km (61 mi) south of the R&D restricted area. Section 2.5 "Meteorology" contains the data along with a wind rose constructed from the data. The data from Scottsbluff were used since it is the closest National Weather Service Station to

TABLE 2.10-1
RADIOLOGICAL PREOPERATIONAL MONITORING PROGRAM
CROW BUTTE R&D PROJECT

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
AIR Particulates						
	Three	Nearest residence with highest predicted airborne radionuclide concentration in each of the two prevailing wind directions and near the town of Crawford	Continuous low volume air sampler with glass fiber filter	Weekly filter change or more frequently, as required by dust loading	Quarterly composite of filters according to location	Natural Uranium Th-230, Ra-226 Pb-210
	One	Control location least prevailent wind direction	same	same	same	same
Radon Gas						
	Four	Same locations as air particulates	Grab[1]	Monthly	Each sample	Rn-222

[1] A grab sample shall consist of at least three(3) separate forty-eight(48) hour composite samples during a period of one(1) month.

Background Radiological Characteristics (Cont'd)

Type of Sample	Sample Collection: Number	Location	Method	Frequency	Sample Analysis: Frequency	Type of Analysis
WATER Ground Water						
	One from each water supply well	All wells within 1 km of R&D restricted area boundary	Grab	Once	Each sample	Total:Natural Uranium, Th-230 Ra-226, Pb-210. Po-210
		Selected wells	Grab	Quarterly	Each sample	Total:Natural Uranium, Ra-226 Pb-210, Po-210 Th-230
	One from each DEC baseline well and monitor well	As required by DEC	Grab	Quarterly	Each sample	Total:Natural Uranium, Ra-226
				Once	Each sample	Th-230, Pb-210
Surface Water						
	One from each body of water	All large permanent impoundments within 2½ mile radius of R&D wellfield	Grab	Semiannually	Each sample	Total:Natural Uranium, Th-230 Ra-226, Pb-210 Po-210
	Two from Squaw Creek	One up-stream, one down-stream of restricted area	Grab	Quarterly	Each sample	Total:Natural Uranium, Th-230 Ra-226
				Semiannually (down-stream only)	Each sample	Pb-210, Po-210

Background Radiological Characteristics (Cont'd)

Type of Sample	Sample Collection: Number	Location	Method	Frequency	Sample Analysis: Frequenc	Type of Analysis
SEDIMENT						
	One from each body of water	From each permanent impoundment within 2½ mile radius of R&D wellfield	Grab	Once	Each sample	Natural Uranium, Th-230, Ra-226, Pb-210
	Two from Squaw Creek	One up-stream, one down-stream of restricted area	Grab	Semiannually	Each sample	Natural Uranium Th-230, Ra-226, Pb-210
SOIL Surface						
	Two	Plant site before topsoil removal	Grab (top 5 cm)	Once	Each sample	Natural Uranium Ra-226
	Two	Plant site after topsoil removal	Grab (top 5 cm)	Once	Each sample	Natural Uranium Ra-226
	Three	Wellfield	Grab (top 5 cm)	Once	Each sample	Natural Uranium Ra-226

Background Radiological Characteristics (Cont'd)

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
	Two	Evaporation ponds before excavation	Grab (top 5 cm)	Once	Each sample	Natural Uranium Ra-226
	One each	Air sampling stations	Grab (top 5 cm)	Once	Each sample	Natural Uranium Ra-226
	One each	Ten location in Section 19	Grab (top 5 cm)	Once	Each sample	Natural Uranium Ra-226
Subsurface						
	One	Plant site	One-third meter composites to a total depth of one meter	Once	Each sample	Natural Uranium Ra-226
	Two	Wellfield	same	same	same	same
	One each	Evaporation ponds (after excavation at deepest point)	Composite core sample to two meters	Once	Each sample	Natural Uranium Ra-226
VEGETATION						
	One each	Air sampling stations	Composite of dominant vegetation present	Once during grazing season	Each sample	Natural Uranium Th-230, Ra-226 Pb-210, Po-210

Background Radiological Characteristics (Cont'd)

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
	One each	Plant site, wellfield	Composite of dominant vegetation present	Once during grazing season (June 83)	Each sample	Natural Uranium Th-230, Ra-226 Pb-210, Po-210
FISH						
	Each significant body of water	Fish from each body of water if a significant pathway to man exists	Grab	Once	Each sample	Natural Uranium Th-230, Ra-226, Pb-210, Po-210
DIRECT RADIATION						
	One each	Air sampling stations and selected area locations	Dosimeter	Continuous	Quarterly	Gamma exposure rate using a continuous integrating device
		Closely spaced grid through wellfield, evaporation ponds and plant areas	Grab	Once	Once	Gamma exposure rate using properly calibrated NaI scintillometer

the Crow Butte R&D Project. From the wind rose it is apparent that the data comprise a bimodal distribution, the two predominant directions being west-northwest and east-southeast. Because of this wind pattern, air monitoring stations were located at AM-1 and AM-2 to correspond to residences with the highest predicted offsite concentrations (See Figure 2.10-1).

The least prevalent wind direction is from the southwest and therefore the air monitoring station located at AM-7 will be used as a background location during the operational phase of the Crow Butte R&D Project. The fourth air monitoring station was located near the town of Crawford and designated AM-6. This site will be used to determine if any increase in the concentration of airborne radionuclides can be measured near Crawford.

All four stations are identical and consist of a Weathertronics, Incorporated instrument shelter standing approximately 1.5 m (5 ft) above ground level. An Eberline Instrument Corporation, RAS-1 Regulated Air Sampler is housed in the shelter. The inlet to the sampler is fitted with a 47 mm filter holder and Gelman type A/E glass fiber filters are used. These filters remove 99.9% of the particles larger than 0.3 μm. The samplers are operated continuously with filter changes on a weekly basis. The flow rates are recorded during each filter change and adjusted to a flow indicator reading of 20 lpm. At this setting the actual flow rate is 18.6 slpm. The filters are composited according to location and analyzed on a quarterly basis. The samplers are calibrated semiannually. Calibration is accomplished using a Teledyne Hastings-Raydist mass flow meter that is certified and calibrated with standards traceable to the National Bureau of Standards(NBS).

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Radon-222 is also measured at the air monitoring stations. The air sample is collected using an Environmental Measurements, Incorporated, Radon I Sampler. This system is a single-pump, single-bag sampler designed to collect a composite ambient air sample over a preselected time interval. Particulates are removed by an inline 37 mm diameter, 5 micron filter. The sample bag is made of Tedlar and has a 30 liter volume. The system is housed in a 225 liter plastic drum.

This unit is used to collect three consecutive composite air samples per month at each air monitoring station. The three samples represent two 48-hour and one 72-hour composite sample. The air in the sample bag is analyzed by WFC personnel for the concentration of radon-222 by using a Lucus cell and an Eberline Instrument Corporation SAC-R5 scintillation detector with an MS-3 scaler.

The specifications for these instruments and those used for air particulate sampling are listed in Appendix 5.7(A). Detailed written operating procedures are also included as well as the calibration techniques. Samples of the data collection forms are shown.

Air sampling will be completed at the end of the first quarter in 1983. The first two quarters of air sampling were completed at the end of September 1982. The results of the air particulate analyses for the first two quarters of sampling are shown in Table 2.10-2. The analyses were performed by Core Laboratories in Denver, Colorado. The filters from each of the four monitoring stations were analyzed for the concentrations of natural uranium, thorium-230, radium-226 and lead-210. From these analyses and the total volume of air sam-

TABLE 2.10-2

RESULTS OF THE AIR PARTICULATE SURVEY

CROW BUTTE R&D PROJECT

Station Location		Natural Uranium $(\mu Ci/ml)x10^{-16}$	Thorium-230 $(\mu Ci/ml)x10^{-16}$	Radium-226 $(\mu Ci/ml)x10^{-16}$	Lead-210 $(\mu Ci/ml)x10^{-16}$	Volume of Air Sampled M^3
AM-1	2nd Quarter 82	1.43	0.0 ± 9.94	2.49 ± 1.24	108. ± 22.4	2,087
	3rd Quarter 82	<0.64	----	1.34 ± 0.730	138. ± 8.89	2,464
AM-2	2nd Quarter 82	3.54	0.0 ± 9.68	2.58 ± 1.94	86.4 ± 21.9	2,108
	3rd Quarter 82	<0.69	----	1.04 ± 0.736	140. ± 9.66	2,310
AM-6	2nd Quarter 82	<0.7	11.9 ± 12.6	1.40 ± 1.40	61.5 ± 21.0	2,047
	3rd Quarter 82	<0.71	----	1.18 ± 0.826	147. ± 9.86	2,247
AM-7	2nd Quarter 82	<0.7	4.47 ± 22.4	7.67 ± 3.20	125. ± 23.9	2,127
	3rd Quarter 82	<0.65	----	1.08 ± 0.541	137. ± 9.03	2,442
10 CFR Part 20 Appendix B Table II		50,000	800	30,000	40,000	

pled, the concentration in air is calculated and listed in Table 2.10-2 as μCi/ml of air.

As can be seen from this table the concentrations of radionuclides do not vary greatly between the four locations and are in the range considered to be background. All locations had natural uranium concentrations below the detection limit of $0.6x10^{-16}$ μCi/ml for at least one quarter, while AM-2 recorded the maximum uranium concentration of $3.54x10^{-16}$ μCi/ml. The maximum concentration reported for Anaconda's Rhode Ranch Project in South Texas is $3.x10^{-16}$ μCi/ml while in Wyoming at Conoco's Sand Rock Mill Project the concentration of uranium was reported to average $20.3x10^{-16}$ μCi/ml (Texas Department of Health,1982; USNRC,1982). In contrast, uranium concentrations in the air in New York City have been reported to vary between $0.7x10^{-16}$ and $10.x10^{-16}$μCi/ml (Eisenbud,1973).

The thorium-230 values at the Crow Butte R&D Project ranged from $0.0x10^{-16}$ to $11.9x10^{-16}$ μCi/ml. The values reported at the Sand Rock Mill Project are in this range while those reported in south Texas are slightly lower. The radium-226 concentrations in the study area ranged from $1.04x10^{-16}$ μCi/ml at AM-2 to $7.67x10^{-16}$ at AM-7. Lead-210 varied from $61.5x10^{-16}$ μCi/ml to $147.x10^{-16}$ μCi/ml at AM-6. These values are consistent with those reported in both South Texas and Wyoming. Atmospheric concentrations of lead-210 have been reported to range from $48.x10^{-16}$ to $260.x10^{-16}$ μCi/ml (Eisenbud, 1973).

Also included in Table 2.10-2 are the values listed in 10 CFR Part 20 Appendix B Table II. These values represent the maximum offsite concentration of the various radionuclides and are given for the insoluble fraction since it is generally more restrictive than the limits for the soluble fraction. These limits are applicable after consideration of naturally occurring background concentrations. The background concentrations measured at the Crow Butte R&D Project generally range from 0.5 percent of the thorium-230 and lead-210 limit to less than 0.001 percent of the uranium limit.

The results of the radon sampling are presented in Table 2.10-3. This table lists the values for the concentration of radon in air that were obtained at the four air monitoring stations for the months of April through November. These data represent two-thirds of a year-long monitoring program. Values are listed for each composite sample collected and analyzed during the month.

The average values for the eight month period range from a low of 0.15×10^{-9} µCi/ml at AM-1 to a high of 0.24×10^{-9} µCi/ml at AM-6. AM-7, the background location averaged 0.19×10^{-9} µCi/ml. Values for radon-222 near the area of the proposed Sand Rock Mill Project in Campbell County, Wyoming have been reported to range from 0.01×10^{-9} to 0.81×10^{-9} µCi/ml (USNRC,1982). Average values ranging from 0.15×10^{-9} to 0.20×10^{-9} µCi/ml of radon-222 have been measured in the region of the Rhode Ranch Project in South Texas (Texas Department of Health,1982). The outdoor levels of radon-222 vary widely and have been reported to range from 0.04×10^{-9} to 2.0×10^{-9} µCi/ml (USNRC,1979a,USEPA,1979). The limit for radon-222 stated in Table II of Appendix B, 10 CFR Part 20 is $3. \times 10^{-9}$ µCi/ml. This limit is for unrestricted locations and is applied after correction for the background radon-222 concentration.

TABLE 2.10-3
RESULTS OF THE RADON SURVEY
CROW BUTTE R&D PROJECT

	Air Monitoring Station No. 1 ($\mu Ci/ml$)x10^{-9}	Air Monitoring Station No. 2 ($\mu Ci/ml$)x10^{-9}	Air Monitoring Station No. 6 ($\mu Ci/ml$)x10^{-9}	Air Monitoring Station No. 7 ($\mu Ci/ml$)x10^{-9}
April	0.02 ± 0.25	0.09 ± 0.18	0.08 ± 0.45	-0.03 ± 0.45
	0.11 ± 0	0.20 ± 0.82	0.21 ± 0.36	0.14 ± 0.54
	0.01 ± 0.2	0.34 ± 0.38	-0.07 ± 0.36	0.1 ± 0.09
May	0.16 ± 0.27	0.08 ± 0.27	0.25 ± 0.45	0.03 ± 0.45
	-1.03 ± 0.27	-0.05 ± 0.18	-0.09 ± 0.36	-0.12 ± 0.27
	0.09 ± 0.72	-1.45 ± 0.09	-0.15 ± 0.54	0.10 ± 0
June	-0.09 ± 0.27	0 ± 0.09	0.17 ± 0.27	0.22 ± 0.45
	0.01 ± 0.18	-0.22 ± 0.36	0.07 ± 0.18	0.08 ± 0.18
	0.01 ± 0.18	0.03 ± 0.36	0.29 ± 0.18	0.02 ± 0.09
July	0.07 ± 0.36	0.11 ± 0.36	0.30 ± 0.36	0.13 ± 0.18
	0.05 ± 0.09	0.07 ± 0.09	0.16 ± 0.18	0.03 ± 0.27
	0.21 ± 0.18	0.14 ± 0.09	0.05 ± 0.27	0.14 ± 0.45
August	0.19 ± 0.36	0.06 ± 0.09	0.07 ± 0.36	0.35 ± 0.72
	0.10 ± 0.09	0.11 ± 0.27	0.38 ± 0.54	0.26 ± 0.36
	0.30 ± 0.27	0.09 ± 0.27	0.09 ± 0.09	0.25 ± 0.18
September	0.06 ± 0.36	0.09 ± 0.63	0.27 ± 0.54	0.08 ± 0
	0.21 ± 0.54	0.27 ± 0.27	0.22 ± 0.45	0.27 ± 0.27
	0.49 ± 0.45	0.18 ± 0.36	0.44 ± 0	0.06 ± 0
October	0.14 ± 0.36	0.38 ± 0.81	0.07 ± 0.36	0.21 ± 0.63
	0.08 ± 0.09	0.27 ± 0.54	0.50 ± 0.63	0.32 ± 0.36
	0.28 ± 0.45	0.14 ± 0.18	0.49 ± 0.27	0.38 ± 0.45
November	0.30 ± 0.63	0.47 ± 0	0.21 ± 0.27	0.29 ± 0.36
	0.14 ± 0.27	0.60 ± 0.72	0.40 ± 0.27	0.52 ± 0.45
	0.26 ± 0.72	0.16 ± 0.63	0.33 ± 0.54	0.30 ± 0.27
Range	-1.03 to 0.49	-1.45 to 0.60	-0.15 to 0.50	-0.12 to 0.52
Average	0.15	0.19	0.24	0.19

2.10.3 Water Sampling Program

Ground Water. In the area around the Crow Butte R&D Project twenty private water wells were used to determine the concentrations of various radionuclides in the ground water. The locations of these wells are shown in Figure 2.10-1. Samples from these wells were analyzed for common ions, trace metals and the radionuclides. Section 2.11 describes the results of the analyses for water quality, this section will be limited to the results of the radiometric analyses.

The sampling program began in October 1981 when a few wells were sampled. By May 1982 all twenty wells had been sampled at least once. The samples were collected at a discharge point closest to the well. The four to eight liter sample is acidified with 2 ml/l of concentrated nitric acid and sent to the laboratory for analysis. The samples were not filtered and the results represent the concentration of the dissolved and suspended radionuclide. The primary analytical laboratory was Core Laboratories, Inc. in Denver Colorado. Some of the analyses for uranium and radium-226 were performed by Natural Resources Laboratory in Denver, Colorado. Duplicate analysis were performed on sample splits by Jordan Laboratories in Corpus Christi, Texas.

Table 2.10-4 contains the results of the analyses on all twenty wells for the concentration of natural uranium, thorium-230, radium-226, lead-210, and polonium-210. Four of the wells have been sampled three times and analyzed for the concentration of the five radionuclides. These four wells are within one kilometer of the Crow Butte R&D Restricted area and will be sampled for one more quarter to complete a one year sampling program. As the results become available they will be submitted to the NRC. The results of the analyses indicate

TABLE 2.10-4
RESULTS OF THE RADIOMETRIC
ANALYSIS OF AREA WATER WELLS
CROW BUTTE R&D PROJECT

Well No. See Figure 2.10-1 For Location	Date of Sample	Lab	Nat. Uranium (µCi/ml)x10^{-9}	Thorium-230 (µCi/ml)x10^{-9}	Radium-226 (µCi/ml)x10^{-9}	Lead-210 (µCi/ml)x10^{-9}	Polonium-210 (µCi/ml)x10^{-9}
8	05/10/82	Core	14	0.1 ± 0.3	0.3 ± 0.1	0.7 ± 0.7	0.1 ± 0.2
11	05/04/82	Core	5.	0.3 ± 0.5	0.3 ± 0.1	0.0 ± 0.7	0.5 ± 0.4
12	05/10/82	Core	2.	0.7 ± 0.5	0.2 ± 0.1	0.6 ± 0.8	0.2 ± 0.2
13	04/29/82	Core	5.	0.0 ± 0.2	0.1 ± 0.1	0.2 ± 0.7	0.5 ± 0.3
16	05/04/82	Core	5	0.5 ± 0.6	0.3 ± 0.1	0.0 ± 0.8	0.3 ± 0.2
17	04/28/82	Core	1	0.1 ± 0.6	0.4 ± 0.1	0.4 ± 0.6	0.1 ± 0.3
	07/13/82	Core	6*	0.0 ± 0.8	0.1 ± 0.1*	0.0 ± 3.5	0.4 ± 0.3
	10/05/82	Core	4*	----	0.6 ± 0.1	0.0 ± 1.8	0.1 ± 0.1
24	05/08/82	Core	2	0.2 ± 0.4	0.3 ± 0.1	0.0 ± 0.7	0.0 ± 0.1
25	04/28/82	Core	2	0.0 ± 0.3	0.3 ± 0.1	0.5 ± 0.6	0.6 ± 0.3
	04/28/82	Jordan	3	-0.4 ± 2.7	0.1 ± 0.1	-1.5 ± -2.3	-.02 ± 0.2
	07/13/82	Core	4*	0.3 ± 1	0.1 ± 0.1*	0.9 ± 3.6	1.4 ± 1.0
	10/04/82	Core	5*	----	0.4 ± 0.1	0.0 ± 1.6	0.3 ± 0.4
26	04/28/82	Core	2	0.6 ± 0.5	0.3 ± 0.1	0.0 ± 0.6	0.2 ± 0.2
	07/14/82	Core	4*	0.0 ± 0.8	0.2 ± 0.1*	0.0 ± 3.2	0.3 ± 0.9
	10/05/82	Core	8*	----	0.4 ± 0.1	0.0 ± 1.6	1.3 ± 1.2
27	05/08/82	Core	3	0.4 ± 0.4	0.3 ± 0.1	0.4 ± 0.7	0.4 ± 0.3
	07/14/82	Core	4	0.6 ± 1.0	0.2 ± 0.1	0.0 ± 3.4	0.0 ± 0.5
	10/05/82	Core	3	----	0.5 ± 0.2	0.0 ± 1.7	0.6 ± 0.5

TABLE 2.10-4
RESULTS OF THE RADIOMETRIC
ANALYSIS OF AREA WATER WELLS
CROW BUTTE R&D PROJECT
(CONT.)

Well No. See Figure 2.10-1 For Location	Date of Sample	Lab	Nat. Uranium (μCi/ml)x10^{-9}	Thorium-230 (μCi/ml)x10^{-9}	Radium-226 (μCi/ml)x10^{-9}	Lead-210 (μCi/ml)x10^{-9}	Polonium-210 (μCi/ml)x10^{-9}
28	05/08/82	Core	3	0.1 ± 0.4	0.5 ± 0.1	0.7 ± 0.7	0.3 ± 0.2
31	05/06/82	Core	3	0.0 ± 0.3	0.1 ± 0.1	0.0 ± 1.0	0.2 ± 0.2
37	05/04/82	Core	4	0.2 ± 0.4	0.3 ± 0.1	0.0 ± 0.7	0.5 ± 0.3
38	05/04/82	Core	6	0.4 ± 0.6	0.2 ± 0.1	0.0 ± 0.7	0.3 ± 0.5
41	05/06/82	Core	2	0.7 ± 0.5	0.4 ± 0.1	0.0 ± 0.8	0.5 ± 0.4
57	04/28/82	Core	5	0.8 ± 0.7	0.4 ± 0.1	0.9 ± 0.7	0.3 ± 0.3
58	05/04/82	Core	10	0.5 ± 0.4	0.5 ± 0.1	0.0 ± 0.7	0.5 ± 0.5
59	05/04/82	Core	26	1.0 ± 0.6	0.2 ± 0.1	0.4 ± 0.9	0.6 ± 0.3
62	04/27/82	Core	22	0.4 ± 0.5	13.8 ± 0.6	10.6 ± 1.3	0.8 ± 0.4
	04/27/82	Jordan	21	.7 ± 1.7	17. ± 1.	22. ± 4.	0.9 ± 0.3
63	04/28/82	Core	8	0.1 ± 0.5	0.5 ± 0.1	0.1 ± 0.7	0.5 ± 0.3

* Analyses performed by Natural Resource Laboratory.

concentrations of the radionuclides are within the expected ranges for naturally occurring background concentrations. Duplicate analyses were performed on two samples and the agreement between the laboratories was good.

Table 2.10-5 lists the uranium and radium-226 concentrations in seven wells selected from the twenty. These wells have been sampled quarterly for at least four quarters. Six of the seven wells are completed in the Brule Formation and exhibit low concentrations of uranium and radium-226. Well 62 is completed in the Chadron Formation and has higher concentrations of both uranium and radium-226 than the wells completed in the Brule Formation. Radium-226 in this well is above the USEPA limit for public water supplies of $5.x10^{-9}$ μCi/ml. This situation is not uncommon in wells that are completed in highly mineralized formations. Also included in Table 2.10-5 are the results of duplicate analyses on a sample from Well 13.

The concentration of uranium in the wells completed in the Brule Formation ranges from $1.x10^{-9}$ to $8.x10^{-9}$ μCi/ml, while the Chadron well varies between $10.x10^{-9}$ and $24.x10^{-9}$ μCi/ml. A recent study of uranium concentrations in ground water was conducted in south-central Nebraska on the north side of the Platte River. This study found uranium concentrations ranging from $0.3x10^{-9}$ to $370.x10^{-9}$ μCi/ml with an average of $54.x10^{-9}$ μCi/ml. The source of this uranium was concluded to be from upgradient irrigated croplands (Spalding,1981).

In another study performed on ground water in Southeastern Harding County, South Dakota the uranium concentrations were reported to range from $0.7x10^{-9}$ to $15.x10^{-9}$

TABLE 2.10-5
URANIUM AND RADIUM-226 IN SELECTED
AREA WATER WELLS
CROW BUTTE R&D PROJECT

Well No.	Date	Natural Uranium (μCi/ml)x10^{-9}	Radium-226 (μCi/ml)x10^{-9}
13	01/29/82	5	0.1 $\pm$ 0.1
(Brule)	04/29/82	5	0.1 $\pm$ 0.1
	07/13/82	5	0.2 $\pm$ 0.1
	07/13/82*	6	0.2 $\pm$ 0.1
17	10/29/81	2	0.1 $\pm$ 0.1
(Brule)	01/28/82	2	< 0.1 $\pm$ 0.1
	04/28/82	1	0.4 $\pm$ 0.1
	07/13/82**	5	0.1 $\pm$ 0.1
25	10/29/81	3	0.1 $\pm$ 0.1
(Brule)	01/28/82	3	0.1 $\pm$ 0.1
	04/28/82	2	0.3 $\pm$ 0.1
	04/28/82*	3	0.1 $\pm$ 0.1
	07/13/82**	4	0.1 $\pm$ 0.1
26	10/29/81	4	0.2 $\pm$ 0.1
(Brule)	01/28/82	4	0.2 $\pm$ 0.1
	04/28/82	2	0.3 $\pm$ 0.1
	07/14/82**	4	0.2 $\pm$ 0.1
27	05/08/82	3	0.3 $\pm$ 0.1
(Brule)	07/14/82	4	0.2 $\pm$ 0.1
57	10/29/81	4	0.4 $\pm$ 0.1
(Brule)	01/29/82	4	0.3 $\pm$ 0.1
	04/28/82	5	0.4 $\pm$ 0.1
	07/14/82	4	0.3 $\pm$ 0.1
62	10/30/81	10	15.2 $\pm$ 0.3
(Chadron)	01/28/82	16	18. $\pm$ 0.4
	04/27/82	22	13.8 $\pm$ 0.6
	04/27/82*	24	17 $\pm$ 1
	07/13/82	18	5.9 $\pm$ 0.2
63	10/29/81	6	0.3 $\pm$ 0.1
(Brule)	01/29/82	6	0.3 $\pm$ 0.1
	04/28/82	8	0.5 $\pm$ 0.1
	07/13/82	7	0.8 $\pm$ 0.1

All analysis performed by Core Laboratory unless designated as follows:

* Jordan Laboratory
** Natural Resources Laboratory

μCi/ml (Struempler, 1980). This area of South Dakota has been studied due to the potential for uranium deposits in the region. Ground water samples collected in the Brule Formation in Northwestern Nebraska and analyzed for uranium concentrations average $12.x10^{-9}$ μCi/ml while samples from wells completed in the Chadron Formation averaged $32.x10^{-9}$ μCi/ml (Struempler, 1979).

In addition to the twenty private wells that were sampled, six additional wells were drilled by Wyoming Fuel Company. These wells were screened in specific formations, four wells were completed in the Chadron and two wells were completed in the Brule. These wells were sampled in late July 1982 and analyzed for the concentration of uranium, thorium-230, radium-226 and lead-210. The wells will be sampled on a quarterly basis for one year and analyzed for the concentration of uranium and radium-226. The results of the first quarter of sampling are shown in Table 2.10-6.

The analyses of the regional baseline wells completed in the Brule display the typically low concentrations that were exhibited by the samples from private water wells believed to be completed in the Brule. Two of the four regional baseline wells completed in the Chadron Formation have radionuclide concentrations that are low, while the other two wells have elevated concentrations of uranium and radium-226. An explanation for these elevated levels is that these wells were completed in a mineralized zone of the Chadron Formation. The Chadron is known to be mineralized and is the formation from which the uranium will be extracted and therefore these elevated levels are not unexpected. The results of the fourth quarterly sampling should be available in late May 1983.

TABLE 2.10-6
RADIOMETRIC ANALYSIS OF REGIONAL BASELINE WELLS
CROW BUTTE R&D PROJECT

Well No.	Formation	Date	Nat. Uranium (μCi/ml)x10^{-9}	Thorium-230 (μCi/ml)x10^{-9}	Radium-226 (μCi/ml)x10^{-9}	Lead-210 (μCi/ml)x10^{-9}
RA-2	Brule	07/22/82	11	0.0 ± 3.3	0.8 ± 0.1	0.0 ± 0.8
RB-3	Brule	08/01/82	4	0.5 ± 3.6	0.4 ± 0.1	0.0 ± 0.8
RC-4	Chadron	07/22/82	44	0.9 ± 3.6	235. ± 5.	1.5 ± 1.1
RC-5	Chadron	07/22/82	2	0.0 ± 3.4	3.8 ± 0.1	0.0 ± 0.8
RC-6	Chadron	07/22/82	4	0.0 ± 3.3	9.9 ± 0.2	0.0 ± 0.8
RC-7	Chardon	07/21/82	2	0.0 ± 3.2	0.8 ± 0.1	0.0 ± 0.8

In addition to these regional baseline wells and the area private wells, samples will be collected from four of the monitor wells and from selected wells within the wellfield pattern. These samples will be collected on a quarterly basis for one year and analyzed once for the concentration of uranium, thorium-230, radium-226 and lead-210. On the remaining three quarterly samples uranium and radium-226 will be determined. These values will be used to assess the actual background concentrations of the radionuclides in the zone to be mined.

Surface Water. Surface waters in the region surrounding the Crow Butte R&D Project have been sampled as part of the preoperational radiological monitoring program. Six impoundments have been incorporated into the program. These impoundments are labelled I-1 through I-6 on the topographic map Figure 2.10-1. There are no impoundments located within the R&D restricted area boundary.

The impoundments were sampled semiannually for one year. Each sample was analyzed for the concentration of natural uranium, thorium-230, radium-226, lead-210 and polonium-210. The samples are not filtered and the results of the analysis represent the combination of both the dissolved and suspended concentrations. Core Laboratories in Denver, Colorado performed the analyses.

The impoundments were sampled in June 1982. The results of the analyses for the first set of samples are shown in Table 2.10-7. All the impoundments appear to have similar concentrations of radionuclides. Uranium varied from $2.x10^{-9}$ to $6.x10^{-9}$ μCi/ml while radium varied from $0.6x10^{-9}$ to

TABLE 2.10-7
RADIOMETRIC ANALYSIS OF WATER SAMPLES FROM
SURFACE WATER IMPOUNDMENTS
CROW BUTTE R&D PROJECT

Sample Location	Date	Nat. Uranium $(\mu Ci/ml)x10^{-9}$	Thorium-230 $(\mu Ci/ml)x10^{-9}$	Radium-226 $(\mu Ci/ml)x10^{-9}$	Lead-210 $(\mu Ci/ml)x10^{-9}$	Polonium-210 $(\mu Ci/ml)x10^{-9}$
I-1	06/24/82	2	1.4 ± 0.8	1.0 ± 0.2	0.2 ± 0.9	0.8 ± 0.6
I-2	06/24/82	3	2.3 ± 0.7	0.6 ± 0.2	0.3 ± 0.6	0.9 ± 1.0
I-3	06/24/82	3	1.5 ± 0.6	0.8 ± 0.2	1.0 ± 1.0	2.0 ± 1.2
I-4	06/24/82	6	3.8 ± 1.7	0.6 ± 0.2	0.6 ± 1.3	0.3 ± 0.6
I-5	06/24/82	4	2.7 ± 1.1	0.8 ± 0.2	0.1 ± 0.9	0.0 ± 0.3
I-6	06/24/82	6	2.0 ± 1.3	0.7 ± 0.2	1.8 ± 1.4	0.2 ± 0.4

$1.0x10^{-9}$ µCi/ml. All of the values are within ranges considered as natural background. Concentrations of uranium in impoundments near the Anaconda Rhode Ranch Project, in South Texas have been reported to vary between $<1.2x10^{-9}$ and $4.6x10^{-9}$ µCi/ml while radium-226 ranged from $0.0x10^{-9}$ to a maximum of $1.4x10^{-9}$ µCi/ml (Texas Department of Health, 1982).

A small stream, Squaw Creek, does pass through the northeastern quadrant of the Crow Butte R&D restricted area. This stream eventually enters the White River downstream of Crawford. In the preoperational radiological monitoring program two sample sites were designated on Squaw Creek. These sites are shown in Figure 2.10-1. Site S-2 is located on Squaw Creek as it enters the R&D restricted area and S-3 is downstream from the R&D restricted area Samples were collected from these locations on a quarterly basis beginning in February 1982. All the samples were analyzed for the concentrations of total uranium, thorium-230 and radium-226. Additionally, on a semiannual basis the upstream sample was analyzed for lead-210 and polonium-210. Core Laboratories in Denver performed a majority of the analyses.

The results obtained on samples collected during the first three quarters are listed in Table 2.10-8. The upstream and downstream samples are consistent within a given sampling period but vary between quarterly samples. While this variance is slight, the differences in stream flow rate at the time of sampling may have resulted in these small perturbations. The results displayed in Table 2.10-8 are consistent with concentrations normally considered as naturally occurring. Squaw Creek empties into the White River and samples collected from the White River show a range in the uranium con-

TABLE 2.10-8
RADIOMETRIC ANALYSIS OF WATER SAMPLES FROM
SQUAW CREEK
CROW BUTTE R&D PROJECT

Sample Location	Date	Nat. Uranium (μCi/ml)x10^{-9}	Thorium-230 (μCi/ml)x10^{-9}	Radium-226 (μCi/ml)x10^{-9}	Lead-210 (μCi/ml)x10^{-9}	Polonium-210 (μCi/ml)x10^{-9}
S-2	02/25/82	1	2.6 ± 0.9	0.4 ± 0.3	--	--
S-3	02/25/82	2	1.8 ± 0.8	1.0 ± 0.5	--	--
S-3*	02/25/82	8	--	0.3 ± 0.1	--	--
S-2	04/19/82	1	0.0 ± 0.4	0.1 ± 0.1	--	--
S-3	04/19/82	2	0.0 ± 0.5	0.2 ± 0.1	0.3 ± 1.0	0.2 ± 0.2
S-2	07/08/82	2	3.3 ± 1.4	0.4 ± 0.2	--	--
S-3	07/08/82	2	1.1 ± 1.6	0.4 ± 0.2	--	--
S-2	10/05/82	0.5	--	0.0 ± 0.3	--	--
S-3	10/05/82	1.0	--	0.1 ± 0.2	1.0 ± 1.8	0.3 ± 0.3

* Duplicate sample analysis performed by Natural Resource Laboratory, Inc.

centrations of between $3.x10^{-9}$ and $5.x10^{-9}$ μCi/ml and radium concentrations between $0.5x10^{-9}$ and $0.8x10^{-9}$ μCi/ml.

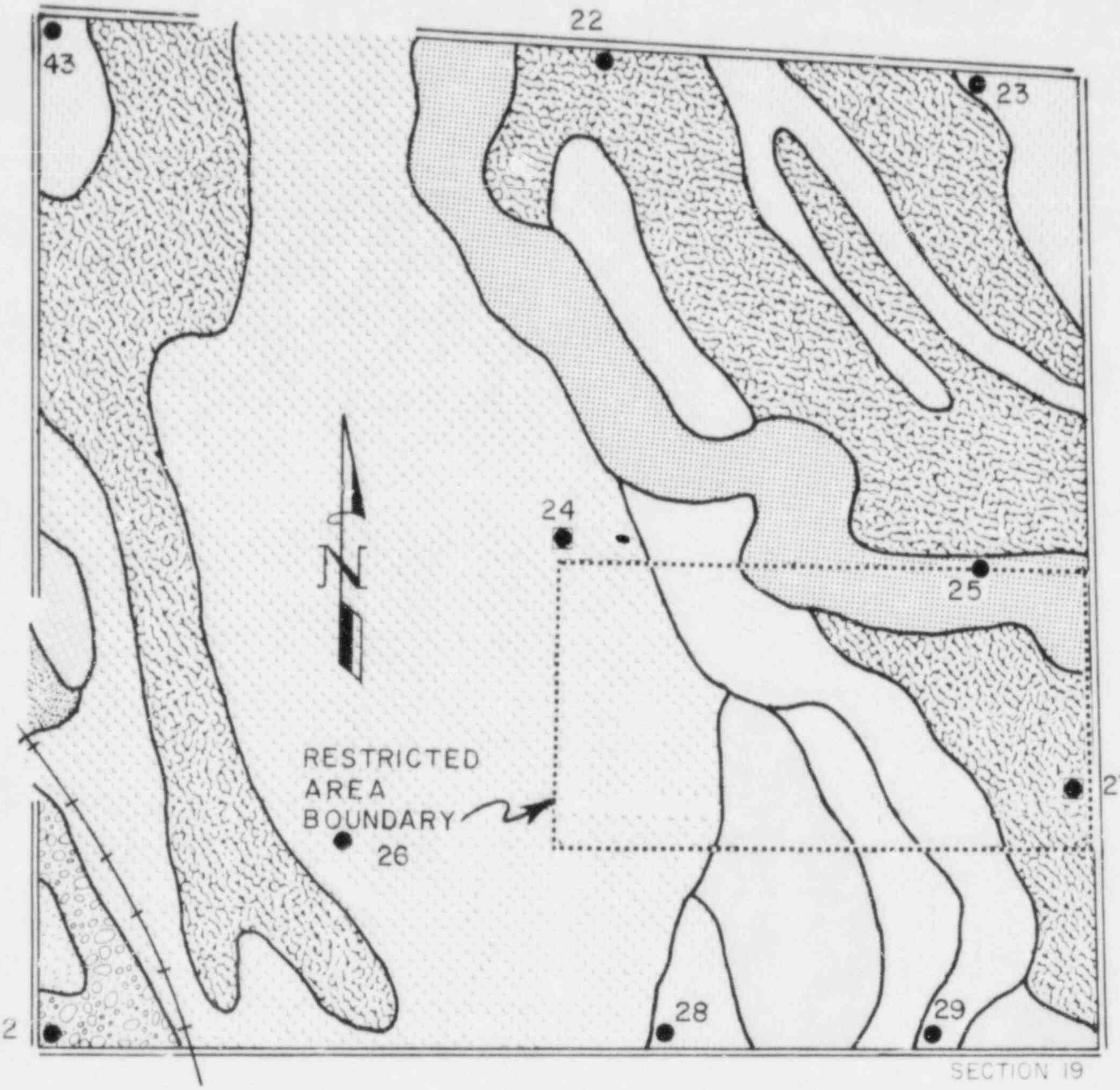
Uranium concentrations in the Platte River in south-central Nebraska have been reported to average $16.x10^{-9}$ μCi/ml (Spalding,1981). The Brazos River in Central Texas has been reported to have uranium concentrations between $0.4x10^{-9}$ and $1.8x10^{-9}$ μCi/ml (Spalding and Exner,1976). In the study of the Brazos River the source of uranium was identified as the phosphate fertilizers used in the region. This source of uranium was also identified as contributing to a uranium concentration of $1.3x10^{-9}$ μCi/ml found in the Navasota River and an average of $0.66x10^{-9}$ μCi/ml in the Little Brazos, both located in Central Texas (Spalding and Sackett,1972).

2.10.4 Soil Sampling Program

Samples of the soils in the area surrounding the Crow Butte R&D Project have been collected. The samples were collected in July 1982 at ten locations in Section 19. The locations are shown in Figure 2.10-2 which is a soils map of Section 19. Six different soils types were sampled. The samples were all surface samples, collected to a depth of 5 centimeters. Two of the sites, No. 24 and 27, also served as subsurface sites. One-third meter composite samples to a total depth of one meter were collected at each of the two locations. Once collected the samples were bagged and sent to Core Laboratories for analysis. The concentrations of uranium and radium-226 were determined as well as the concentrations of various metals. Only the radiometric analyses will be presented in this section. The nonradiometric analyses are discussed in Section 2.11.

The results of the surface soil sampling program are presented in Table 2.10-9 and the subsurface soil sample results are in Table 2.10-10. The uranium concentration varied from $0.38x10^{-6}$ to $3.3x10^{-6}$ μCi/g, while radium-226 ranged between $0.1x10^{-6}$ and $1.3x10^{-6}$ μCi/g. The radionuclide concentrations appear to be similar for most of the soils types and no distinctions between types are readily apparent. The radionuclide concentrations are also found to be homogeneous through the first meter of soil. Also included in Table 2.10-9 are the results of the surface soil samples collected at the air monitoring stations. These results appear similar to the samples collected in Section 19 with the exception of the uranium concentration in the sample collected at AM-6. This uranium value is slightly higher than the other samples. A possible explanation for this anomaly is that AM-6 is located very close to the compacted dirt driveway of a local motel and that the surface sample may have included a substantial contribution from the roadbed material. This value for uranium is still considered low and at this time there does not appear to be a need for resampling AM-6.

The concentration of uranium in sandstones has been reported to be between $0.3x10^{-6}$ and $0.4x10^{-6}$ μCi/g (Eisenbud,1973,Eicholz,1976). In Campbell Country, Wyoming near Conoco's proposed Sand Rock Mill Project the results of the surface soil sampling showed radium-226 in the range of $0.1x10^{-6}$ to $1.86x10^{-6}$ μCi/g and the highest concentration of uranium was reported to be $5.1x10^{-6}$ μCi/g (USNRC,1982). Soil samples collected around Ray Point and Falls City, Texas had a reported average radium-226 concentration of $0.9x10^{-6}$ μCi/g with a range of $0.5x10^{-6}$ to $1.4x10^{-6}$ μCi/g (USNRC, 1979a).



	AcD2	Alliance silt loam, 3 to 9% slopes, eroded
	BuD2	Busher loamy very fine sand, 5 to 9% slopes, eroded
	BuF	Busher loamy very fine sand, 9 to 20% slopes
	ByF	Busher and Tassel loamy very fine sands, 5 to 20% slopes
	JvD	Jayem and Vetal loamy very fine sands, 5 to 9% slopes
	Sn	Sandy alluvial land
	SvF	Sarben and Vetal loamy very fine sands, 9 to 30% slopes
	SyF	Schamber soils, 3 to 30%
	TaF	Tassel soils, 3 to 30% slopes
	VeC	Vetal and Bayard soils, 1 to 5% slopes

● - Surface Sample Site

● - Surface and Subsurface Sample Site

METERS

400 200 0 400

1250 750 250 0 1250

FEET

REV	BY	DATE	**WYOMING FUEL COMPANY**
			CROW BUTTE PROJECT Dawes County, Nebraska
			SOIL SAMPLE LOCATIONS
			PREPARED BY:
			DWN BY: R.E. LARSON DATE: 9-30-82 FIGURE 2.10-2

TABLE 2.10-9
RADIOMETRIC ANALYSIS OF SURFACE
SOIL SAMPLES FROM SECTION 19
CROW BUTTE R&D PROJECT

Sample Location	Soil Type	Natural Uranium $(\mu Ci/g)x10^{-6}$	Radium-226 $(\mu Ci/g)x10^{-6}$
22	Vetal and Bayard soils	3.3	1.3 ± 0.2
27	Vetal and Bayard soils	1.7	0.9 ± 0.2
24	Busher and Tassel loamy very fine sand	3.6	1.4 ± 0.3
26	Busher and Tassel loamy very fine sand	1.2	0.8 ± 0.2
23	Jayem and Vetal loamy very fine sands	1.3	1.2 ± 0.2
28	Jayem and Vetal loamy very fine sands	0.38	0.7 ± 0.2
43	Jayem and Vetal loamy very fine sands	1.5	0.9 ± 0.2
25	Sandy alluvial land	1.6	0.9 ± 0.2
29	Sarben and Vetal loamy very fine sands	1.2	1.2 ± 0.2
42	Busher loamy very fine sands	0.85	0.7 ± 0.2
AM-1	----	1.3	1.1 ± 0.2
AM-2	----	0.72	1.4 ± 0.3
AM-6	----	6.4	0.9 ± 0.2
AM-7	----	1.3	2.0 ± 0.4

TABLE 2.10-10
RADIOMETRIC ANALYSES OF SUBSURFACE SOIL SAMPLES
IN SECTION 19

Sample Location	Depth	Natural Uranium (μCi/g)x10^{-6}	Radium-226 (μCi/g)x10^{-6}
24	0-0.33m	1.2	0.4 ± 0.1
24	0.34-0.66m	1.2	0.3 ± 0.1
24	0.67-1.0 m	1.2	0.2 ± 0.1
27	0-0.33m	1.2	0.3 ± 0.1
27	0.34-0.66m	0.6	0.1 ± 0.1
27	0.67-1.0 m	0.6	0.2 ± 0.1

In addition to the ten surface samples collected in Section 19, seven surface samples were collected within the Crow Butte R&D restricted area boundary. Three of these samples are in the wellfields and four are in the plant and pond areas. Two additional surface samples will be collected in the plant area after removal of the topsoil and prior to compaction. The locations of the samples in the Crow Butte R&D restricted area are shown in Figure 2.10-3. Of the seven surface sample sites, three sites were chosen for subsurface sampling, one subsurface site in each wellfield and one in the plant area. These subsurface sites were sampled to a depth of one meter with composite samples prepared at one third meter intervals. At the time that the ponds are excavated it is proposed that one sample will be collected from the lowest point in each pond. This sample will be a composite sample to a total depth of two meters below pond bottom.

All of the samples collected within the R&D restricted area boundary were analyzed for the concentration of natural uranium and radium-226. All the samples were collected in December 1982 with the exception of the subsurface samples from the pond bottoms and the surface samples in the plant area after topsoil removal. The results of the analyses are contained in Table 2.10-11. The radionuclide concentrations are consistent with those obtained from samples collected in Section 19 and presented in Tables 2.10-9 and 2.10-10.

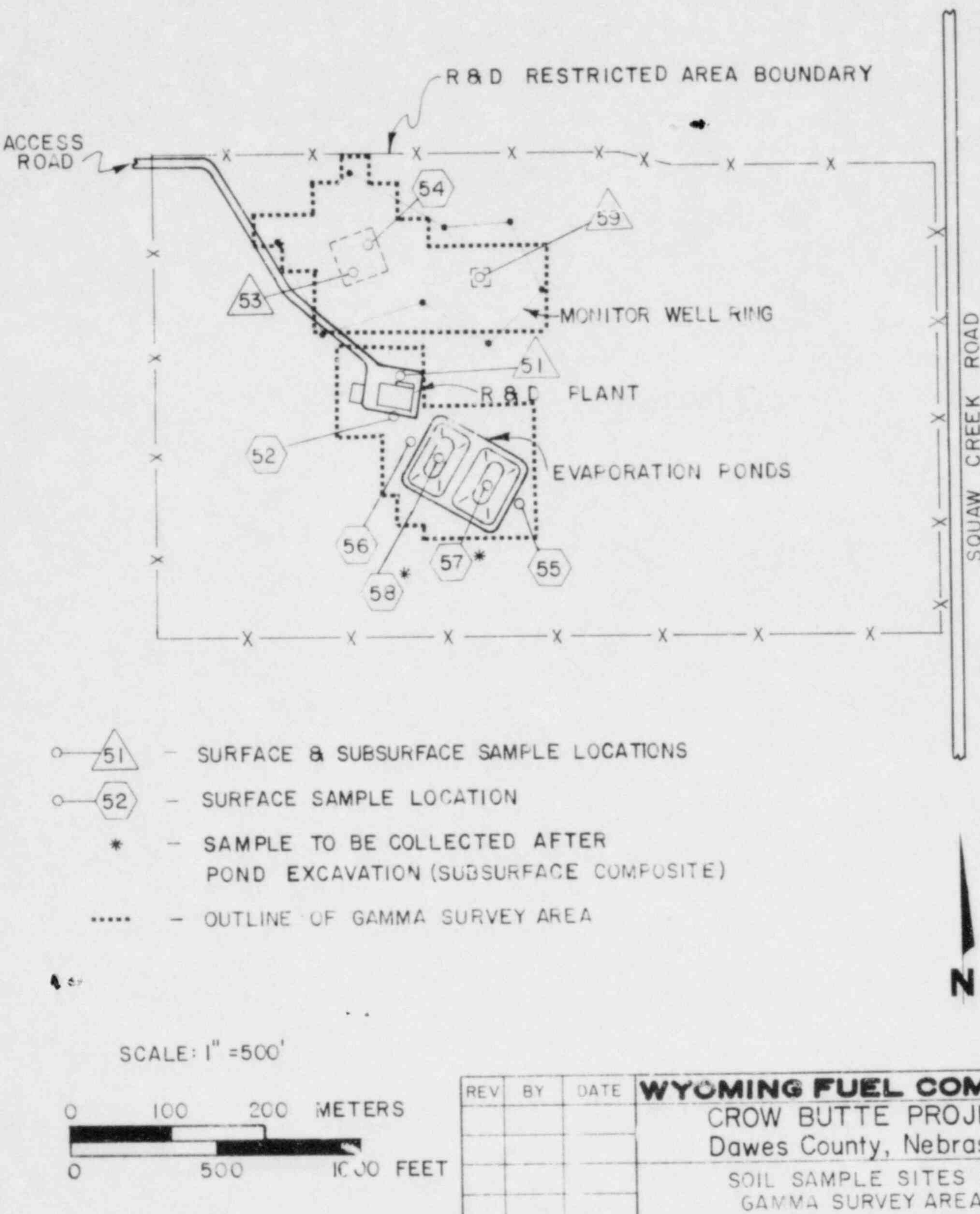
2.10.5 Sediment Sampling Program

Sediments in selected impoundments and Squaw Creek have been sampled as part of the preoperational radiological sampling program. These sediments were analyzed for the concentration of natural uranium, thorium-230, radium-226, lead-210

TABLE 2.10-11

RADIOMETRIC ANALYSES OF SOIL SAMPLES WITHIN THE CROW BUTTE RESTRICTED AREA BOUNDARY

Sample Location	Depth	Natural Uranium (μCi/g)x10^{-6}	Radium-226 (μCi/g)x10^{-6}
51	Surface	1.2	0.1 ± 0.1
51	0-0.33m	1.8	0.3 ± 0.1
51	0.34-0.66m	1.2	0.1 ± 0.1
51	0.67-1.0 m	1.2	0.2 ± 0.1
52	Surface	1.2	0.1 ± 0.1
53	Surface	1.8	0.0 ± 0.1
53	0-0.33m	0.6	0.1 ± 0.1
53	0.34-0.66m	0.6	0.1 ± 0.1
53	0.67-1.0 m	1.2	0.2 ± 0.1
54	Surface	4.2	0.1 ± 0.1
55	Surface	1.2	0.4 ± 0.1
56	Surface	1.2	0.1 ± 0.1
59	Surface	1.2	0.2 ± 0.1
59	0-0.33m	1.8	0.1 ± 0.1
59	0.34-0.66m	1.2	0.1 ± 0.1
59	0.67-1.0 m	1.8	0.2 ± 0.2



REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			SOIL SAMPLE SITES & GAMMA SURVEY AREA
			PREPARED BY:
			DWN BY: R. LARSON · DATE: 1-4-83 · FIGURE 2.10-3

and polonium-210. Sediments from Squaw Creek were sampled semiannually. The first sampling was in May 1982 and then again in December 1982. The location for the sampling was the same as for the water samples. Site S-2 is upstream from the R&D restricted area while S-3 is downstream of the restricted area. The results from the analysis of the sediments collected in May 1982 are listed in Table 2.10-12. The results from the sampling conducted in December 1982 have not been received and will be submitted at a later date.

The radionuclide concentrations in the sediments at the two sites are very similar and are typical of background concentrations. Sediment samples collected near the Sand Rock Mill Project in Wyoming had reported maximum values of $13.x10^{-6}$ µCi/g for uranium, $3.5x10^{-6}$ µCi/g for radium-226, $3.4x10^{-6}$ µCi/g for thorium-230 and $22.x10^{-6}$ µCi/g for lead-210 (USNRC,1982). Sediments from impoundments near Anaconda's propose Rhode Ranch Project in South Texas had maximum uranium concentrations of $11.x10^{-6}$ µCi/g and radium-226 concentrations ranged from $0.1x10^{-6}$ to $1.2x10^{-6}$ µCi/g with an average of $0.5x10^{-6}$ µCi/g (Texas Department of Health,1982).

Three impoundments, I-1, I-3 and I-4 also had sediment samples collected in December of 1982. The results of the analyses of these samples are presented in Table 2.10-13. The concentrations of radionuclides in these sediments are similar to those reported for sediments from Squaw Creek.

2.10.6 Vegetation Sampling Program

As part of the preoperational radiological monitoring program vegetation samples were collected at the four air monitoring stations. These samples were collected in June 1982

TABLE 2.10-12
RADIOMETRIC ANALYSES OF SEDIMENT
SAMPLES FROM SQUAW CREEK
CROW BUTTE R&D PROJECT

Sample Location	Date	Nat. Uranium (µCi/g)x10^{-6}	Thorium-230 (µCi/g)x10^{-6}	Radium-226 (µCi/g)x10^{-6}	Lead-210 (µCi/g)x10^{-6}	Polonium-210 (µCi/g)x10^{-6}
S-2	05/01/82	1.1	10.5 ± 3.4	0.6 ± 0.1	0.0 ± 0.8	0.6 ± 0.7
S-3	02/25/82	0.9	9.3 ± 3.7	0.3 ± 0.1	0.0 ± 1.0	0.7 ± 0.5

TABLE 2.10-13
Radiometric Analyses of Sediment Samples
From Area Impoundments

Sample Location	Date	Nat. Uranium $(\mu Ci/g)x10^{-6}$	Thorium-230 $(\mu Ci/g)x10^{-6}$	Radium-226 $(\mu Ci/g)x10^{-6}$	Lead-210 $(\mu Ci/g)x10^{-6}$	Polonium-210 $(\mu Ci/g)x10^{-6}$
I-1	12/15/82	0.6	2.8 ± 4.5	0.2 ± 0.1	1.1 ± 0.9	0.8 ± 0.3
I-3	12/15/82	1.2	0.0 ± 2.4	0.3 ± 0.1	0.7 ± 0.9	0.8 ± 0.3
I-4	12/15/82	1.2	3.2 ± 1.5	0.2 ± 0.1	1.0 ± 1.0	0.4 ± 0.3

and analyzed by Core Laboratories, Inc. for the concentrations of natural uranium, thorium-230, radium-226, lead-210 and polonium-210.

The results of the analyses are presented in Table 2.10-14. The vegetation sample at each air monitoring station was a composite sample of the vegetation present in proportion to occurrance. Table 2.10-15 lists the vegetation species that were composited at each location. The results of the analyses are typical of naturally occurring concentrations. Vegetation samples collected in the vicinity of the proposed Rhode Ranch Mill in South Texas had a range in the radium-226 concentrations from $10.x10^{-6}$ to $700.x10^{-6}$ µCi/kg while the concentration of lead-210 ranged from $500.x10^{-6}$ to $1080.x10^{-6}$ µCi/kg (Texas Department of Health, 1982). Vegetation collected in Campbell County, Wyoming had maximum uranium concentrations of $140.x10^{-6}$ µCi/kg, $52.x10^{-6}$ µCi/kg of radium-226, $93.x10^{-6}$ µCi/kg of thorium-230, $3,200.x10^{-6}$ µCi/kg of lead-210 and $410.x10^{-6}$ µCi/kg of polonium-210 (USNRC,1982). The concentrations reported for Campbell County were considered normal background levels. The uranium concentration in pine tree branches has been reported to be $3.1x10^{-6}$ µCi/kg, $11.x10^{-6}$ µCi/kg in grapes, $180.x10^{-6}$ µCi/kg in celery leaves and $270.x10^{-6}$ µCi/kg in garlic (Eichholz,1976).

It is proposed that two additional vegetation samples will be collected, one in the vicinity of the R&D plant and one in the wellfield. This sampling is scheduled for June 1983. When the results are available they will be submitted.

TABLE 2.10-14
CONCENTRATION OF RADIONUCLIDES
IN VEGETATION
CROW BUTTE R&D PROJECT

Sample Location	Nat. Uranium (μCi/kg)x10^{-6}	Thorium-230 (μCi/kg)x10^{-6}	Radium-226 (μCi/kg)x10^{-6}	Lead-210 (μCi/kg)x10^{-6}	Polonium-210 (μCi/kg)x10^{-6}
AM-1	30.	12.1 ± 14.0	31.7 ± 4.5	30.2 ± 14.8	28.0 ± 9.4
AM-2	42	24.6 ± 17.0	35.7 ± 4.7	14.4 ± 13.2	10.2 ± 6.0
AM-6	30	19.2 ± 13.2	41.0 ± 5.4	42.0 ± 15.1	33.4 ± 8.1
AM-7	30	11.2 ± 10.7	28.3 ± 4.2	73.1 ± 20	45.8 ± 10.2

TABLE 2.10-15
VEGETATION USED IN RADIOLOGICAL
COMPOSITE SAMPLE
CROW BUTTE R&D PROJECT

Species	Sample Location			
	AM-1	AM-2	AM-6	AM-7
Crested Wheatgrass (Agropyron cristatum)			X	
Intermediate Wheatgrass (Agropyron intermedium)	X	X		X
Western Wheatgrass (Agropyron smithii)	X			X
Blue Grama (Bouteloua gracilis)				X
Smooth Brome (Bromus inermis)	X		X	
Japanese Brome (Bromus japonicus)		X		
Brome (Bromus tectorum)	X	X	X	X
Buffalo grass (Buchloe dactyloides)				X
Sixweeks Fescue (Festuca octoflora)	X	X		X
Yellow Sweetclover (Melilotus officinalis)		X		
Little Barley (Hordeum pusillum)		X		
Kentucky Bluegrass (Poa pratensis)			X	
Needlegrass				
(Stipa comata)	X			X
(Stipa viridula)				X

2.10.7 Fish Sampling Program

As part of the preoperational radiological sampling program, fish were collected from several area impoundments for radiological analyses. Impoundments designated I-2, I-5 and I-6 possessed a significant fish population and were sampled while impoundments I-1, I-3 and I-4 did not have a sufficient fish population to justify sampling. Additionally impoundment L-1 was sampled. This impoundment is in a different watershed than the Crow Butte R&D restricted area and as a result it should not be influenced by the R&D plant operation. In addition to these impoundments, two larger impoundments Johnson Lake and Whitney Lake located to the northwest of the restricted area were sampled.

The fish samples were collected during the fourth week of June 1982. The collection methods used were electric shocking and netting. The fish were composited in the following order of preference; 1) game and food fish, 2) marginal game fish and 3) forage fish. After collection the fish were eviscerated and the internal organs discarded. The samples were bagged and transported to Core Laboratories in Denver, Colorado for analyses. The samples were analyzed for the concentration of natural uranium, thorium-230, radium-226, lead-210 and polonium-210.

Table 2.10-16 contains the results of the analyses. Table 2.10-17 lists the species that were included in each composite sample. The samples appear to have similar concentrations with uranium exhibiting the greatest variability. These values are considered background concentrations. For example samples of fish collected in South Texas near Anaconda's proposed Rhode Ranch Mill were determined to have lead-210 concentrations between $20.x10^{-6}$ to $120.x10^{-6}$ μCi/kg and a maximum polonium-210 concentration of $400.x10^{-6}$ μCi/kg (Texas

TABLE 2.10-16
RADIOMETRIC ANALYSIS OF FISH
SAMPLES FROM AREA IMPOUNDMENT
CROW BUTTE R&D PROJECT

Sample Location	Date	Nat. Uranium $(\mu Ci/kg) \times 10^{-6}$	Thorium-230 $(\mu Ci/kg) \times 10^{-6}$	Radium-226 $(\mu Ci/kg) \times 10^{-6}$	Lead-210 $(\mu Ci/kg) \times 10^{-6}$	Polonium-210 $(\mu Ci/kg) \times 10^{-6}$
I-2	06/26/82	30	51.3 ± 19.7	38.7 ± 5.2	183.6 ± 19.9	145.3 ± 21.2
I-5	06/23/82	60	17.2 ± 18.6	32.8 ± 4.8	91.9 ± 15.6	71.4 ± 12.9
I-6	06/26/82	120	51.8 ± 22.0	44.7 ± 6.1	64.9 ± 19.0	56.1 ± 14.1
L-1	06/25/82	42	8.4 ± 6.0	23.3 ± 2.7	76.7 ± 8.8	34.0 ± 8.5
Johnson Lake	06/24/82	18	38.8 ± 16.2	37.3 ± 4.3	195.3 ± 20.5	178.2 ± 23.9
Whitney Lake	06/27/82	24	34.4 ± 15.5	39.0 ± 4.8	59.8 + 18.5	53.2 ± 13.8

TABLE 2.10-17
SPECIES OF FISH USED FOR
RADIOLOGICAL COMPOSITE SAMPLE
CROW BUTTE R&D PROJECT

Species	L-1	I-2	I-5	I-6	Whitney Lake	Johnson Lake
Brown Trout	X					
Rainbow Trout	X					
Brook Trout	X			X		
Largemouth Bass						X
White Bass					X	
Bluegill						X
Green Sunfish		X	X			
Black Crappie					X	
White Sucker		X				
Creek Chub		X				
Fathead Minnow			X	X		
Golden Shiner			X	X		
Longnose Dace				X		

Department of Health, 1982). Samples of fish collected from Lake Corpus Christi located north of the city of Corpus Christi, Texas were reported to contain radium-226 concentrations ranging from $70.x10^{-6}$ to $580.x10^{-6}$ µCi/kg. Thorium-230 values ranged from $10.x10^{-6}$ to $30.x10^{-6}$ µCi/kg in the same samples while radium-226 was reported to vary between $10.x10^{-6}$ and $80.x10^{-6}$ µCi/kg (Texas Department of Health, 1981).

2.10.8 Direct Gamma Radiation

As part of the preoperational monitoring program the gamma radiation in the environment around the Crow Butte R&D Project area was measured. This was accomplished using thermoluminescence dosimitry (TLD). Lithium fluoride chips were used and housed in rugged containers to provide protection from the weather. A total of five chips are located in each container. The containers or monitors are placed at predetermined locations approximately one meter above ground level. They are exchanged with new monitors on a quarterly basis and the exposed monitors are returned to Eberline Instrument Corporation for processing. The results are reported by Eberline in mRem per week. These devices provide an integrated exposure for the period between annealing and processing. A control monitor is stored in a lead shield during the environmental exposure period.

A total of ten locations in Section 19 were chosen for placement of the gamma TLD monitors. These locations are shown on the topographic map (Figure 2.10-1). In addition to these ten locations, a monitor was placed at each of the air monitoring stations. The monitors were initially placed in service during the second quarter of 1982. The results for the second and third quarters of 1982 are listed in Table 2.10-18. The data show a range from 1.40 to 2.05 mRem per week. The preoperational monitoring program proposes a year long survey and when the results of the fourth quarter 1982 and first quarter 1983 are available they will be submitted to the agency.

In addition to the environmental gamma monitors, the background gamma radiation in the plant, ponds and wellfield areas was measured with a Ludlum Measurement 1"x 1" NaI(Tl) scintillator and Model 16 analyzer. This instrument was calibrated on November 1, 1982 and the gamma survey was performed on December 14, 1982. Transects at 90 degree angles were set-up through the plant and pond areas at fifty foot intervals and through the wellfield at one hundred foot intervals. The area covered by this survey is shown in Figure 2.10-3.

The data obtained from the survey in the plant and pond areas are listed in Table 2.10-19 and the data from the wellfield survey are contained in Table 2.10-20. The data in the tables correspond to instrument readings obtained at the intersection of the transects, while holding the scintillator at approximately one meter above ground level. In both tables the numerical axis corresponds to east-west direction with the numbers increasing to the east and the lettered axis corresponding to the north-south direction with the letter A representing the southern-most boundary. In the plant area 152 readings were obtained ranging from a low value of 0.037 mR/hr to a high of 0.050 mR/hr. The average reading was 0.043 mR/hr with a standard deviation of 0.0025 mR/hr. The results appear to be randomly occurring through the survey area and no attempt was made to contour the results. The survey in the wellfield resulted in 52 readings with an average of 0.043 mR/hr and a standard deviation of 0.0044 mR/hr. Again the in-

TABLE 2.10-18
RESULTS OF GAMMA TLD DOSIMETERS
CROW BUTTE R&D PROJECT

Location	2nd Quarter 1982 mRem/week	3rd Quarter 1982 mRem/week	4th Quarter 1982 mRem/week	1st Quarter 1983 mRem/week
22	1.51	1.98		
23	1.60	1.93		
24	1.70	1.94		
25	1.53	1.89		
26	1.53	----		
27	1.46	2.05		
28	1.68	1.89		
29	1.54	1.97		
42	1.46	1.65		
43	1.51	1.84		
AM-1	1.46	1.64		
AM-2	1.40	1.88		
AM-6	1.51	1.80		
AM-7	1.56	1.79		

TABLE 2.10-19
RESULTS OF GAMMA SURVEY IN
PLANT AND POND AREA
CROW BUTTE R&D PROJECT
(in μR/hr)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
N	41	45	47	45	45	44	43	--	--	--	--	--	--	--	--
M	45	42	45	43	41	42	40	--	--	--	--	--	--	--	--
L	48	50	42	41	42	45	45	--	--	--	--	--	--	--	--
K	46	42	45	45	48	44	48	--	--	--	--	--	--	--	--
J	45	40	40	42	45	45	42	42	45	43	42	43	45	47	45
I	42	42	45	45	45	42	40	45	45	42	42	48	45	41	45
H	45	40	40	45	42	40	40	37	44	40	41	45	42	40	44
G	--	--	--	42	40	45	40	40	45	48	43	45	42	40	45
F	--	--	--	40	40	45	40	40	45	45	45	45	45	40	40
E	--	--	--	40	45	42	38	40	45	45	40	42	42	45	40
D	--	--	--	45	48	45	40	40	45	42	45	45	40	45	45
C	--	--	--	--	45	42	40	40	45	45	40	40	45	40	42
B	--	--	--	--	45	45	44	45	45	42	46	45	49	45	45
A	--	--	--	--	--	--	40	40	40	40	43	45	45	45	43

GRID COORDINATES

Average - 43 μR/hr
Standard Deviation - 2 μR/hr

TABLE 2.10-20
RESULTS OF THE GAMMA SURVEY IN THE WELLFIELD
CROW BUTTE R&D PROJECT
(in μR/hr)

	1	2	3	4	5	6	7	8	9	10	11
G	--	--	--	45	45	--	--	--	--	--	--
F	--	--	45	40	45	40	--	--	--	--	--
E	42	40	4[illegible]	42	42	42	42	--	--	--	--
D	42	40	40	43	42	40	40	40	42	43	40
C	--	48	70	40	41	50	44	45	42	42	42
B	--	--	40	42	40	42	45	40	45	42	40
A	--	--	45	45	45	41	42	43	45	45	45

GRID COORDINATES

Average - 43 μR/hr
Standard Deviation - 4 μR/hr

dividual readings seemed to be randomly distributed and contouring of the results was not applicable.

The average of the TLD gamma monitors was 1.69 mRem per week which, assuming a relative biological efficiency of unity corresponds to 0.010 mR/hr. The average background gamma level in the Western Great Plains has been reported to be 0.014 mR/hr (USNRC,1979b), which corresponds well to the results obtained with the TLD gamma monitors. The results obtained during the gamma survey with scintillation detector appear to be about two to three times the level that would normally be expected. A second survey will be conducted through the plant and pond areas after removal of the topsoil. This will be accomplished with a recalibrated NaI probe. If significantly different values are obtained then the survey in the wellfield will be repeated. The results of the second survey will be submitted to the agency when they are available.

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SECTION 2.11

BACKGROUND NONRADIOLOGICAL CHARACTERISTICS

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2.11 BACKGROUND NONRADIOLOGICAL CHARACTERISTICS

In order to establish baseline conditions of the R&D site and surrounding areas a preoperational monitoring program was conducted for nonradiological values. Categories chosen for sampling included water, sediment and soils. Sample and measurement locations were chosen with reference to Regulatory Guide 3.46 (Task FP818-4), Regulatory Guide 4.14 (1980), Staff Technical Position Paper #WM-8102 (1981) and Nebraska Department of Environmental Control Underground Injection Control Regulations. Wherever possible sites for radiological and nonradiological samples were the same.

During the year of 1982 and continuing into 1983 a preoperational nonradiological environmental monitoring program was conducted for the Wyoming Fuel Company Crow Butte Project. This program was designed to collect baseline environmental data for both the R&D and the commercial scale operations simultaneously. Coordination of these two programs allowed more comprehensive surveys plus availability of regional data for the R&D phase. The results of the R&D project preoperational monitoring are presented in the section. Also included are summaries of the data from the commercial program where comparison on a regional scale is applicable.

The R&D nonradiological monitoring program is presented in Table 2.11-1. This program is adapted from the monitoring recommended in U.S. NRC Regulatory Guide 4.14 to provide companion data to the Crow Butte preoperational radiological monitoring program described in Section 2.10 of this report. Site specific data have been collected from monitor and baseline wells, Squaw Creek which passes through the restricted ar-

TABLE 2.11-1
NONRADIOLOGICAL PREOPERATIONAL MONITORING PROGRAM
CROW BUTTE R&D PROJECT

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
WATER						
Ground Water						
	One from each monitor well	Surrounding and above R&D well-field	Grab	4 times	Each sample	Total baseline analysis, pH, conductivity, U and Ra-226
	One from each baseline well	Baseline wells within the well-field	Grab	4 times	Each sample	same
	One from selected private water wells	With 2½ mile radius of R&D wellfield	Grab	Quarterly	Quarterly	Total baseline analysis-once; common ions only-other quarters
Surface Water						
	One from each pond or impoundment	Within 2½ mile radius of R&D wellfield	Grab	Once	Once	Total baseline analysis
	Two from Squaw Creek	One up-stream, one down-stream of restricted area	Grab	Quarterly	Quarterly	Total baseline analysis-winter, summer; common ions-spring, fall

Background Nonradiological Characteristics (Cont'd)

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
	Two from Squaw Creek	One up-stream, one down-stream of restricted area	Grab	Quarterly	Quarterly	Suspended sediment
Water Levels						
	One from each monitor well, baseline well, and selected private wells	Surrounding and within wellfield	Electric line	Monthly	Monthly	Contour map
Flow						
	Two from Squaw Creek	One up-stream, one down-stream of restricted area	Flow meter	Monthly	Monthly	Tabular
SOILS Surface						
	Two	Plant site	Grab	Once	Once	Vanadium, Arsenic Selenium
	Three	Wellfield	Grab	Once	Once	Vanadium, Arsenic Selenium
	One each	Bottom of pond(s) after excavation	Grab	Once	Once	Vanadium, Arsenic Selenium
	One each	Six locations in Section 19	Grab	Once	Once	Molybdenum, Copper, Arsenic, Selenium

ea, and soils. Other ground water and impoundment samples were obtained within the area of 2¼ miles in radius from the R&D wellfield. Sampling of this larger area was done to comply with requirements of the Underground Injection Control permit. Soils reported here were collected within Section 19 which contains the restricted area.

Figure 2.11-1 is a topographic map locating the nonradiological sample points for the R&D project. Illustrated are water, sediment and soil sites within the restricted area and the 2¼ mile radius area of review. The town of Crawford is located 5.5 km (3.4 mi) northwest of the restricted area. Baseline sampling at Crawford and on the nearby White River were included in the commercial program but were outside the area of review for this R&D project.

2.11.1 Ground Water

Investigations of the ground water quality and usage were made for this report. Usage was determined for an area 2¼ miles in radius with well PT-7 in the R&D wellfield as center point. This was done in compliance with the Nebraska Department of Environmental Control (DEC), Underground Injection Control Regulations. Certain of the information from the DEC required water user survey is also applicable to this report, thus it has been included in Section 2.6.

The next step was to identify the aquifers present on a regional basis between the White River to the north and the Pine Ridge escarpment to the south. Geologic literature and maps were consulted to determine boundaries of outcropping formations and the local stratigraphy. Electric logs were examined and sand units within the formations identified. The

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water user survey provided information on which aquifers are currently being tapped for potable water. In some cases potentiometric data were also available. Existing hydrologic studies were then compared with these findings. A thorough discussion of the ground water hydrology is found in Section 2.6.1 of this document.

Water samples were taken from selected wells within the R&D project and surrounding areas. The objective of this sampling was to characterize the water quality in the mineralized production zone and any overlaying aquifer(s). This was accomplished in several ways. First, five of the nearby private wells identified in the water user survey were chosen for quarterly sampling during 1982. Their selection was to provide information supplemental to that from wells installed by Wyoming Fuel Company. A majority of the local private wells and all of those sampled are completed in shallow Brule sands due to the lower drilling costs and more desirable quality water than that of the deeper Chadron Formation aquifer.

Table 2.11-2 lists the private wells that were sampled to evaluate the local water quality. Water samples from well 13 were obtained directly from the outlet pipe when the windmill was functioning. Samples from wells 17, 25, 26 and 57 were taken at the first available faucet downline from the well. In the latter case, the water was allowed to run until the stale water was evacuated from the pipe, after which the fresh water was sampled.

Six wells drilled by WFC expressly for baseline determination were sampled (Table 2.11-2). Two are completed in the Brule Formation and four in the Chadron Formation (production zone). These wells were sampled using an air-lift system sim-

TABLE 2.11-2
WELLS SAMPLED WITHIN 2¼ MILE
RADIUS OF CROW BUTTE R&D SITE

Well No.	Formation	Depth*	Type	Use
Private Wells				
13	Brule	----	Windmill	Stock
17	Brule	24.4	Pump	Domestic, Stock
25	Brule	22.9	Pump	Domestic, Stock
26	Brule	24.4	Pump	Domestic, Stock
57	Brule	7.6	Pump	Domestic, Stock
WFC Wells				
RA-2	Brule	12.2	Air-lift	Baseline
RB-3	Brule	42.7	Air-lift	Baseline
RC-4	Chadron	121.9	Air-lift	Baseline
RC-5	Chadron	196.9	Air-lift	Baseline
RC-6	Chadron	224.9	Air-lift	Baseline
RC-7	Chadron	237.7	Air-lift	Baseline

* Depths given as meters below ground surface

ilar to the pressure-vacuum lysimeter recommended by EPA for wells used in monitoring solid waste disposal sites. Identical air-lift systems are currently being used in monito wells surrounding in-situ uranium mines at four Mobil Oil Corporation sites, two Everest Minerals Corporation sites, Uranium Resources Inc. sites and others. It has been determined through the experience of these operators that this method yields as accurate a sample of the water quality parameters as does pumping. Sampling of these wells consists of removing a sufficient volume of water to insure that fresh formation water is being obtained instead of stagnant fluid.

Sample collection and preservation were performed in the following manner using standard EPA methods. Water was collected in clean rinsed containers. Immediately, measurements of pH, temperature and specific conductance were made. Visual and olfactory observations were also recorded. The schedule outlined in Table 2.11-1 specifies which analyses were performed. When appropriate, aliquots of the water were filtered before preservation using pressure filtration through a 0.45 micron membrane filter. Preservation techniques were HNO_3 to pH <2, H_2SO_4 to pH <2 and cooling to 4°C. Preservation, filtration and analysis were according to EPA (1974) and American Public Health Association (1976) recommendations and methods. All samples were labeled in a permanent manner with the following information 1) company, 2) site designation, 3) well or other sample identification, 4) sample number, 5) sampling time and date, and 6) treatment (preservatives, filtration, etc.). Periodically, sample splits were sent to a second laboratory for verifying analysis.

Prior to sampling, all meters were calibrated using known standards. In some cases, a backup meter was also used to verify readings from the primary instrument. The pH meter, an Orion Model 407 A/F, uses a combination pH electrode. Calibration was performed using two buffers which bracketed the expected pH range. This was done at the beginning of each day prior to sampling, and periodically thereafter to confirm maintenance of calibration. Field measurement of specific conductance was with a Model 33 Yellow Springs Instrument Co. conductivity meter. Potassium chloride standard solutions bracketing the anticipated range in conductivities were used to calibrate the meter. Frequency was the same as described above for pH.

Results of the one year sampling program are included as Appendix 2.11(A). A summary of these results is given in Table 2.11-3.

2.11.2 R&D Area Ground Water Quality

Initial baseline samples have been collected from the R&D wellfield and selected monitor wells. Figure 2.11-2 illustrates the locations of the production zone baseline and overlaying aquifer baseline wells. As a result of their close proximity and small size of the wellfields, production zone monitor wells may be completed in mineralized portions of the sands. Table 2.11-4 lists the depth and geologic unit for each baseline well. For further discussion of these wells, refer to Section 2.6.1, Hydrologic Test.

Water samples were collected in the same manner as the regional baseline wells. A submersible pump was used to remove an amount of water equal to at minimum 1.5 times the contained casing volume. During that time measurements of temperature,

TABLE 2.11-3

AQUIFER WATER QUALITY SUMMARY
Within 2½ Mile Radius Area of Review

Brule Formation *

	Range	Mean
Calcium	38 - 116	71
Magnesium	5.0 - 15	9.4
Sodium	14 - 39	20
Potassium	4.5 - 11	6.3
Bicarbonate	180 - 346	281
Sulfate	7 - 25	12
Chloride	3 - 31	8
Conductance	286 - 742	483
pH	7.4 - 8.1	7.6
Uranium	0.004 - 0.015	0.007
Radium-226	0.2 - 0.8	0.3

Chadron Formation *

	Range	Mean
Calcium	15 - 37	22
Magnesium	3.1 - 7.0	4.2
Sodium	355 - 420	386
Potassium	9.1 - 16	11.6
Bicarbonate	320 - 405	365
Sulfate	320 - 365	370
Chloride	165 - 220	184
Conductance	1665 - 1910	1825
pH	8.0 - 8.3	8.2
Uranium	0.002 - 0.468	0.102
Radium-226	0.8 - 235	53

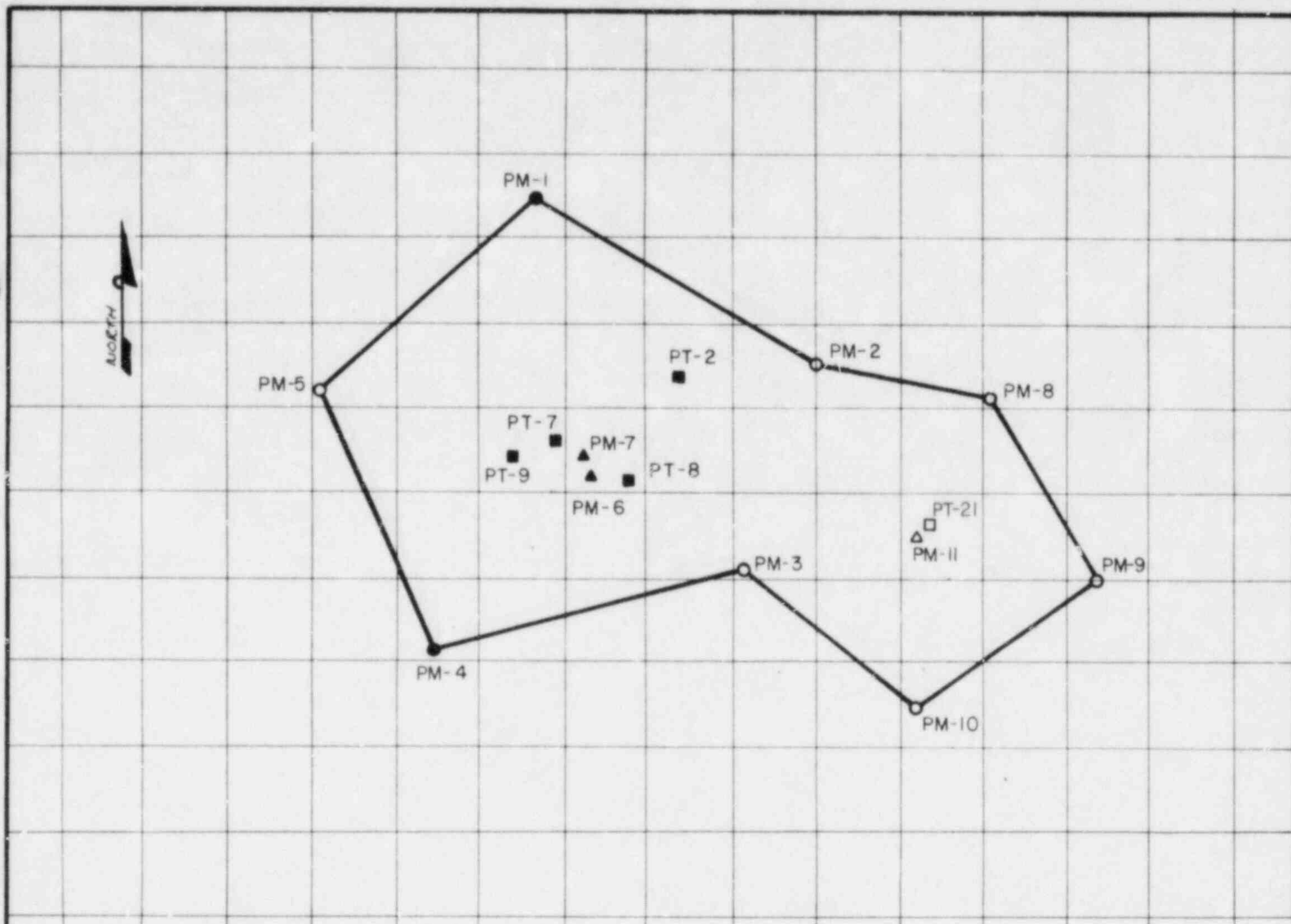
* Summary of average values for wells in Table 2.11-2 and Appendix 2.11(A). In mg/l, except pH(units) and Ra-226(pCi/l).

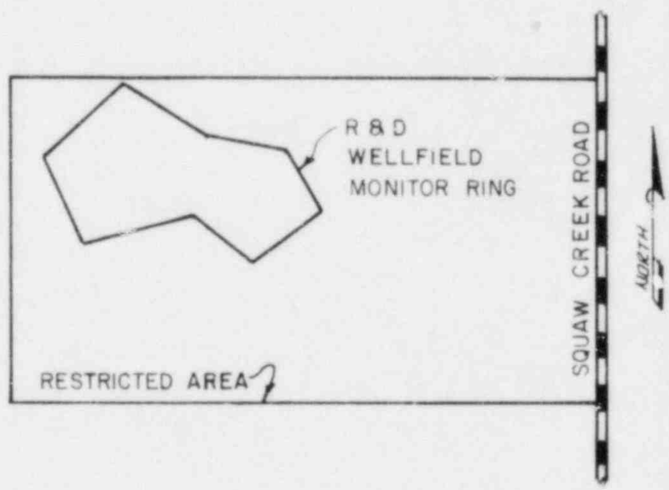
TABLE 2.11-4

WATER QUALITY BASELINE WELLS FOR THE
CROW BUTTE R&D PROJECT
(Well Numbers Refer To Figure 2.11-2)

Well No.	Formation	Depth*
Monitor Wells		
PM-1	Chadron	205.6
PM-4	Chadron	205.6
PM-6	Brule	66.3
PM-7	Brule	39.5
Wellfield Wells		
PT-2	Chadron	202.8
PT-7	Chadron	205.0
PT-8	Chadron	205.6
PT-9	Chadron	207.4

* Depths given as meters below ground surface





LEGEND

- ● - PRODUCTION ZONE MONITOR WELL - BASELINE WELL
- ○ - PRODUCTION ZONE MONITOR WELL - PROPOSED WELL
- ▲ - UPPER AQUIFIER MONITOR WELL - BASELINE WELL
- ■ - PRODUCTION ZONE PUMP TEST WELL - BASELINE WELL
- △ - UPPER AQUIFIER MONITOR WELL - PROPOSED WELL
- □ - PRODUCTION ZONE WELL - PROPOSED BASELINE WELL

50 25 0 50 METERS

200 100 0 200 FEET

SCALE: 1" = 200"

REV	BY	DATE	
			WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			BASELINE WELL LOCATIONS
			PREPARED BY:
			DWN BY: R.E. LARSON · DATE: 12-10-82 · FIGURE 2.11-2

pH and specific conductance were taken periodically. Criteria to be satisfied prior to sampling were 1) evacuation of minimum 1.5 casing volumes, 2) consistent conductivity for three consecutive readings, 3) stabilized pH in range anticipated for aquifer, and 4) constant temperature. Samples were then collected, filtered and preserved as described above.

At this time only one sample set has been taken from the R&D baseline wells. Future sampling will occur on a quarterly basis until four data sets have been obtained from each well. Air-lifting systems may also be used in further sampling of these wells.

Results of this sampling are presented in Tables 2.11-5, 2.11-6 and 2.11-7.

2.11.3 Water Levels

Monthly water level measurements were made on 14 wells within the 2¼ mile radius area of review. Of these wells 10 are completed in the Brule Formation and 4 in the Chadron Formation aquifers. The objective was to determine if seasonal or periodic fluctuation in the piezometric surfaces occurs in the Crow Butte area.

Seasonal fluctuations in water level are commonly observed in shallow unconfined aquifers where effects of the hydrologic cycle are more immediate. Decreases occur in response to aquifer discharge to surface water systems during dry periods. Infiltration of precipitation, runoff and excess stream flow will serve to recharge the aquifer. Confined aquifers should exhibit little fluctuation in the piezometric sur-

TABLE 2.11-5
R&D WELLFIELD BASELINE WATER QUALITY
CROW BUTTE R&D PROJECT

Well No. / Date Sampled	PT-2 12/03/82	PT-7 12/03/82	PT-8 12/03/82	PT-9 12/03/82	MIN	MAX	MEAN	STD DEV σn-1
Calcium (mg/l)	15	17	20	17	15	20	17	2.1
Magnesium (mg/l)	3.6	4.0	3.6	2.8	2.8	4.0	3.7	.23
Sodium (mg/l)	406	402	389	408	389	408	401	8.5
Potassium (mg/l)	16	12	17	13	12	17	15	2.4
Carbonate (mg/l)	5	0	5	23	0	23	8.3	10.1
Bicarbonate (mg/l)	368	383	368	353	353	383	368	12.2
Sulfate (mg/l)	355	355	341	355	341	355	352	7.0
Chloride (mg/l)	188	186	180	190	180	190	186	4.3
Ammonia-N (mg/l)	.52	.51	.54	.82	.51	.82	.60	.149
Nitrite-N (mg/l)	<.01	<.01	.01	<.01	<.01	.01	.01	0
Nitrate-N (mg/l)	.05	.04	.03	<.01	<.01	.05	.03	.017
Fluoride (mg/l)	.66	.63	.60	.69	.60	.69	.65	.039
Silica (mg/l)	11	14	16	13	11	16	14	2.1
TDS-180°C (mg/l)	1220	1220	1190	1240	1190	1240	1218	20.6
Conductivity-Field (umhos)								
Conductivity-Lab (umhos)	1830	1810	1740	1900	1740	1900	1820	65.8
Conductivity-Dilute (umhos)	2190	2170	2090	2240	2090	2240	2173	62.4
Alkalinity (mg/l)	310	314	310	327	310	327	315	8.1
pH - Field								
pH - Lab	8.42	8.10	8.44	8.82	8.10	8.82	8.45	.29
Arsenic (mg/l)	.006	.001	.005	.014	.001	.014	.007	.0054
Barium (mg/l)	.09	.04	.11	.10	.04	.11	.08	.042
Cadmium (mg/l)	<.0001	.0004	.0001	<.0001	<.0001	.0004	.0002	.00015
Chromium (mg/l)	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0
Copper (mg/l)	.003	.004	.007	.004	.003	.007	.005	.0017
Iron (mg/l)	.02	.01	.01	.02	.01	.02	.02	.006
Lead (mg/l)	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0
Manganese (mg/l)	.007	.008	.001	.008	.006	.009	.007	.001
Mercury (mg/l)	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0
Molybdenum (mg/l)	.02	.02	.03	.05	.02	.05	.03	.014
Nickel (mg/l)	<.01	<.01	<.01	<.01	<.01	<.01	<.01	0
Selenium (mg/l)	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0
Vanadium (mg/l)	.01	<.01	<.01	.03	<.01	.03	.02	.023
Zinc (mg/l)	.010	.017	.027	.008	.008	.027	.016	.0086
Boron (mg/l)	1.0	1.1	.97	.99	.97	1.1	1.02	.053
Uranium (mg/l)	.933	.119	.322	.441	.119	.933	.454	346.1
Radium-226 (pCi/l)	136±1	379±1	151±1	602±2	136±1	602±2	317	220.1

TABLE 2.11-6
PRODUCTION ZONE MONITOR WELLS
BASELINE WATER QUALITY
CROW BUTTE R&D PROJECT

Well No. / Date Sampled	PM-1 12/03/82	PM-4 12/03/82	MIN	MAX	MEAN	STD DEV σn-1
Calcium (mg/l)	17	16			17	.7
Magnesium (mg/l)	2.9	3.5			3.2	.42
Sodium (mg/l)	417	408			413	6.4
Potassium (mg/l)	13	11			12	1.4
Carbonate (mg/l)	13	0			7	9.2
Bicarbonate (mg/l)	368	386			377	12.7
Sulfate (mg/l)	358	359			359	.7
Chloride (mg/l)	208	187			198	14.8
Ammonia-N (mg/l)	.48	.49			.49	.007
Nitrite-N (mg/l)	.02	<.01			.02	.007
Nitrate-N (mg/l)	<.01	.02			.02	.007
Fluoride (mg/l)	.67	.66			.67	.007
Silica (mg/l)	15	18			17	2.1
TDS-180°C (mg/l)	1260	1250			1255	7.1
Conductivity-Field (umhos)						
Conductivity-Lab (umhos)	1940	1820			1880	84.9
Conductivity-Dilute (umhos)	2300	2190			2245	77.8
Alkalinity (mg/l)	324	316			320	5.7
pH - Field						
pH - Lab	8.61	8.26			8.44	.247
Arsenic (mg/l)	.001	.001			.001	
Barium (mg/l)	.05	.03			.04	.014
Cadmium (mg/l)	<.0001	<.0001			<.0001	
Chromium (mg/l)	<.001	<.001			<.001	
Copper (mg/l)	.005	.004			.005	.0007
Iron (mg/l)	.02	.03			.03	.007
Lead (mg/l)	<.001	<.001			<.001	
Manganese (mg/l)	.004	.014			.009	.007
Mercury (mg/l)	<.0001	<.0001			<.0001	
Molybdenum (mg/l)	.02	.02			.02	
Nickel (mg/l)	<.01	<.01			<.01	
Selenium (mg/l)	<.001	<.001			<.001	
Vanadium (mg/l)	<.01	.02			.02	.007
Zinc (mg/l)	.012	.019			.016	.0049
Boron (mg/l)	.99	1.0			1.0	.007
Uranium (mg/l)	.085	.036			.061	.0346
Radium-226 (pCi/l)	99±1	71±1			85	19.8

TABLE 2.11-7
UPPER AQUIFER MONITOR WELLS
BASELINE WATER QUALITY
CROW BUTTE R&D PROJECT

Well No. / Date Sampled	PM-6	PM-7	MIN	MAX	MEAN	STD DEV σn-1
Calcium (mg/l)	4.4	15				
Magnesium (mg/l)	0.05	0.43				
Sodium (mg/l)	100	64				
Potassium (mg/l)	10	20				
Carbonate (mg/l)	11	14				
Bicarbonate (mg/l)	200	187				
Sulfate (mg/l)	38	8				
Chloride (mg/l)	9	10				
Ammonia-N (mg/l)	0.13	0.07				
Nitrite-N (mg/l)	<0.01	0.02				
Nitrate-N (mg/l)	0.46	0.73				
Fluoride (mg/l)	0.44	0.27				
Silica (mg/l)	69	59				
TDS-180°C (mg/l)	363	301				
Conductivity-Field (umhos)						
Conductivity-Lab (umhos)	466	396				
Conductivity-Dilute (umhos)	488	416				
Alkalinity (mg/l)	182	177				
pH - Field						
pH - Lab	8.78	8.88				
Arsenic (mg/l)	0.009	<0.001				
Barium (mg/l)	0.01	0.07				
Cadmium (mg/l)	<0.0001	<0.0001				
Chromium (mg/l)	0.003	0.007				
Cobalt (mg/l)						
Copper (mg/l)	0.006	0.011				
Iron (mg/l)	<0.01	0.02				
Lead (mg/l)	<0.001	<0.001				
Manganese (mg/l)	<0.001	<0.001				
Mercury (mg/l)	<0.0001	<0.0001				
Molybdenum (mg/l)	<0.01	<0.01				
Nickel (mg/l)	<0.01	<0.01				
Selenium (mg/l)	<0.001	<0.001				
Vanadium (mg/l)	<0.01	<0.01				
Zinc (mg/l)	0.270	0.011				
Boron (mg/l)	<0.01	<0.01				
Uranium (mg/l)	0.007	0.025				
Radium-226 (pCi/l)	1.0±0.1	1.1±0.1				

face except where ground water withdrawal rates are high and/or seasonal.

Water levels were determined using battery operated instruments. Measurements were recorded together with the date and name of individual taking the readings. Values were then corrected to mean sea level (msl) and meters. The results are presented in Figures 2.11-3 and 2.11-4.

2.11.4 Surface Water Quality

Samples were collected from Squaw Creek and all surface bodies of water within a 2½ mile radius of the R&D wellfield. Table 2.11-1 outlines the sampling schedule and the parameters for analysis. This schedule was begun in 1982 and will continue into 1983. All currently available data are presented here.

Squaw Creek passes through the Crow Butte R&D restricted area as it flows towards the White River. Two sampling points on Squaw Creek are shown in Figure 2.11-1. A third location, S-1, is upstream in the Ponderosa State Wildlife Area and is part of the commercial monitoring program. Location W-2 on the White River is also part of the commercial preoperational monitoring program. Data from sites S-1 and W-2 are included here for comparison.

Stream samples were obtained using the grab method at preselected flow measurement sites. Immediately upon collection measurements of pH, temperature, conductivity and disolved oxygen were made. Water was then filtered and preserved as appropriate for the analysis parameters specified.

Water quality results of the sampling are included in Appendix 2.11(B). As can be seen, none of the EPA drinking water standards are exceeded in any sample. Total dissolved solids are generally in the 200 to 300 mg/l range with calcium and bicarbonate being the predominant ions. When the stream stiff diagrams are compared with those of Brule water samples (Appendix 2.11(A)) a similarity in appearance is noticed. This has been previously discussed in Section 2.6, and is attributed to contact with the same geologic formation and periodic commingling of waters.

The stream and river samples were also analyzed for suspended sediment content. These data are presented in Table 2.11-8. Squaw Creek suspended sediment ranged from <5 mg/l consistently at station S-2 to a high of 76 mg/l at S-3. Both S-1 and S-3 exhibited more fluctuation than S-2. The White River carried an average of 74 mg/l total suspended solids for the year period.

Three impoundments are located within the 2¼ mile radius area of review; I-1, I-3 and I-4. The former is on Squaw Creek while the later two are on English Creek to the northwest of the site (Figure 2.11-1).

Samples were collected and handled in the same manner as described above. Sampling sites were also used for obtaining sediment material for radiometric determinations discussed in Section 2.10. Results of the baseline analyses are given in Appendix 2.11(B). Stiff diagrams are also included for comparison with the stream waters and the Brule Formation aquifer.

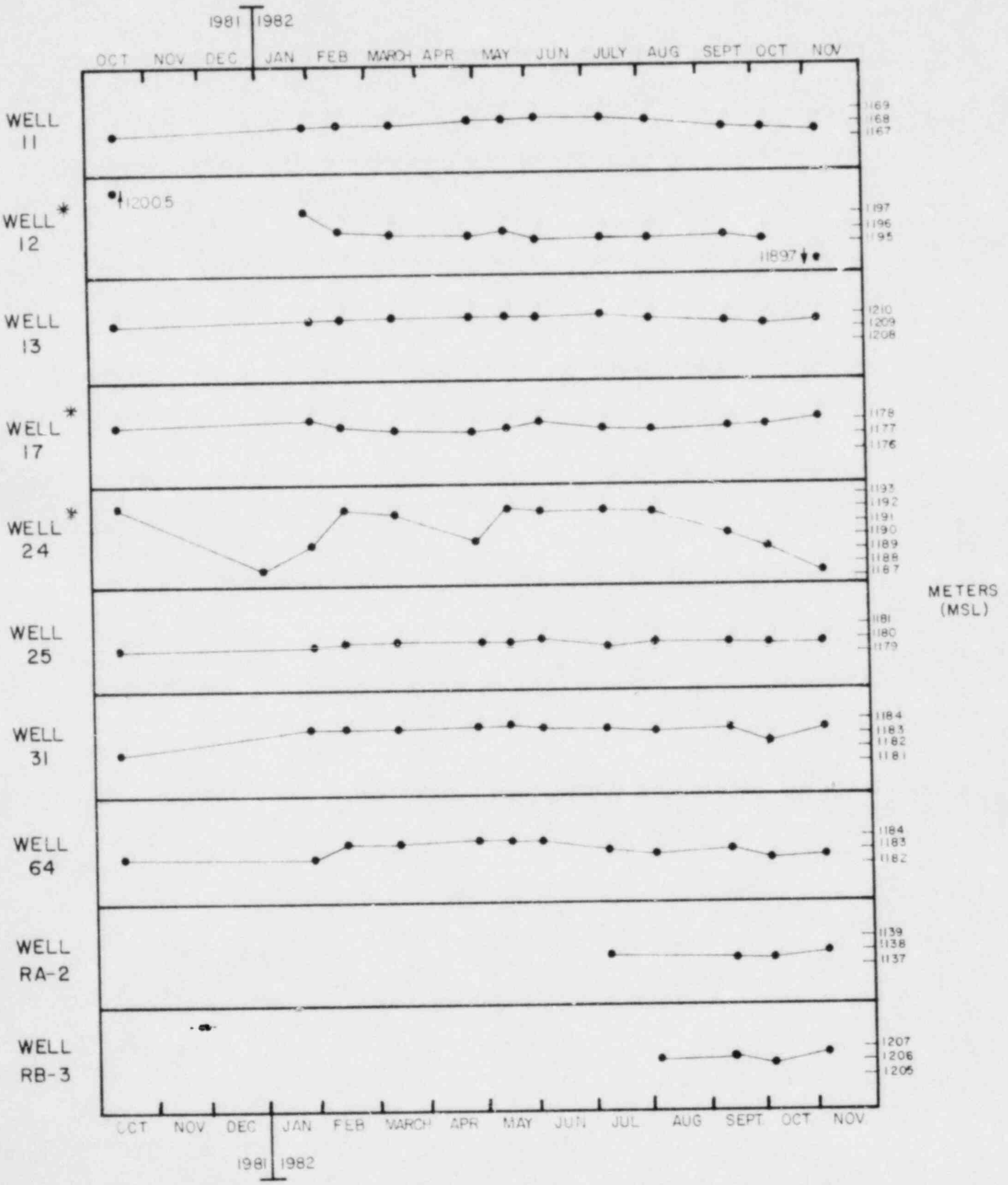
FIGURE 2.11-3

SEASONAL WATER LEVEL FLUCTUATIONS

In Wells Within Area of Review

Crow Butte R & D Project

Brule Formation



1-12-83

* – Well pumping prior to water level measurement in some cases

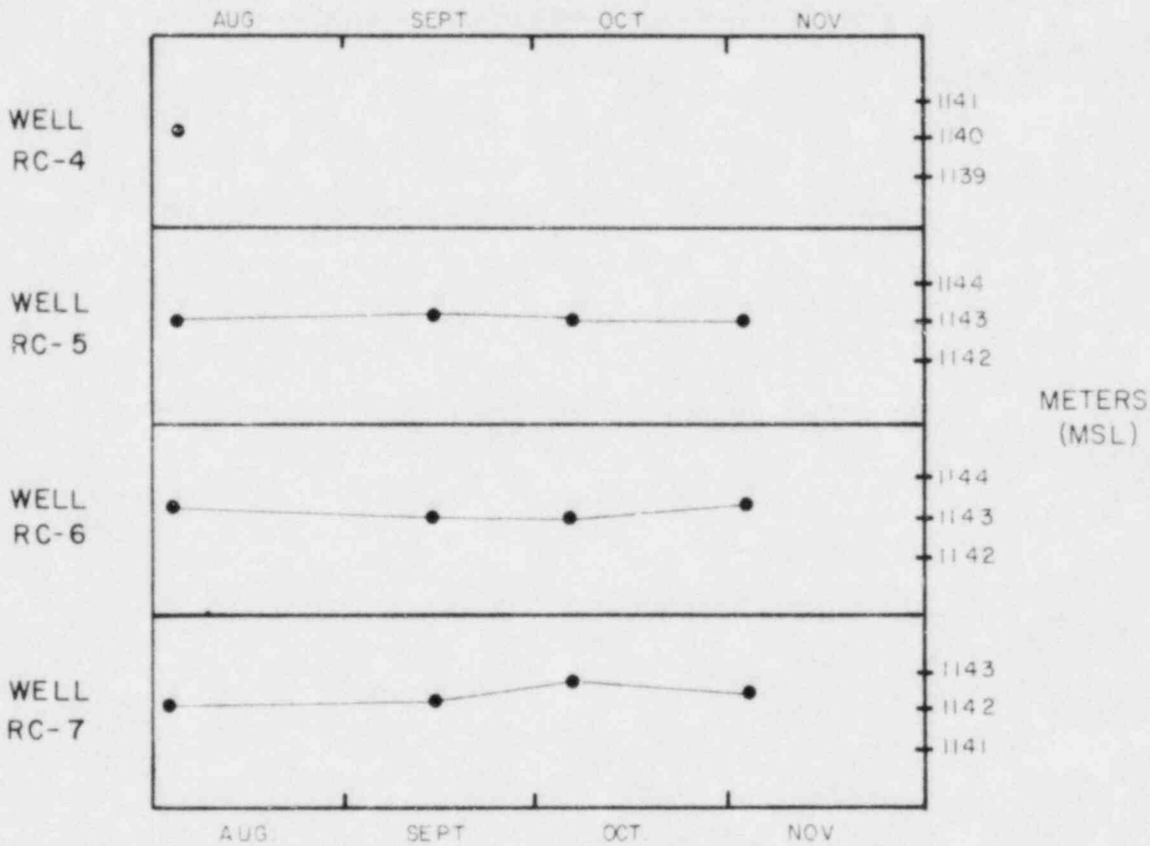
FIGURE 2.11-4

SEASONAL WATER LEVEL FLUCTUATIONS

In Wells Within Area of Review

Crow Butte R&D Project

Chadron Formation



1-12-83

TABLE 2.11-8

SUSPENDED SEDIMENT IN FLOWING WATERS
SQUAW CREEK AND WHITE RIVER

Results given as Total Suspended Solids in mg/l.

	Date Sampled			
	2/82	4/19/82	7/8/82	10/5/82
S-1	36	8	5	5
S-2	<5	<5	<5	<5
S-3	12	76	<5	20
W-2	190	54	44	7

Analysis by Natural Resources Laboratory, Inc. (NRL), Lakewood, Colorado.

2.11.5 Stream Flow

Squaw Creek flows through the Crow Butte R&D restricted area from east to northwest. The flow rate of this perennial stream was monitored at two locations according to the schedule given in Table 2.11-1. In addition discharge rates of the Squaw Creek headwaters and the White River are being monitored for the commercial application. Portions of those data are presented here for comparison. Figure 2.11-1 shows locations of all but the White River station. The latter is positioned 1700 m (5575 ft) upstream of the confluence with Squaw Creek.

Measurement locations were chosen using three criteria. 1) the stream channel must be free of permanent obstructions that would create nonlaminar flow, 2) the channel should be straight for 10 m (30 ft) upstream of the measuring point if possible to preclude measurements in a situation where channel physical shape is causing change in flow rate, 3) the channel must be well defined, not subject to frequent or seasonal change in position, and 4) the site should be easily accessible for repeatable measurements.

A cross-sectional picture of the channel was constructed for each site. Natural reference points such as trees and bridges were incorporated where available. In some instances stakes were emplaced for future reference. Results from monthly measurements, including depth and surface level, were recorded on these cross-sections.

Flow was determined using a Weather Measure Corporation Model F581-B water current meter. This instrument operates utilizing a propeller driven photo-optical device to measure water velocity. It is a broad range, low threshold instrument. Measurement range is 0-6.1 m/sec (0-2 ft/sec) with an accuracy of ±1 percent.

Flow rates were determined as follows. First the height of the water at the deepest point and width of water were measured and drawn on the cross-section. Next, the number of flow measurements to be taken were determined. If the stream width was less than one meter, then one measurement taken at a point 0.5 times the width. The depth of measurement was 0.6 times the depth, down from the surface. If the width was greater than one meter, then three sets of measurements were made at two depths each (USDI,1981). Data were then analyzed by determining the cross-sectional area of the water and the average flow velocity.

Table 2.11-9 lists the flow rates measured during 1982. An upstream station, S-1 and a White River station, W-2, are included for comparison. These data are discussed further in Section 2.6.2 of this report.

2.11.6 Soils

Soils samples were collected to determine baseline concentrations of selected elements in the different soils types. Six locations were chosen within Section 19 to provide area information (Figure 2.11-1). Seven sites were also sampled in the R&D plant, wellfield and pond areas (Figure 2.11-5). At the plant and pond locations another set of samples will be obtained after topsoil removal and excavation is complete.

Material collected for nonradiological analysis was in the form of surface samples. These were collected as follows. A two meter transect was laid out in either a north-south or east-west direction at the desired location. Points along this line were situated at 0, 0.67, 1.33 and 2 meters. At

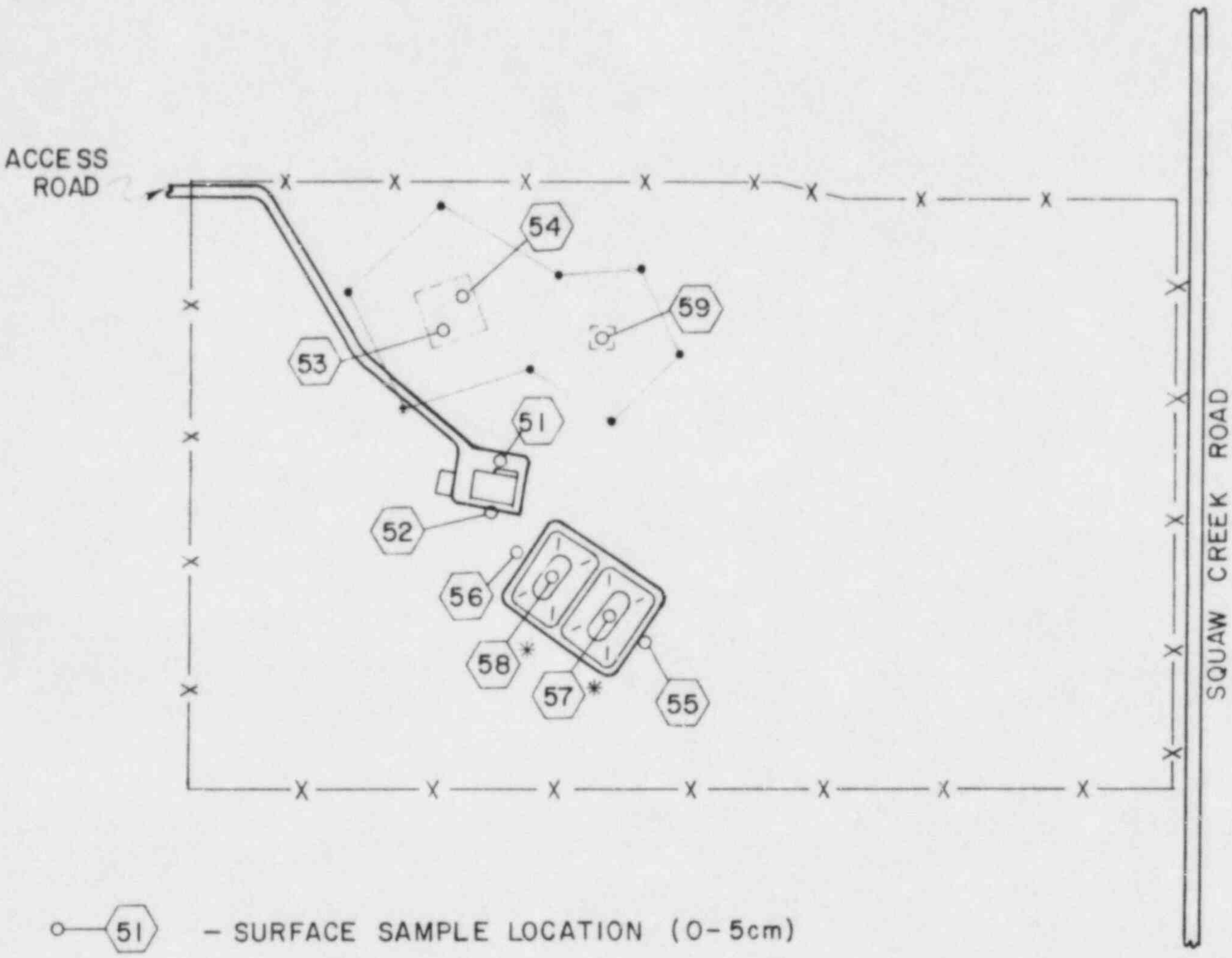
TABLE 2.11-9

1982 STREAM DISCHARGE RATES

(m^3/sec)

CROW BUTTE R&D PROJECT

Station	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Squaw Creek 1 (S-1)	.023	.038	.039	.064	.068	.038	.026	.003	.017	.003
Squaw Creek 2 (S-2)	.007	.029	.030	.041	.128	.008	.007	.002	.017	.013
Squaw Creek 3 (S-3)	.027	.018	.022	.046	.040	.023	.002	.000	.020	.028
White River 2 (W-2)	.707	.783	.901	.844	.763	.595	.463	.315	.806	.571



51 – SURFACE SAMPLE LOCATION (0-5cm)

* – SAMPLE TO BE COLLECTED AFTER POND EXCAVATION

SCALE: 1" = 500'

REV	BY	DATE	
			WYOMING FUEL COMPANY CROW BUTTE PROJECT Dawes County, Nebraska
			SOIL SAMPLE LOCATION MAP
			PREPARED BY:
			DWN BY: R.E. Larson — DATE 12-21-82 — FIGURE 2.11-5

each point soil was removed from a 5 to 7.6 cm (2 to 3 in.) diameter circular area to a depth of 5 cm (2 in.). The soil was placed in a labeled zip-lock bag and composited with that of all four points along the transect. Plants, large roots, and other large organic trash were removed from the sample. At sites where both radiometric and trace element analysis was desired, soil from each transect point was divided in half before being placed in the two bags. The samples were sent to the laboratory for radiometric and trace element analysis.

Five minor and trace elements were chosen for consideration in this sampling. Arsenic, selenium, molybdenum and vanadium are commonly associated with uranium ore deposits. This is especially true in roll-front type deposits where halos of metal sulfides and other reduced compounds occur at the "nose" or in front of the uranium mineralization. When leaching takes place during mining, varying concentrations of these companion compounds will also be solubilized. Thus, a surface spill of leach solution might contain small amounts of any of these four elements. The Crow Butte ore body appears to have more associated vanadium than molybdenum. In the wellfield, pond and plant areas soil was analyzed for vanadium.

Copper levels were also assayed. This was done to calculate the ratio of copper to molybdenum in the soil. In cases where the copper fraction is too low or the molybdenum becomes elevated above normal, then a condition called molybdenosis may occur in cattle. This condition is treated by application of copper compounds on the soil. Uranium mining has sometimes been implicated in causing or worsening this condition. In a few cases this was true, however the majority of areas had naturally occurring imbalances in the soil copper/molybdenum ratio.

Results of the soils sampling are presented in Table 2.11-10. Due to similarities of local soil composition and origin, soils type does not appear to greatly influence concentrations of these elements. Within the VeC soils type arsenic measured 0.88 and 0.72 µg/g. VeC soil selenium was <0.01 and 0.05 µg/g. For all area soils arsenic ranged from 0.64 to 1.00 µg/g and selenium ranged from <0.01 to 0.05 µg/g. The copper/molybdenum ratio was >65 at the highest in BxF soil and >44 at the lowest in VeC soil. The average was 52.2 with a standard deviation of 6.7. The narrow range in concentrations is logical since most of the soils originate from the Brule Formation or overlying Arikaree Group.

In a study conducted by the University of Texas, (Henry,1980) it was found in areas of mining and mineralization that high soils concentrations of molybdenum, arsenic or selenium occur predominantly in areas of shallow mineralization and result from natural processes.

Soils develop over long periods of time and contained elements are in equilibrium with the established chemical environment. Several factors govern solubility and stability of elements in soils. These include pH, drainage status, organic content, sulfate content, etc. In addition, many studies have pointed out there is no absolute correlation between the total concentration of an element in the soil and its uptake by plants. However, uptake of arsenic, selenium, molybdenum, copper, and vanadium by plants depends highly on the chemical form and availability of the elements and upon the plant species.

TABLE 2.11-10

SOILS ANALYSIS RESULTS
CROW BUTTE R&D PROJECT

Sample Site *	Soils Map Unit	Arsenic µg/g	Copper µg/g	Molybdenum µg/g	Selenium µg/g	Vanadium µg/g	Cu:Mo
22	VeC	0.88	5.20	<0.1	<0.01		>52
24	BxF	1.00	6.50	<0.1	0.03		>65
25	Sn	0.64	5.50	<0.1	0.04		>55
26	BxF	0.99	4.90	<0.1	0.01		>49
27	VeC	0.72	4.40	<0.1	0.05		>44
28	JvD	0.94	4.80	<0.1	0.03		>48

* Site numbers refer to locations shown in Figures 2.11-1 and 2.11-3

Molybdenosis in ruminant animals is caused by ingestion of forage either high in molybdenum or low in copper. Either imbalance can cause blockage of metabolism of copper. A copper/molybdenum ratio of 6 or 7 to 1 has been suggested as ideal, while a ratio of 2 to 1 is too low. The ratios of 44-65 to 1 found in the Crow Butte area indicate that molybdenosis should never be a problem due to the low quantities of molybdenum in the soil, depth of the ore body, and lack of molybdenum in the ore.

Arsenic is an essential element to animal growth but not to plants. Excess arsenic in soils would inhibit plant growth before levels toxic to animals could accumulate in the soil as low as 5 to 30 ppm can reduce plant growth by as much as 50 percent. Selenium toxicity levels depend on the plant species and availability of selenium from the soil.

Vanadium occurs in many soils, with a concentration as high as 0.470 mg/g being reported. Vegetation growing on such soil may contain as much as 0.010 mg/g. Small quantities of vanadium, less than 0.010 mg/g, appear beneficial to both animals and plants (McKee and Wolf, 1978).

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APPENDIX 2.11(A)
GROUND WATER BASELINE DATA

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: WELL 13
Well Type: BASELINE WELL
Formation: BRULE

Surface Elevation: 1225 m MSL
Well Depth: NA m MSL
Distance From Wellfield: 2670 m

	EPA Standards	SAMPLE RESULTS					MINIUM	MAXIMUM	AVERAGE
Date Sampled		01/29/82	04/29/82	07/13/82	07/13/82	10/05/82			
Lab Name		NRL	NRL	NRL	JORDAN	NRL			
Calcium (mg/l)		72	73	71	73	71	71	73	72
Magnesium (mg/l)		9.6	9.6	9.6	9.4	10	9.4	10.0	9.6
Sodium (mg/l)		21	21	21	21	21	21	21	21
Potassium (mg/l)		4.3	5.0	4.7	4.3	4.8	4.3	5.0	4.7
Carbonate (mg/l)		<2	<2	<2	0	<2	<2	<2	<2
Bicarbonate (mg/l)		310	310	310	305	300	300	310	307
Sulfate (mg/l)	250	13	<5	9	10	7	7	13	10
Chloride (mg/l)	250	2	3	3	10	3	2	10	4
Ammonia-N (mg/l)				0.18			0.18	0.18	0.18
Nitrite-N (mg/l)		<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	1.3	1.3	1.2	1.1	1.4	1.1	1.4	1.3
Fluoride (mg/l)	1.4-2.4	0.6	0.7	0.6	0.69	0.3	0.3	0.7	0.6
Silica (mg/l)		62	62	60	63	59	59	63	61
TDS-180°C (mg/l)	500	340	350	370	362	360	340	370	356
Conductivity - Field (umhos)		170	415	400	400	380	170	415	353
Conductivity - Lab (umhos)		472	499	488	486	468	468	499	483
Conductivity - Dilute (umhos)			545	548	527	520	520	548	535
Alkalinity (mg/l)			260	260	250	250	250	260	255
pH - Field		6.71	7.5	7.2	7.2	6.85	6.7	7.5	7.1
pH - Lab		7.2	7.6	7.4	7.46	7.4	7.2	7.6	7.4
Aluminum (mg/l)			<0.1				<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05		0.002				0.002	0.002	0.002
Barium (mg/l)	1		0.3				0.3	0.3	0.3
Cadmium (mg/l)	0.01		<0.001				<0.001	<0.001	<0.001
Chromium (mg/l)	0.05		<0.001				<0.001	<0.001	<0.001
Cobalt (mg/l)			<0.001				<0.001	<0.001	<0.001
Copper (mg/l)	1		0.002				0.002	0.002	0.002
Iron (mg/l)	0.3		0.40				0.40	0.40	0.40
Lead (mg/l)	0.05		<0.005				<0.005	<0.005	<0.005
Manganese (mg/l)	0.05		<0.1				<0.1	<0.1	<0.1
Mercury (mg/l)	0.002		<0.0001				<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)			0.002				0.002	0.002	0.002
Nickel (mg/l)			<0.002				<0.002	<0.002	<0.002
Selenium (mg/l)	0.01		<0.002				<0.002	<0.002	<0.002
Vanadium (mg/l)			0.010				0.010	0.010	0.010
Zinc (mg/l)	5		0.44				0.44	0.44	0.44
Boron (mg/l)			<0.5				<0.5	<0.5	<0.5
Uranium (µg/l)		9	8	9	8	8	8	9	8.
Radium 226 (pCi/l)	5	0.1	0.1	0.2	0.2	0.9	0.1	0.9	0.3
Dissolved Oxygen (ppm)							---	---	---
Temperature (°C)		10	6	11	11	12	6	12	10
Water Level (m) MSL		1209.6	1209.9	1209.9	1209.9	1209.3	1209.3	1209.9	1209.7

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: WELL 17
Well Type: BASELINE WELL
Formation: BRULE

Surface Elevation: 1192 m MSL
Well Depth: 24.4 m MSL
Distance From Wellfield: 915 m

	EPA Standards	SAMPLE RESULTS					MINIUM	MAXIMUM	AVERAGE
Date Sampled		10/29/81	01/28/82	04/28/82	07/13/82	10/05/82			
Lab Name		NRL	NRL	NRL	NRL	NRL			
Calcium (mg/l)		59	57	60	61	60	57	61	59
Magnesium (mg/l)		7.7	8.0	8.0	8.0	9.0	7.7	9.0	8.1
Sodium (mg/l)		17	18	19	17	18	17	19	18
Potassium (mg/l)		4.8	4.0	4.7	4.5	4.6	4.0	4.8	4.5
Carbonate (mg/l)		<2	<2	<2	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		250	240	240	240	250	240	250	244
Sulfate (mg/l)	250	10	13	12	10	11	10	13	11
Chloride (mg/l)	250	4	2	3	4	3	2	4	3
Ammonia-N (mg/l)									
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	1.3	1.2	1.2	1.3	1.2	1.2	1.3	1.2
Fluoride (mg/l)	1.4-2.4	0.8	0.6	0.7	0.6	0.6	0.6	0.8	0.7
Silica (mg/l)		59	62	61	59	59	59	62	60
TDS-180°C (mg/l)	500	310	260	280	330	320	266	330	300
Conductivity - Field (umhos)		160	270	365	370	350	160	370	303
Conductivity - Lab (umhos)		422	393	409	412	404	393	422	408
Conductivity - Dilute (umhos)				451	450	448	448	451	450
Alkalinity (mg/l)				200	200	210	200	210	203
pH - Field		7.5	6.81	7.45	7.1	6.9	6.8	7.5	7.2
pH - Lab		7.8	7.4	7.9	7.4	7.6	7.4	7.9	7.6
Aluminum (mg/l)				<0.1			<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05			0.003			0.003	0.003	0.003
Barium (mg/l)	1			0.2			0.2	0.2	0.2
Cadmium (mg/l)	0.01			<0.001			<0.001	<0.001	<0.001
Chromium (mg/l)	0.05			<0.001			<0.001	<0.001	<0.001
Cobalt (mg/l)				<0.001			<0.001	<0.001	<0.001
Copper (mg/l)	1			0.002			0.002	0.002	0.002
Iron (mg/l)	0.3	<0.05		<0.05			<0.05	<0.05	<0.05
Lead (mg/l)	0.05			<0.005			<0.005	<0.005	<0.005
Manganese (mg/l)	0.05			<0.1			<0.1	<0.1	<0.1
Mercury (mg/l)	0.002			<0.0001			<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)				0.002			0.002	0.002	0.002
Nickel (mg/l)				<0.002			<0.002	<0.002	<0.002
Selenium (mg/l)	0.01			<0.002			<0.002	<0.002	<0.002
Vanadium (mg/l)				0.005			0.005	0.005	0.005
Zinc (mg/l)	5			0.024			0.024	0.024	0.024
Boron (mg/l)				<0.5			<0.5	<0.5	<0.5
Uranium (µg/l)		4	4	2	8	4	2	8	4.
Radium 226 (pCi/l)	5	0.1	<0.1	0.4	0.1	0.6	<0.1	0.6	0.3
Dissolved Oxygen (ppm)							---	---	---
Temperature (°C)		17	11	9	14	13	9	17	13
Water Level (m) MSL			1178.1	1177.3	1177.6	1177.7	1177.3	1178.1	1177.7

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: WELL 25
Well Type: BASELINE WELL
Formation: BRULE

Surface Elevation: 1190 m MSL
Well Depth: 22.9 m MSL
Distance From Wellfield: 915 m

	EPA Standards	SAMPLE RESULTS					MINIUM	MAXIMUM	AVERAGE
Date Sampled		01/28/82	04/28/82	04/28/82	07/13/82	10/04/82			
Lab Name		NRL	NRL	JORDAN	NRL	NRL			
Calcium (mg/l)		73	78	75	77	79	73	79	76
Magnesium (mg/l)		10.0	11	10	10	12	10	12	11
Sodium (mg/l)		14	14	13	13	16	13	16	14
Potassium (mg/l)		4.4	4.7	4.7	4.6	5.1	4.4	5.1	4.7
Carbonate (mg/l)		<2	<2	0	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		290	290	287	290	300	287	300	291
Sulfate (mg/l)	250	7	7	8	7	7	7	8	7
Chloride (mg/l)	250	4	5	7	3	5	3	7	5
Ammonia-N (mg/l)				0.08			0.08	0.08	0.08
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	3.8	4.6	4.0	3.9	4.5	3.8	4.6	4.2
Fluoride (mg/l)	1.4-2.4	0.6	0.7	0.71	0.6	0.6	0.6	0.7	0.6
Silica (mg/l)		55	54	52	54	52	52	55	53
TDS-180°C (mg/l)	500	310	340	332	350	370	310	370	340
Conductivity - Field (umhos)		290	390	390	460	430	290	460	392
Conductivity - Lab (umhos)		470	496	475	493	492	470	496	485
Conductivity - Dilute (umhos)			546	494	541	546	494	546	532
Alkalinity (mg/l)			230	235	240	240	230	240	236
pH - Field		7.4	7.3	7.3	7.0	6.6	6.6	7.4	7.1
pH - Lab		7.1	7.8	7.44	7.6	7.4	7.1	7.3	7.5
Aluminum (mg/l)			<0.1	0.07			0.07	<0.1	<0.09
Arsenic (mg/l)	0.05		0.003	0.005			0.003	0.005	0.004
Barium (mg/l)	1		0.1	0.03			0.03	0.1	0.06
Cadmium (mg/l)	0.01		<0.001	<0.0001			<0.0001	<0.001	<0.0006
Chromium (mg/l)	0.05		<0.001	<0.001			<0.001	<0.001	<0.001
Cobalt (mg/l)			<0.001	<0.01			<0.001	<0.01	<0.006
Copper (mg/l)	1		0.004	0.007			0.004	0.007	0.006
Iron (mg/l)	0.3		<0.05	0.02			0.02	<0.05	<0.04
Lead (mg/l)	0.05		<0.005	<0.001			<0.001	<0.005	<0.003
Manganese (mg/l)	0.05		<0.1	0.005			0.005	<0.1	<0.05
Mercury (mg/l)	0.002		<0.0001	<0.0001			<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)			0.002	<0.01			0.002	<0.01	<0.006
Nickel (mg/l)			<0.002	<0.01			<0.002	<0.01	<0.006
Selenium (mg/l)	0.01		<0.002	<0.001			<0.001	<0.002	<0.002
Vanadium (mg/l)			0.013	0.01			0.01	0.013	0.012
Zinc (mg/l)	5		0.026	0.25			0.026	0.25	0.138
Boron (mg/l)			<0.5	0.02			0.02	<0.5	<0.26
Uranium (µg/l)		5	3	5	6	5	3	6	5.
Radium 226 (pCi/l)	5	0.1	0.3	0.1	0.1	0.4	0.1	0.4	0.2
Dissolved Oxygen (ppm)							—	—	—
Temperature (°C)		10	4	4	16	14	4	16	10
Water Level (m) MSL		1179.6	1179.9	1179.9	1179.4	1179.7	1179.4	1179.9	1179.7

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: WELL 26
Well Type: BASELINE WELL
Formation: BRULE

Surface Elevation: 1164 m MSL
Well Depth: 24.4 m MSL
Distance From Wellfield: 1145 m

	EPA Standards	SAMPLE RESULTS					MINIUM	MAXIMUM	AVERAGE
Date Sampled		10/29/81	01/28/82	04/28/82	07/14/82	10/05/82			
Lab Name		NRL	NRL	NRL	NRL	NRL			
Calcium (mg/l)		120	120	110	110	120	110	120	116
Magnesium (mg/l)		15	15	14	14	19	14	19	15
Sodium (mg/l)		15	15	15	14	15	14	15	15
Potassium (mg/l)		6.9	5.7	6.5	6.3	6.9	5.7	6.9	6.5
Carbonate (mg/l)		<2	<2	<2	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		340	360	350	350	330	330	360	346
Sulfate (mg/l)	250	28	21	21	21	36	21	36	25
Chloride (mg/l)	250	33	33	24	28	38	24	38	31
Ammonia-N (mg/l)									
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	11.0	13.0	11	10	12	10	13.0	11.4
Fluoride (mg/l)	1.4-2.4	0.8	0.6	0.7	0.6	0.6	0.6	0.8	0.7
Silica (mg/l)		46	51	51	49	48	46	51	49
TDS-180°C (mg/l)	500	500	480	470	490	550	470	550	498
Conductivity - Field (umhos)		700	510	700	700	700	510	700	662
Conductivity - Lab (umhos)		751	740	720	699	802	699	802	742
Conductivity - Dilute (umhos)				810	779	926	779	926	838
Alkalinity (mg/l)				290	290	270	270	290	283
pH - Field		7.3	6.80	7.2	6.9	6.9	6.8	7.3	7.0
pH - Lab		7.5	7.0	7.8	7.3	7.2	7.0	7.8	7.4
Aluminum (mg/l)				<0.1			<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05			0.003			0.003	0.003	0.003
Barium (mg/l)	1			0.3			0.3	0.3	0.3
Cadmium (mg/l)	0.01			<0.001			<0.001	<0.001	<0.001
Chromium (mg/l)	0.05			<0.001			<0.001	<0.001	<0.001
Cobalt (mg/l)				<0.001			<0.001	<0.001	<0.001
Copper (mg/l)	1			0.007			0.007	0.007	0.007
Iron (mg/l)	0.3	0.05		<0.05			<0.05	0.05	0.05
Lead (mg/l)	0.05			<0.005			<0.005	<0.005	<0.005
Manganese (mg/l)	0.05			<0.1			<0.1	<0.1	<0.1
Mercury (mg/l)	0.002			<0.0001			<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)				0.002			0.002	0.002	0.002
Nickel (mg/l)				<0.002			<0.002	<0.002	<0.002
Selenium (mg/l)	0.01			<0.002			<0.002	<0.002	<0.002
Vanadium (mg/l)				0.007			0.007	0.007	0.007
Zinc (mg/l)	5			0.046			0.046	0.046	0.046
Boron (mg/l)				<0.5			<0.5	<0.5	<0.5
Uranium (µg/l)		7	7	4	6	8	4	8	6.
Radium 226 (pCi/l)	5	0.2	0.2	0.3	0.2	0.4	0.2	0.4	0.3
Dissolved Oxygen (ppm)							---	---	---
Temperature (°C)		13	11	9	15	13	9	15	12
Water Level (m) MSL							---	---	---

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: WELL 57
Well Type: BASELINE WELL
Formation: BRULE

Surface Elevation: 1158 m MSL
Well Depth: 7.6 m MSL
Distance From Wellfield: 1755 m

	EPA Standards	SAMPLE RESULTS				MINIUM	MAXIMUM	AVERAGE
Date Sampled		10/29/81	01/29/82	04/28/82	10/04/82			
Lab Name		NRL	NRL	NRL	NRL			
Calcium (mg/l)		64	62	65	64	62	65	64
Magnesium (mg/l)		7.4	7.6	7.6	8.5	7.4	8.5	7.8
Sodium (mg/l)		17	17	17	17	17	17	17
Potassium (mg/l)		6.5	5.6	6.1	5.8	5.6	6.5	6.0
Carbonate (mg/l)		<2	<2	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		260	260	260	310	260	310	273
Sulfate (mg/l)	250	11	16	5	7	5	16	10
Chloride (mg/l)	250	4	<2	2	3	2	4	3
Ammonia-N (mg/l)								
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	2.1	2.2	2.2	2.0	2.0	2.2	2.1
Fluoride (mg/l)	1.4-2.4	0.6	0.5	0.6	0.5	0.5	0.6	0.6
Silica (mg/l)		54	56	59	58	54	59	57
TDS-180°C (mg/l)	500	310	320	310	340	310	340	320
Conductivity - Field (umhos)		362	315	400	370	315	400	362
Conductivity - Lab (umhos)		430	415	427	424	415	430	424
Conductivity - Dilute (umhos)				468	468	468	468	468
Alkalinity (mg/l)				210	260	210	260	235
pH - Field		7.6	6.89	7.6	6.95	6.9	7.6	7.3
pH - Lab		7.6	7.2	8.0	7.4	7.2	8.0	7.6
Aluminum (mg/l)				<0.1		<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05			0.002		0.002	0.002	0.002
Barium (mg/l)	1			0.2		0.2	0.2	0.2
Cadmium (mg/l)	0.01			<0.001		<0.001	<0.001	<0.001
Chromium (mg/l)	0.05			<0.001		<0.001	<0.001	<0.001
Cobalt (mg/l)				<0.001		<0.001	<0.001	<0.001
Copper (mg/l)	1			0.001		0.001	0.001	0.001
Iron (mg/l)	0.3	<0.05		<0.05		<0.05	<0.05	<0.05
Lead (mg/l)	0.05			<0.005		<0.005	<0.005	<0.005
Manganese (mg/l)	0.05			<0.1		<0.1	<0.1	<0.1
Mercury (mg/l)	0.002			0.0002		0.0002	0.0002	0.0002
Molybdenum (mg/l)				<0.002		<0.002	<0.002	<0.002
Nickel (mg/l)				<0.002		<0.002	<0.002	<0.002
Selenium (mg/l)	0.01			<0.002		<0.002	<0.002	<0.002
Vanadium (mg/l)				0.006		0.006	0.006	0.006
Zinc (mg/l)	5			0.44		0.44	0.44	0.44
Boron (mg/l)				<0.5		<0.5	<0.5	<0.5
Uranium (µg/l)			7	8	7	7	8	7.
Radium 226 (pCi/l)	5		0.3	0.4	0.8	0.3	0.8	0.5
Dissolved Oxygen (ppm)						—	—	—
Temperature (°C)		9	11	9	13	9	13	11
Water Level (m) MSL						—	—	—

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: WELL 62
Well Type: BASELINE WELL
Formation: CHADRON

Surface Elevation: 1152 m MSL
Well Depth: 143.3 m MSL
Distance From Wellfield: 2970 m

	EPA Standards	SAMPLE RESULTS					MINIUM	MAXIMUM	AVERAGE
Date Sampled		01/28/82	04/27/82	04/27/82	07/13/82	10/04/82			
Lab Name		NRL	NRL	JORDAN	NRL	NRL			
Calcium (mg/l)		15	15	15	16	16	15	16	15
Magnesium (mg/l)		3.7	3.4	3.4	3.7	4.3	3.4	4.3	3.7
Sodium (mg/l)		380	390	396	380	400	380	400	389
Potassium (mg/l)		9.5	9.8	14	10	11	9.5	14.0	10.9
Carbonate (mg/l)		<2	<2	0	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		380	390	382	400	390	380	400	388
Sulfate (mg/l)	250	340	360	338	360	370	338	370	354
Chloride (mg/l)	250	180	180	186	150	170	150	186	173
Ammonia-N (mg/l)				0.44			0.44	0.44	0.44
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	<0.01	0.02	0.07	0.03	0.04	<0.01	0.07	0.03
Fluoride (mg/l)	1.4-2.4	0.6	0.6	0.69	0.6	0.6	0.6	0.7	0.6
Silica (mg/l)		11	12	11	11	11	11	12	11
TDS-180°C (mg/l)	500	1100	1100	1200	1200	1200	1100	1200	1160
Conductivity - Field (umhos)		1400	1700	1700	1650	1600	1400	1700	1610
Conductivity - Lab (umhos)		1790	1900	1870	1890	1800	1790	1900	1850
Conductivity - Dilute (umhos)			2140	2090	2180	2100	2090	2180	2128
Alkalinity (mg/l)			320	313	330	320	313	330	321
pH - Field		7.46	7.75	7.75	7.8	7.65	7.5	7.8	7.7
pH - Lab		7.9	8.0	8.13	7.8	8.1	7.8	8.1	8.0
Aluminum (mg/l)			<0.1	0.07			0.07	<0.1	<0.09
Arsenic (mg/l)	0.05		<0.002	<0.001			<0.001	<0.002	<0.002
Barium (mg/l)	1		<0.1	0.04			0.04	<0.1	<0.07
Cadmium (mg/l)	0.01		<0.001	<0.0001			<0.0001	<0.001	<0.0006
Chromium (mg/l)	0.05		<0.001	<0.001			<0.001	<0.001	<0.001
Cobalt (mg/l)			<0.001	<0.01			<0.001	<0.01	<0.006
Copper (mg/l)	1		0.001	0.004			0.001	0.004	0.003
Iron (mg/l)	0.3		<0.05	0.03			0.03	<0.05	<0.04
Lead (mg/l)	0.05		<0.005	<0.001			<0.001	<0.005	<0.003
Manganese (mg/l)	0.05		<0.1	0.013			0.013	<0.1	<0.06
Mercury (mg/l)	0.002		0.0003	0.0004			0.0003	0.0004	0.0004
Molybdenum (mg/l)			0.022	<0.01			<0.01	0.022	0.016
Nickel (mg/l)			<0.002	<0.01			<0.002	<0.01	<0.006
Selenium (mg/l)	0.01		<0.002	<0.001			<0.001	<0.002	<0.002
Vanadium (mg/l)			0.006	<0.01			0.006	<0.01	<0.008
Zinc (mg/l)	5		0.11	0.11			0.11	0.11	0.11
Boron (mg/l)			1.2	0.73			0.73	1.2	0.97
Uranium (µg/l)		27	39	36	31	20	20	39	31.
Radium 226 (pCi/l)	5	18.0	13.8	17	5.9	16.9	5.9	18.0	14.3
Dissolved Oxygen (ppm)							—	—	—
Temperature (°C)		13	11	11	13	12	11	13	12
Water Level (m) MSL		1141.3	1141.4	1179.9	1141.2	1141.5	1141.2	1179.9	1149.1

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: RA-2
Well Type: BASELINE WELL
Formation: BRULE

Surface Elevation: 1140 m MSL
Well Depth: 10.4 m MSL
Distance From Wellfield: 3660 m

	EPA Standards	SAMPLE RESULTS		MINIUM	MAXIMUM	AVERAGE
Date Sampled		07/22/82	09/29/82			
Lab Name		NRL	NRL			
Calcium (mg/l)		67	73	67	73	70
Magnesium (mg/l)		9.1	10	9.1	10.0	9.6
Sodium (mg/l)		41	36	36	41	39
Potassium (mg/l)		11.	11	11	11	11
Carbonate (mg/l)		<2	<2	<2	<2	<2
Bicarbonate (mg/l)		330	320	320	330	325
Sulfate (mg/l)	250	19	14	14	19	17
Chloride (mg/l)	250	5	6	5	6	6
Ammonia-N (mg/l)		<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	2.4	0.01	0.01	2.4	1.21
Fluoride (mg/l)	1.4-2.4	0.9	0.7	0.7	0.9	0.8
Silica (mg/l)		56	57	56	57	57
TDS-180°C (mg/l)	500	370	380	370	380	375
Conductivity - Field (umhos)		370	540	370	540	455
Conductivity - Lab (umhos)		568	541	541	568	555
Conductivity - Dilute (umhos)		617	575	575	617	596
Alkalinity (mg/l)		270	260	260	270	265
pH - Field		7.8	6.9	6.9	7.8	7.4
pH - Lab		7.6	7.4	7.4	7.6	7.5
Aluminum (mg/l)		<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05	0.005	0.007	0.005	0.007	0.006
Barium (mg/l)	1	0.3	0.2	0.2	0.3	0.3
Cadmium (mg/l)	0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	0.001	<0.001	<0.001	0.001	0.001
Cobalt (mg/l)		<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	1	<0.001	0.003	<0.001	0.003	0.002
Iron (mg/l)	0.3	<0.05	<0.05	<0.05	<0.05	<0.05
Lead (mg/l)	0.05	<0.005	0.005	<0.005	0.005	0.005
Manganese (mg/l)	0.05	<0.10	<0.1	<0.10	<0.10	<0.10
Mercury (mg/l)	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		<0.002	0.014	<0.002	0.014	0.008
Nickel (mg/l)		<0.002	<0.002	<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		0.012	0.010	0.010	0.012	0.011
Zinc (mg/l)	5	0.19	0.180	0.180	0.19	0.185
Boron (mg/l)		0.6	0.5	0.5	0.6	0.6
Uranium (µg/l)		16	14	14	16	15.
Radium 226 (pCi/l)	5	0.8	0.5	0.5	0.8	0.7
Dissolved Oxygen (ppm)				---	---	---
Temperature (°C)		12	11	11	12	12
Water Level (m) MSL		1137.8	1137.5	1137.5	1137.8	1137.7

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: RB-3
Well Type: BASELINE WELL
Formation: BRULE

Surface Elevation: 1230 m MSL
Well Depth: 36.6 m MSL
Distance From Wellfield: 3200 m

	EPA Standards	SAMPLE RESULTS		MINIUM	MAXIMUM	AVERAGE
Date Sampled		08/01/82	09/30/82			
Lab Name		NRL	NRL			
Calcium (mg/l)		38	37	37	38	38
Magnesium (mg/l)		5.1	4.8	4.8	5.1	5.0
Sodium (mg/l)		14	21	14	21	18
Potassium (mg/l)		6.1	6.9	6.1	6.9	6.5
Carbonate (mg/l)		<2	<2	<2	<2	<2
Bicarbonate (mg/l)		180	180	180	180	180
Sulfate (mg/l)	250	7	<5	7	7	7
Chloride (mg/l)	250	2	4	2	4	3
Ammonia-N (mg/l)		<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite-N (mg/l)		0.01	<0.01	<0.01	0.01	0.01
Nitrate-N (mg/l)	10	0.48	<0.01	<0.01	0.48	0.24
Fluoride (mg/l)	1.4-2.4	0.3	0.3	0.3	0.3	0.3
Silica (mg/l)		61	62	61	62	62
TDS-180°C (mg/l)	500	230	290	230	290	260
Conductivity - Field (umhos)		230	350	230	350	290
Conductivity - Lab (umhos)		290	282	282	290	286
Conductivity - Dilute (umhos)		303	295	295	303	299
Alkalinity (mg/l)		150	140	140	150	145
pH - Field		7.65	8.2	7.7	8.2	7.9
pH - Lab		7.9	8.3	7.9	8.3	8.1
Aluminum (mg/l)		<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05	<0.002	0.002	<0.002	0.002	0.002
Barium (mg/l)	1	0.2	0.2	0.2	0.2	0.2
Cadmium (mg/l)	0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	0.001	0.001	0.001	0.001	0.001
Cobalt (mg/l)		<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	1	0.001	0.001	0.001	0.001	0.001
Iron (mg/l)	0.3	<0.05	<0.05	<0.05	<0.05	<0.05
Lead (mg/l)	0.05	<0.005	0.005	<0.005	0.005	0.005
Manganese (mg/l)	0.05	<0.10	<0.1	<0.10	<0.10	<0.10
Mercury (mg/l)	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		<0.002	0.007	<0.002	0.007	0.005
Nickel (mg/l)		<0.002	0.002	<0.002	0.002	0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		0.007	0.001	0.001	0.007	0.004
Zinc (mg/l)	5	0.064	0.008	0.008	0.064	0.036
Boron (mg/l)		<0.5	0.5	<0.5	0.5	0.5
Uranium (µg/l)		6	6	6	6	6.
Radium 226 (pCi/l)	5	0.4	0.1	0.1	0.4	0.3
Dissolved Oxygen (ppm)				—	—	—
Temperature (°C)		15	13	13	15	14
Water Level (m) MSL		1206.1	1205.8	1205.8	1206.1	1206.0

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: RC-4
Well Type: BASELINE WELL
Formation: CHADRON

Surface Elevation: 1141 m MSL
Well Depth: 111.3 m MSL
Distance From Wellfield: 3660 m

	EPA Standards	SAMPLE RESULTS		MINIUM	MAXIMUM	AVERAGE
Date Sampled		07/22/82	09/30/82			
Lab Name		NRL	NRL			
Calcium (mg/l)		17	18	17	18	18
Magnesium (mg/l)		3.7	4.2	3.7	4.2	4.0
Sodium (mg/l)		390	380	380	390	385
Potassium (mg/l)		9.3	8.9	8.9	9.3	9.1
Carbonate (mg/l)		<2	<2	<2	<2	<2
Bicarbonate (mg/l)		400	410	400	410	405
Sulfate (mg/l)	250	350	340	340	350	345
Chloride (mg/l)	250	170	160	160	170	165
Ammonia-N (mg/l)		0.18	0.45	0.18	0.45	0.31
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	0.02	<0.01	<0.01	0.02	0.01
Fluoride (mg/l)	1.4-2.4	0.6	0.5	0.5	0.6	0.6
Silica (mg/l)		10	10	10	1.	10
TDS-180°C (mg/l)	500	1100	1100	1100	1100	1100
Conductivity - Field (umhos)		1440	1875	1440	1875	1658
Conductivity - Lab (umhos)		1870	1810	1810	1870	1840
Conductivity - Dilute (umhos)		2080	2020	2020	2080	2050
Alkalinity (mg/l)		330	330	330	330	330
pH - Field		8.3	7.8	7.8	8.3	8.1
pH - Lab		8.1	8.2	8.1	8.2	8.2
Aluminum (mg/l)		<0.1	0.1	<0.1	0.1	0.1
Arsenic (mg/l)	0.05	<0.002	<0.002	<0.002	<0.002	<0.002
Barium (mg/l)	1	<0.1	0.1	<0.1	0.1	0.1
Cadmium (mg/l)	0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	0.001	<0.001	<0.001	0.001	0.001
Cobalt (mg/l)		<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	1	<0.001	0.001	<0.00.	0.001	0.001
Iron (mg/l)	0.3	<0.05	<0.05	<0.05	<0.05	<0.05
Lead (mg/l)	0.05	<0.005	0.005	<0.005	0.005	0.005
Manganese (mg/l)	0.05	<0.10	<0.1	<0.10	<0.10	<0.10
Mercury (mg/l)	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		0.018	0.028	0.018	0.028	0.023
Nickel (mg/l)		<0.002	<0.002	<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		0.007	0.001	0.001	0.007	0.004
Zinc (mg/l)	5	0.11	0.059	0.059	0.11	0.084
Boron (mg/l)		1.2	0.9	0.9	1.2	1.1
Uranium (µg/l)		65	870	65	870	468.
Radium 226 (pCi/l)	5	235	430	235	430	333.
Dissolved Oxygen (ppm)				---	---	---
Temperature (°C)		17	15	15	17	16
Water Level (m) MSL		1140.0	-	1140	1140	1140

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: RC-5
Well Type: BASELINE WELL
Formation: CHADRON

Surface Elevation: 1189 m MSL
Well Depth: 182.9 m MSL
Distance From Wellfield: 1370 m

	EPA Standards	SAMPLE RESULTS		MINIUM	MAXIMUM	AVERAGE
Date Sampled		07/22/82	09/30/82			
Lab Name		NRL	NRL			
Calcium (mg/l)		19	18	18	19	19
Magnesium (mg/l)		3.2	3.0	3.0	3.2	3.1
Sodium (mg/l)		390	370	370	390	380
Potassium (mg/l)		11.	10	10	11	11
Carbonate (mg/l)		<2	2	<2	2	2
Bicarbonate (mg/l)		370	350	350	370	360
Sulfate (mg/l)	250	370	360	360	370	365
Chloride (mg/l)	250	180	190	180	190	185
Ammonia-N (mg/l)		0.19	0.35	0.19	0.35	0.27
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride (mg/l)	1.4-2.4	0.6	0.5	0.5	0.6	0.6
Silica (mg/l)		13	13	13	13	13
TDS-180°C (mg/l)	500	1100	1100	1100	1100	1100
Conductivity - Field (umhos)		1520	1900	1520	1900	1710
Conductivity - Lab (umhos)		1870	1850	1850	1870	1860
Conductivity - Dilute (umhos)		2140	2050	2050	2140	2095
Alkalinity (mg/l)		310	290	290	310	300
pH - Field		8.25	8.2	8.2	8.3	8.2
pH - Lab		8.1	8.4	8.1	8.4	8.3
Aluminum (mg/l)		<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05	<0.002	<0.002	<0.002	<0.002	<0.002
Barium (mg/l)	1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium (mg/l)	0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	0.001	<0.001	<0.001	0.001	0.001
Cobalt (mg/l)		<0.001	0.001	<0.001	0.001	0.001
Copper (mg/l)	1	<0.001	0.003	<0.001	0.003	0.002
Iron (mg/l)	0.3	<0.05	<0.05	<0.05	<0.05	<0.05
Lead (mg/l)	0.05	<0.005	0.010	<0.005	0.010	0.008
Manganese (mg/l)	0.05	<0.10	<0.1	<0.10	<0.10	<0.10
Mercury (mg/l)	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		0.005	0.006	0.005	0.006	0.006
Nickel (mg/l)		<0.002	<0.002	<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		0.007	0.001	0.001	0.007	0.004
Zinc (mg/l)	5	0.016	0.012	0.012	0.016	0.014
Boron (mg/l)		0.9	1.0	0.9	1.0	0.9
Uranium (µg/l)		3	6	3	6	5.
Radium 226 (pCi/l)	5	3.8	3.0	3.0	3.8	3.4
Dissolved Oxygen (ppm)				---	---	---
Temperature (°C)		18	15	15	18	17
Water Level (m) MSL		1143.0	-	1143	1143	1143

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: RC-6
Well Type: BASELINE WELL
Formation: CHADRON

Surface Elevation: 1201 m MSL
Well Depth: 193.5 m MSL
Distance From Wellfield: 1370 m

	EPA Standards	SAMPLE RESULTS		MINIUM	MAXIMUM	AVERAGE
Date Sampled		07/22/82	09/28/82			
Lab Name		NRL	NRL			
Calcium (mg/l)		35	38	35	38	37
Magnesium (mg/l)		6.8	7.2	6.8	7.2	7.0
Sodium (mg/l)		400	440	400	440	420
Potassium (mg/l)		14.	18	14	18	16
Carbonate (mg/l)		<2	5	<2	5	4
Bicarbonate (mg/l)		330	310	310	330	320
Sulfate (mg/l)	250	470	460	460	470	465
Chloride (mg/l)	250	190	250	190	250	220
Ammonia-N (mg/l)		0.31	0.58	0.31	0.58	0.44
Nitrite-N (mg/l)		<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate-N (mg/l)	10	0.01	0.03	0.01	0.03	0.02
Fluoride (mg/l)	1.4-2.4	0.7	0.6	0.6	0.7	0.7
Silica (mg/l)		18	16	16	18	17
TDS-180°C (mg/l)	500	1200	1300	1200	1300	1250
Conductivity - Field (umhos)		1600	2200	1600	2200	1900
Conductivity - Lab (umhos)		2020	1800	1800	2020	1910
Conductivity - Dilute (umhos)		2160	2460	2160	2460	2310
Alkalinity (mg/l)		270	250	250	270	260
pH - Field		8.0	8.6	8.0	8.6	8.3
pH - Lab		8.0	8.4	8.0	8.4	8.2
Aluminum (mg/l)		<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05	0.008	0.005	0.005	0.008	0.007
Barium (mg/l)	1	<0.1	0.1	<0.1	0.1	0.1
Cadmium (mg/l)	0.01	0.001	<0.001	<0.001	0.001	0.001
Chromium (mg/l)	0.05	0.001	<0.001	<0.001	0.001	0.001
Cobalt (mg/l)		<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	1	0.002	0.002	0.002	0.002	0.002
Iron (mg/l)	0.3	<0.05	<0.05	<0.05	<0.05	<0.05
Lead (mg/l)	0.05	<0.005	0.010	<0.005	0.010	0.008
Manganese (mg/l)	0.05	<0.10	<0.1	<0.10	<0.10	<0.10
Mercury (mg/l)	0.002	<0.0001	0.0001	<0.0001	0.0001	0.0001
Molybdenum (mg/l)		0.019	0.032	0.019	0.032	0.026
Nickel (mg/l)		<0.002	0.002	<0.002	0.002	0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		0.008	0.002	0.002	0.008	0.005
Zinc (mg/l)	5	0.096	0.030	0.030	0.096	0.063
Boron (mg/l)		1.1	0.7	0.7	1.1	0.9
Uranium (µg/l)		6	3	3	6	5.
Radium 226 (pCi/l)	5	9.9	0.4	0.4	9.9	5.1
Dissolved Oxygen (ppm)				—	—	—
Temperature (°C)		19	16	16	19	18
Water Level (m) MSL		1143.2	1143.0	1143.0	1143.2	1143.1

CROW BUTTE PROJECT
RESTRICTED AREA BASELINE WATER QUALITY

Well Number: RC-7
Well Type: BASELINE WELL
Formation: CHADRON

Surface Elevation: 1229 m MSL
Well Depth: 217.9 m MSL
Distance From Wellfield: 3200 m

	EPA Standards	SAMPLE RESULTS		MINIUM	MAXIMUM	AVERAGE
Date Sampled		07/21/82	09/28/82			
Lab Name		NRL	NRL			
Calcium (mg/l)		19	25	19	25	22
Magnesium (mg/l)		3.1	3.5	3.1	3.5	3.3
Sodium (mg/l)		360	350	350	360	355
Potassium (mg/l)		11.	11	11	11	11
Carbonate (mg/l)		<2	<2	<2	<2	<2
Bicarbonate (mg/l)		360	340	340	360	350
Sulfate (mg/l)	250	330	310	310	330	320
Chloride (mg/l)	250	170	180	170	180	175
Ammonia-N (mg/l)		0.37	0.45	0.37	0.45	0.41
Nitrite-N (mg/l)		0.01	<0.01	<0.01	0.01	0.01
Nitrate-N (mg/l)	10	0.02	0.01	0.01	0.02	0.01
Fluoride (mg/l)	1.4-2.4	0.8	0.7	0.7	0.8	0.8
Silica (mg/l)		15	16	15	16	16
TDS-180°C (mg/l)	500	1000	1100	1000	1100	1050
Conductivity - Field (umhos)		1650	1700	1650	1700	1675
Conductivity - Lab (umhos)		1720	1610	1610	1720	1665
Conductivity - Dilute (umhos)		1940	1850	1850	1940	1895
Alkalinity (mg/l)		290	280	280	290	285
pH - Field		8.5	8.2	8.2	8.5	8.4
pH - Lab		8.0	8.3	8.0	8.3	8.2
Aluminum (mg/l)		<0.1	0.6	<0.1	0.6	0.4
Arsenic (mg/l)	0.05	<0.002	0.002	<0.002	0.002	0.002
Barium (mg/l)	1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium (mg/l)	0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	0.001	0.001	0.001	0.001	0.001
Cobalt (mg/l)		<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	1	<0.001	0.003	<0.001	0.003	0.002
Iron (mg/l)	0.3	<0.05	0.31	<0.05	0.31	0.18
Lead (mg/l)	0.05	<0.005	0.010	<0.005	0.010	0.008
Manganese (mg/l)	0.05	<0.10	<0.1	<0.10	<0.10	<0.10
Mercury (mg/l)	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		0.018	0.017	0.017	0.018	0.018
Nickel (mg/l)		<0.002	<0.002	<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		0.007	0.003	0.003	0.007	0.005
Zinc (mg/l)	5	0.004	0.038	0.004	0.038	0.021
Boron (mg/l)		1.3	0.9	0.9	1.3	1.1
Uranium (µg/l)		3	1	1	3	2.
Radium 226 (pCi/l)	5	0.8	0.4	0.4	0.8	0.6
Dissolved Oxygen (ppm)				---	---	---
Temperature (°C)		19	19	19	19	19
Water Level (m) MSL		1142.1	1142.7	1142.1	1142.7	1142.4

TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 13

Sample Date: 01/29/82 LAB NAME: NRL

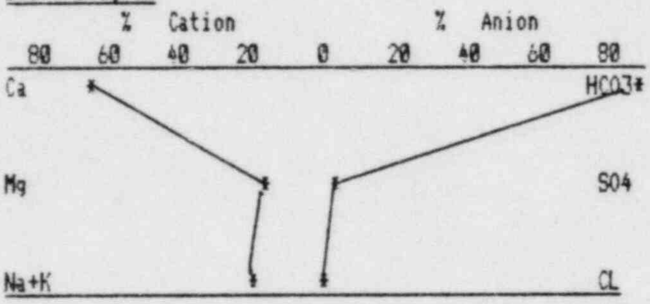
Major Constituents (mg/l)

Calcium	72	Carbonate	<2
Magnesium	9.6	Bicarbonate	310
Sodium	21	Sulfate	13
Potassium	4.3	Chloride	2
		Nitrate-N	1.3
		Fluoride	0.6
		Silica	62

Accuracy Check

Ion Balance	0.983
TDS Balance	0.998
Conductance Balance	0.000

Stiff Diagram



Sample Date: 04/29/82 LAB NAME: NRL

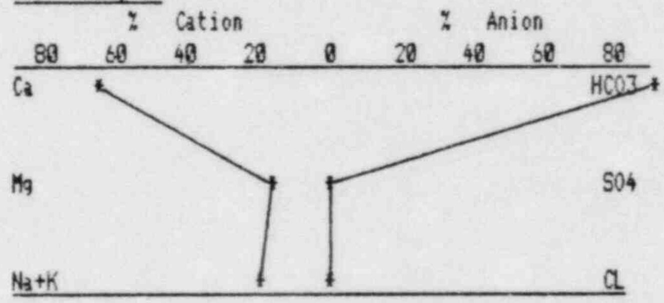
Major Constituents (mg/l)

Calcium	73	Carbonate	<2
Magnesium	9.6	Bicarbonate	310
Sodium	21	Sulfate	<5
Potassium	5.0	Chloride	3
		Nitrate-N	1.3
		Fluoride	0.7
		Silica	62

Accuracy Check

Ion Balance	1.021
TDS Balance	1.043
Conductance Balance	1.043

Stiff Diagram



Sample Date: 07/13/82 LAB NAME: JORDAN

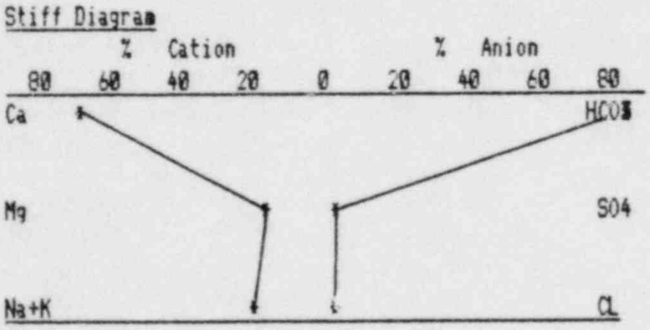
Major Constituents (mg/l)

Calcium	73	Carbonate	0
Magnesium	9.4	Bicarbonate	305
Sodium	21	Sulfate	10
Potassium	4.9	Chloride	10
		Nitrate-N	1.1
		Fluoride	0.69
		Silica	63

Accuracy Check

Ion Balance	0.980
TDS Balance	1.047
Conductance Balance	0.977

Stiff Diagram



Sample Date: 07/13/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	71	Carbonate	<2
Magnesium	9.6	Bicarbonate	310
Sodium	21	Sulfate	9
Potassium	4.7	Chloride	3
		Nitrate-N	1.2
		Fluoride	0.6
		Silica	60

Accuracy Check

Ion Balance	0.987
TDS Balance	1.104
Conductance Balance	1.049

Stiff Diagram

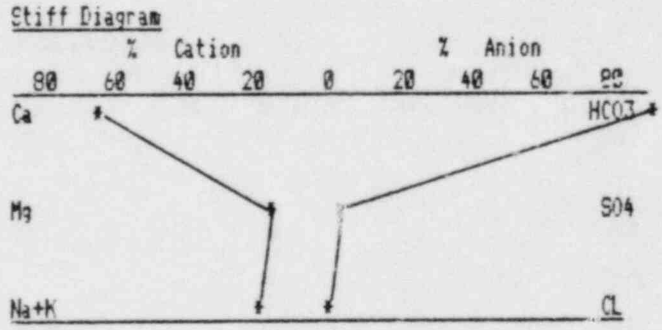


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 13

Sample Date: 10/05/82   LAB NAME: NRL

Major Constituents (mg/l)

Calcium	71	Carbonate	<2
Magnesium	10	Bicarbonate	300
Sodium	21	Sulfate	7
Potassium	4.8	Chloride	3
		Nitrate-N	1.4
		Fluoride	0.3
		Silica	59

Accuracy Check

Ion Balance 1.029
TDS Balance 1.099
Conductance Balance 1.010

Stiff Diagram

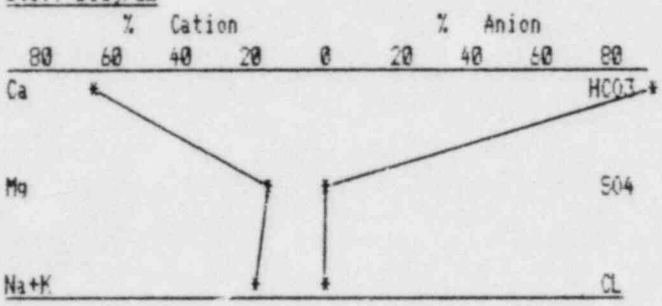
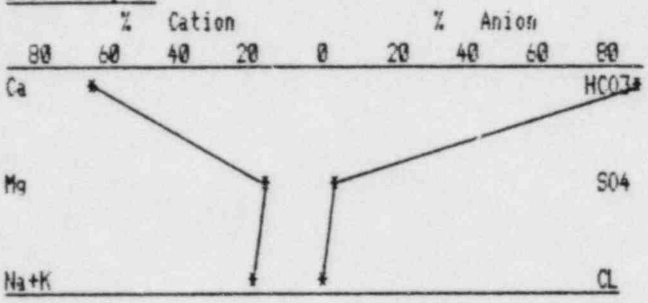


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 17

Sample Date: 10/29/81 LAB NAME: NRL

Major Constituents (mg/l)			
Calcium	59	Carbonate	<2
Magnesium	7.7	Bicarbonate	250
Sodium	17	Sulfate	10
Potassium	4.8	Chloride	4
		Nitrate-N	1.3
Accuracy Check		Fluoride	0.8
Ion Balance	0.984	Silica	59
TDS Balance	1.074		
Conductance Balance	0.000		

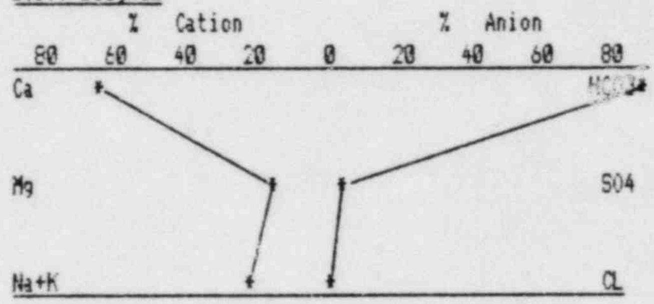
Stiff Diagram



Sample Date: 01/28/82 LAB NAME: NRL

Major Constituents (mg/l)			
Calcium	57	Carbonate	<2
Magnesium	8.0	Bicarbonate	240
Sodium	18	Sulfate	13
Potassium	4.0	Chloride	2
		Nitrate-N	1.2
Accuracy Check		Fluoride	0.6
Ion Balance	1.010	Silica	62
TDS Balance	0.910		
Conductance Balance	0.000		

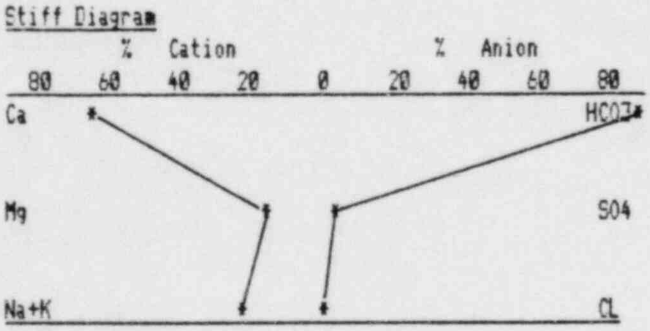
Stiff Diagram



Sample Date: 04/28/82 LAB NAME: NRL

Major Constituents (mg/l)			
Calcium	60	Carbonate	<2
Magnesium	8.0	Bicarbonate	240
Sodium	19	Sulfate	12
Potassium	4.7	Chloride	3
		Nitrate-N	1.2
Accuracy Check		Fluoride	0.7
Ion Balance	1.056	Silica	61
TDS Balance	0.967		
Conductance Balance	1.030		

Stiff Diagram



Sample Date: 07/13/82 LAB NAME: NRL

Major Constituents (mg/l)			
Calcium	61	Carbonate	<2
Magnesium	8.0	Bicarbonate	240
Sodium	17	Sulfate	10
Potassium	4.5	Chloride	4
		Nitrate-N	1.3
Accuracy Check		Fluoride	0.6
Ion Balance	1.048	Silica	59
TDS Balance	1.156		
Conductance Balance	1.033		

Stiff Diagram

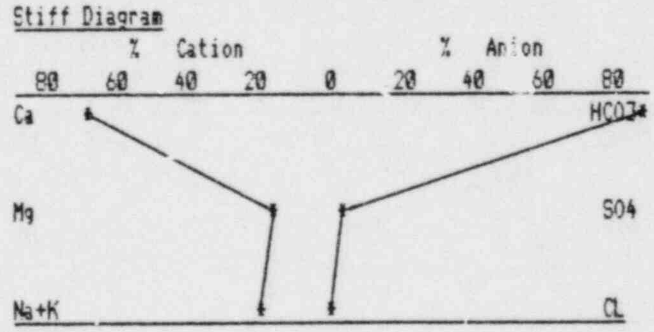


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 17

Sample Date: 10/05/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	60	Carbonate	<2
Magnesium	9.0	Bicarbonate	250
Sodium	18	Sulfate	11
Potassium	4.6	Chloride	3
		Nitrate-N	1.2
		Fluoride	0.6
		Silica	59

Accuracy Check

Ion Balance 1.031

TDS Balance 1.098

Conductance Balance 1.007

Stiff Diagram

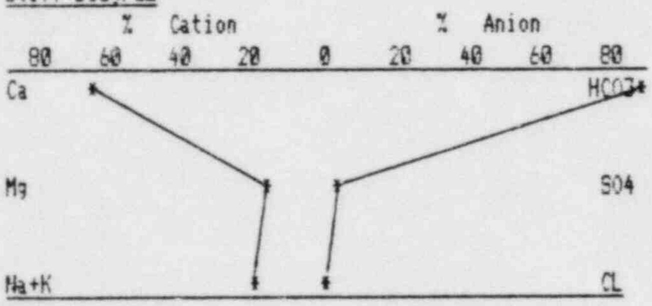


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 25

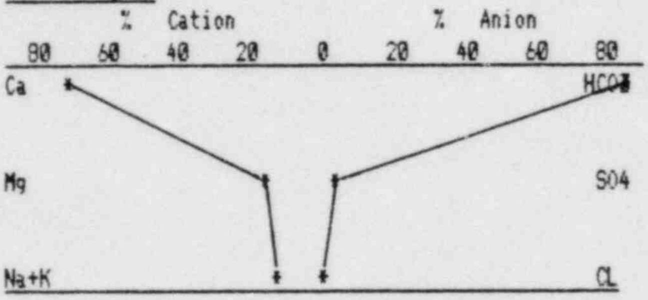
Sample Date: 10/29/81 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	74	Carbonate	<2
Magnesium	9.9	Bicarbonate	290
Sodium	13	Sulfate	9
Potassium	4.8	Chloride	5
		Nitrate-N	3.8
		Fluoride	0.8
		Silica	55

Accuracy Check
Ion Balance 0.971
TDS Balance 1.062
Conductance Balance 0.000

Stiff Diagram



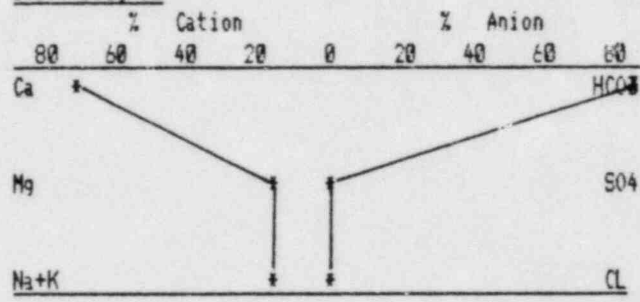
Sample Date: 01/28/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	73	Carbonate	<2
Magnesium	10.0	Bicarbonate	290
Sodium	14	Sulfate	7
Potassium	4.4	Chloride	4
		Nitrate-N	3.8
		Fluoride	0.6
		Silica	55

Accuracy Check
Ion Balance 0.982
TDS Balance 0.979
Conductance Balance 0.000

Stiff Diagram



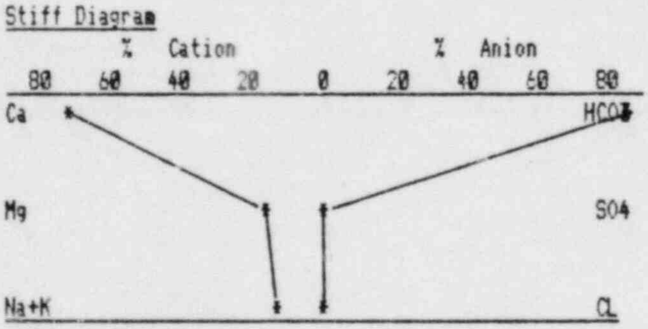
Sample Date: 04/28/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	78	Carbonate	<2
Magnesium	11	Bicarbonate	290
Sodium	14	Sulfate	7
Potassium	4.7	Chloride	5
		Nitrate-N	4.6
		Fluoride	0.7
		Silica	54

Accuracy Check
Ion Balance 1.029
TDS Balance 1.049
Conductance Balance 1.021

Stiff Diagram



Sample Date: 04/28/82 LAB NAME: JORDAN

Major Constituents (mg/l)

Calcium	75	Carbonate	0
Magnesium	10	Bicarbonate	287
Sodium	13	Sulfate	8
Potassium	4.7	Chloride	7
		Nitrate-N	4.0
		Fluoride	0.71
		Silica	52

Accuracy Check
Ion Balance 0.981
TDS Balance 1.044
Conductance Balance 0.947

Stiff Diagram

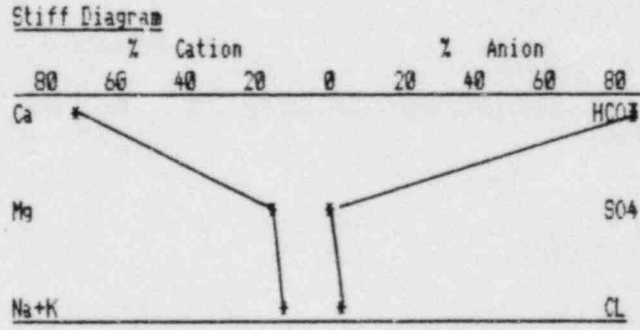


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 25

Sample Date: 07/13/82 LAB NAME: NRL

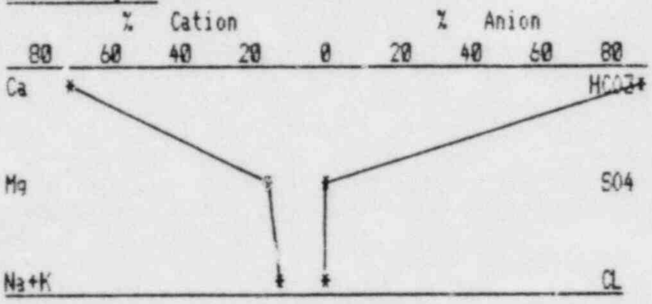
Major Constituents (mg/l)

Calcium	77	Carbonate	<2
Magnesium	10	Bicarbonate	290
Sodium	13	Sulfate	7
Potassium	4.6	Chloride	3
		Nitrate-N	3.9
		Fluoride	0.6
		Silica	54

Accuracy Check

Ion Balance	1.016
TDS Balance	1.100
Conductance Balance	1.044

Stiff Diagram



Sample Date: 10/04/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	79	Carbonate	<2
Magnesium	12	Bicarbonate	300
Sodium	16	Sulfate	7
Potassium	5.1	Chloride	5
		Nitrate-N	4.5
		Fluoride	0.6
		Silica	52

Accuracy Check

Ion Balance	1.042
TDS Balance	1.117
Conductance Balance	0.987

Stiff Diagram

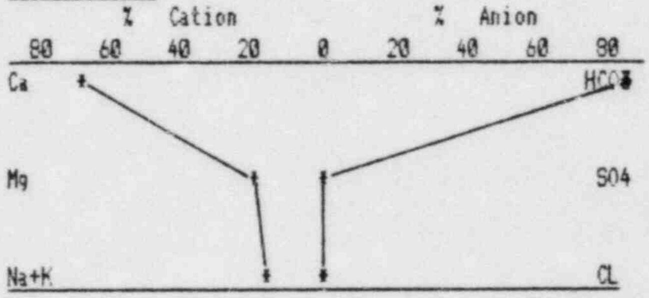


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 26

Sample Date: 10/29/81 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	120	Carbonate	<2
Magnesium	15	Bicarbonate	340
Sodium	15	Sulfate	28
Potassium	6.9	Chloride	33
		Nitrate-N	11.0
		Fluoride	0.8
		Silica	46

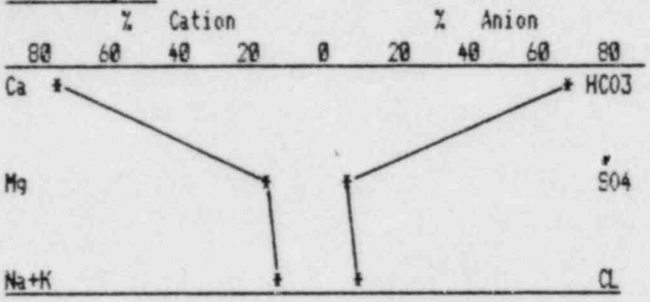
Accuracy Check

Ion Balance 1.023

TDS Balance 1.122

Conductance Balance 0.000

Stiff Diagram



Sample Date: 01/28/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	120	Carbonate	<2
Magnesium	15	Bicarbonate	360
Sodium	15	Sulfate	21
Potassium	5.7	Chloride	33
		Nitrate-N	13.0
		Fluoride	0.6
		Silica	51

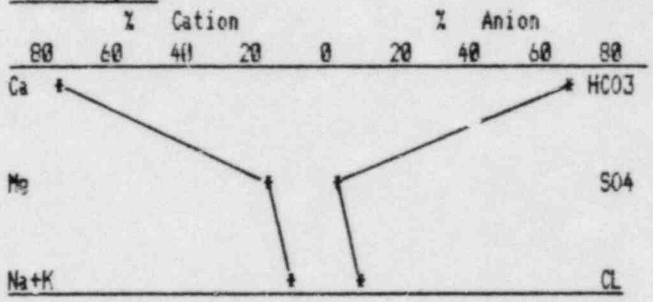
Accuracy Check

Ion Balance 0.978

TDS Balance 1.057

Conductance Balance 0.000

Stiff Diagram



Sample Date: 04/28/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	110	Carbonate	<2
Magnesium	14	Bicarbonate	350
Sodium	15	Sulfate	21
Potassium	6.5	Chloride	24
		Nitrate-N	11
		Fluoride	0.7
		Silica	51

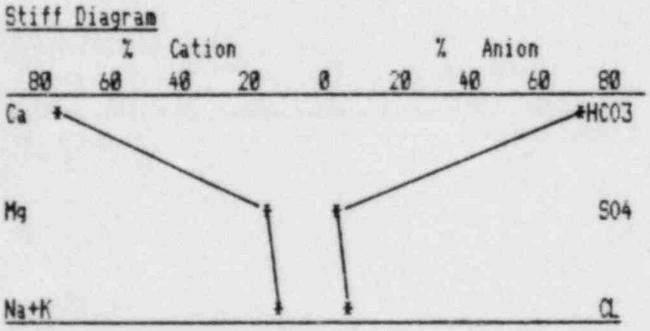
Accuracy Check

Ion Balance 0.977

TDS Balance 1.098

Conductance Balance 1.048

Stiff Diagram



Sample Date: 07/14/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	110	Carbonate	<2
Magnesium	14	Bicarbonate	350
Sodium	14	Sulfate	21
Potassium	6.3	Chloride	28
		Nitrate-N	10
		Fluoride	0.6
		Silica	49

Accuracy Check

Ion Balance 0.965

TDS Balance 1.145

Conductance Balance 1.007

Stiff Diagram

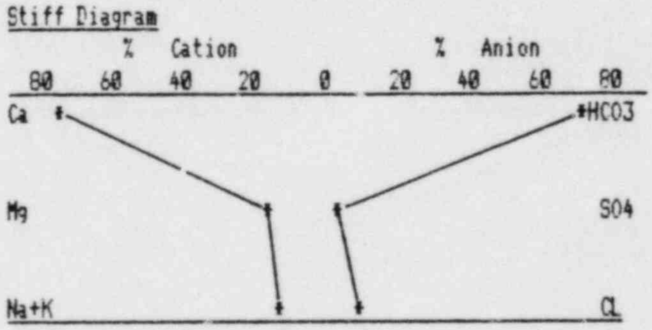


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 26

Sample Date: 10/05/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	120	Carbonate	<2
Magnesium	19	Bicarbonate	330
Sodium	15	Sulfate	36
Potassium	6.9	Chloride	38
		Nitrate-N	12
		Fluoride	0.6
		Silica	48

Accuracy Check

Ion Balance 1.036
TDS Balance 1.194
Conductance Balance 1.074

Stiff Diagram

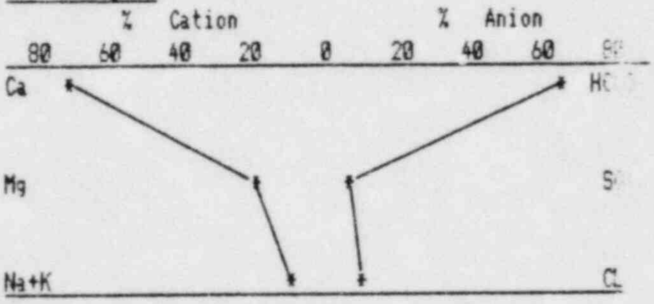


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 57

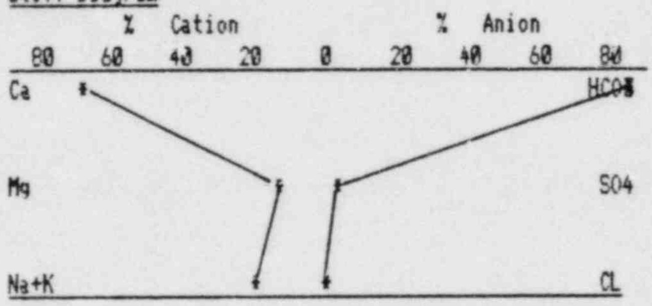
Sample Date: 10/29/81 LAB NAME: NRL

Major Constituents (mg/l)			
Calcium	64	Carbonate	<2
Magnesium	7.4	Bicarbonate	260
Sodium	17	Sulfate	11
Potassium	6.5	Chloride	4
		Nitrate-N	2.1
		Fluoride	0.6
		Silica	54

Accuracy Check

Ion Balance	0.991
TDS Balance	1.045
Conductance Balance	0.000

Stiff Diagram



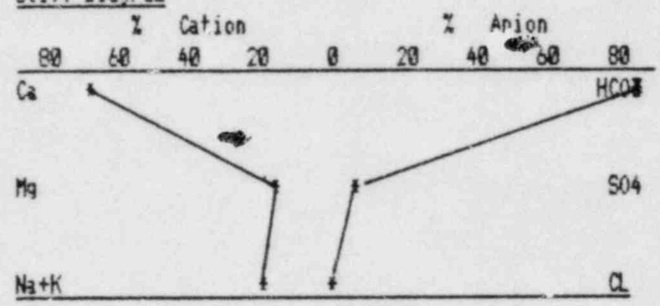
Sample Date: 01/29/82 LAB NAME: NRL

Major Constituents (mg/l)			
Calcium	62	Carbonate	<2
Magnesium	7.6	Bicarbonate	260
Sodium	17	Sulfate	16
Potassium	5.6	Chloride	<2
		Nitrate-N	2.2
		Fluoride	0.5
		Silica	56

Accuracy Check

Ion Balance	0.957
TDS Balance	1.071
Conductance Balance	0.000

Stiff Diagram



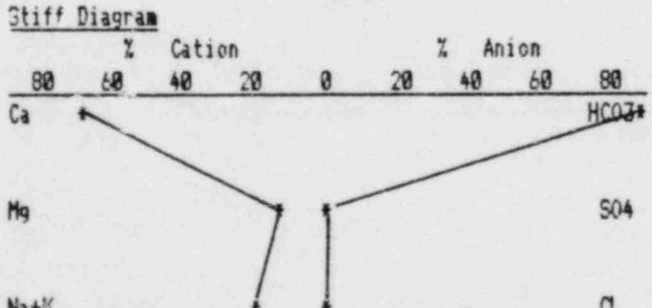
Sample Date: 04/28/82 LAB NAME: NRL

Major Constituents (mg/l)			
Calcium	65	Carbonate	<2
Magnesium	7.6	Bicarbonate	266
Sodium	17	Sulfate	5
Potassium	6.1	Chloride	2
		Nitrate-N	2.2
		Fluoride	0.6
		Silica	59

Accuracy Check

Ion Balance	1.040
TDS Balance	1.053
Conductance Balance	1.031

Stiff Diagram



Sample Date: 10/04/82 LAB NAME: NRL

Major Constituents (mg/l)			
Calcium	64	Carbonate	<2
Magnesium	6.5	Bicarbonate	310
Sodium	17	Sulfate	7
Potassium	5.8	Chloride	3
		Nitrate-N	2.0
		Fluoride	0.5
		Silica	58

Accuracy Check

Ion Balance	0.877
TDS Balance	1.060
Conductance Balance	0.947

Stiff Diagram

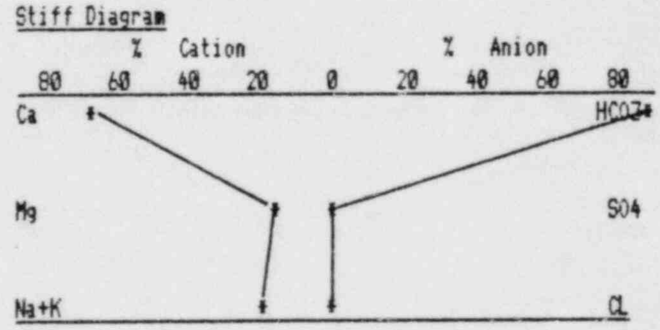


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 62

Sample Date: 10/30/81 LAB NAME: NRL

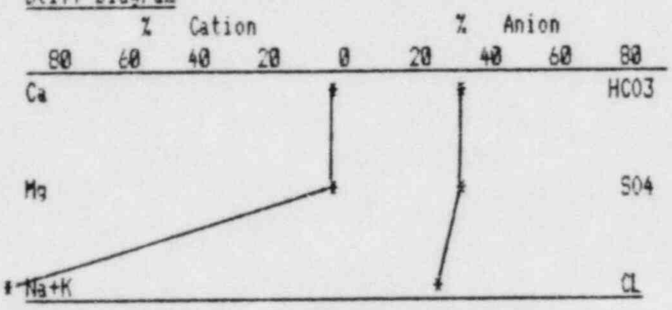
Major Constituents (mg/l)

Calcium	12	Carbonate	<2
Magnesium	3.0	Bicarbonate	430
Sodium	400	Sulfate	350
Potassium	9.2	Chloride	200
		Nitrate-N	0.03
		Fluoride	0.9
		Silica	8.8

Accuracy Check

Ion Balance 0.925
TDS Balance 1.001
Conductance Balance 0.000

Stiff Diagram



Sample Date: 01/28/82 LAB NAME: NRL

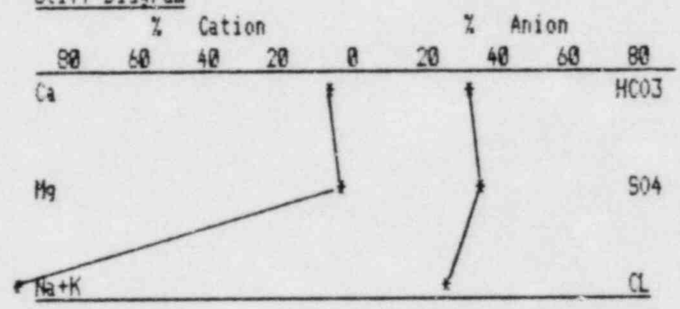
Major Constituents (mg/l)

Calcium	15	Carbonate	<2
Magnesium	3.7	Bicarbonate	380
Sodium	380	Sulfate	340
Potassium	9.5	Chloride	180
		Nitrate-N	<0.01
		Fluoride	0.6
		Silica	11

Accuracy Check

Ion Balance 0.970
TDS Balance 0.974
Conductance Balance 0.000

Stiff Diagram



Sample Date: 04/27/82 LAB NAME: NRL

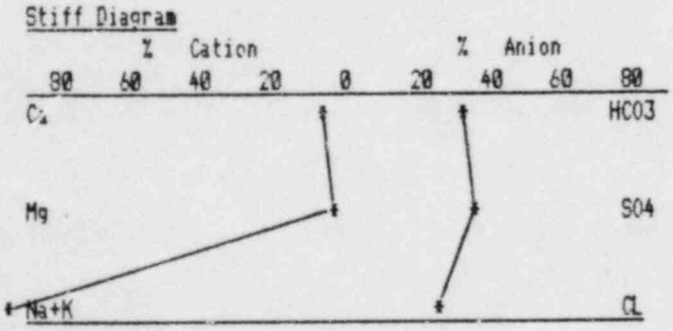
Major Constituents (mg/l)

Calcium	15	Carbonate	<2
Magnesium	3.4	Bicarbonate	390
Sodium	390	Sulfate	360
Potassium	9.8	Chloride	180
		Nitrate-N	0.02
		Fluoride	0.6
		Silica	12

Accuracy Check

Ion Balance 0.962
TDS Balance 0.944
Conductance Balance 1.011

Stiff Diagram



Sample Date: 04/27/82 LAB NAME: JORDAN

Major Constituents (mg/l)

Calcium	15	Carbonate	0
Magnesium	3.4	Bicarbonate	382
Sodium	396	Sulfate	338
Potassium	14	Chloride	186
		Nitrate-N	0.07
		Fluoride	0.69
		Silica	11

Accuracy Check

Ion Balance 1.003
TDS Balance 1.039
Conductance Balance 0.998

Stiff Diagram

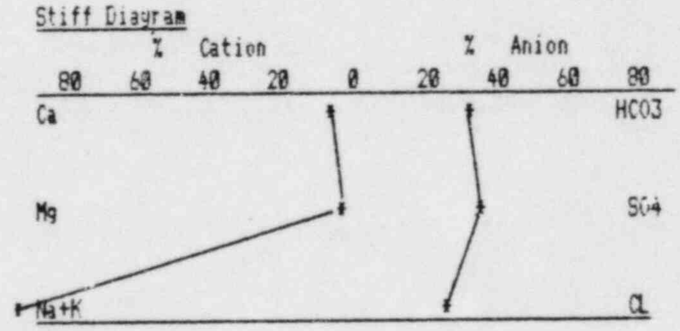


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. 62

Sample Date: 07/13/82 LAB NAME: NRL

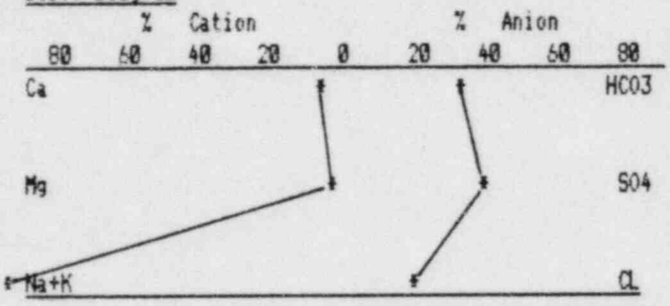
Major Constituents (mg/l)

Calcium	16	Carbonate	<2
Magnesium	3.7	Bicarbonate	400
Sodium	380	Sulfate	360
Potassium	10	Chloride	150
		Nitrate-N	0.03
		Fluoride	0.6
		Silica	11

Accuracy Check

Ion Balance	0.978
TDS Balance	1.061
Conductance Balance	1.067

Stiff Diagram



Sample Date: 10/04/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	16	Carbonate	<2
Magnesium	4.3	Bicarbonate	390
Sodium	400	Sulfate	370
Potassium	11	Chloride	170
		Nitrate-N	0.04
		Fluoride	0.6
		Silica	11

Accuracy Check

Ion Balance	0.997
TDS Balance	1.019
Conductance Balance	0.981

Stiff Diagram

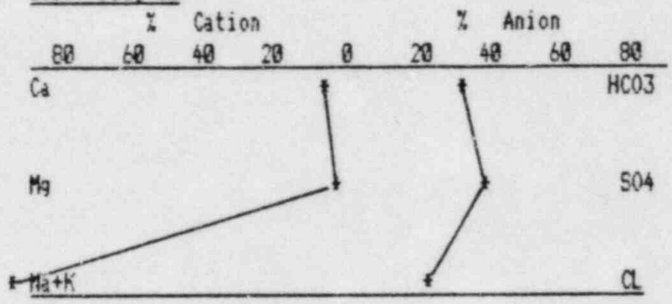


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. RA-2

Sample Date: 07/22/82 LAB NAME: NRL

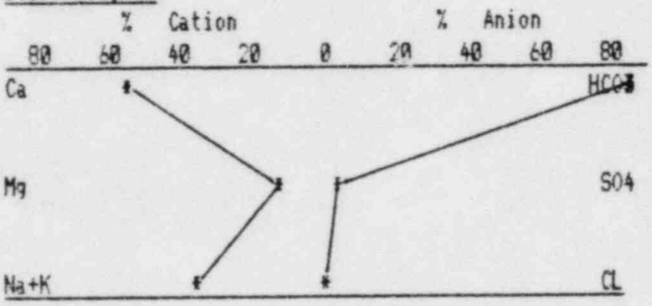
Major Constituents (mg/l)

Calcium	67	Carbonate	<2
Magnesium	9.1	Bicarbonate	330
Sodium	41	Sulfate	19
Potassium	11.	Chloride	5
		Nitrate-N	2.4
		Fluoride	0.9
		Silica	56

Accuracy Check

Ion Balance	1.007
TDS Balance	0.983
Conductance Balance	1.021

Stiff Diagram



Sample Date: 09/29/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	73	Carbonate	<2
Magnesium	10	Bicarbonate	320
Sodium	36	Sulfate	14
Potassium	11	Chloride	6
		Nitrate-N	0.01
		Fluoride	0.7
		Silica	57

Accuracy Check

Ion Balance	1.106
TDS Balance	1.033
Conductance Balance	0.978

Stiff Diagram

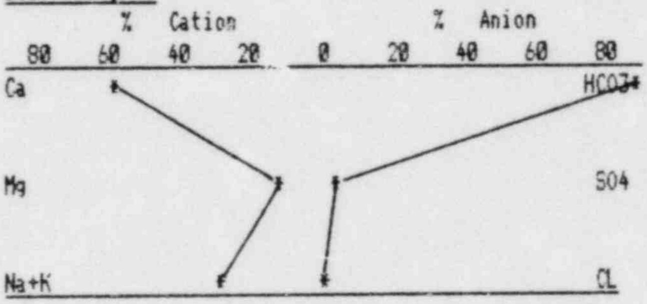


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. RB-3

Sample Date: 08/01/82 LAB NAME: NRL

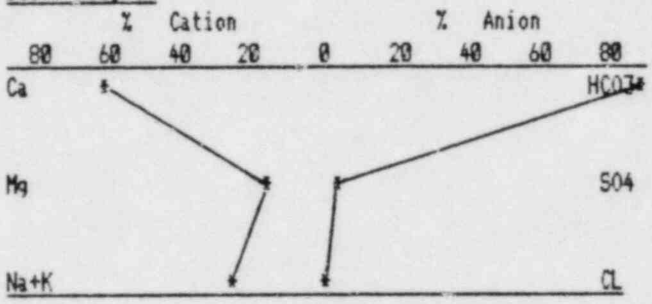
Major Constituents (mg/l)

Calcium	38	Carbonate	<2
Magnesium	5.1	Bicarbonate	180
Sodium	14	Sulfate	7
Potassium	6.1	Chloride	2
		Nitrate-N	0.48
		Fluoride	0.3
		Silica	61

Accuracy Check

Ion Balance 0.967
TDS Balance 1.027
Conductance Balance 0.993

Stiff Diagram



Sample Date: 09/30/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	37	Carbonate	<2
Magnesium	4.8	Bicarbonate	180
Sodium	21	Sulfate	<5
Potassium	6.9	Chloride	4
		Nitrate-N	<0.01
		Fluoride	0.3
		Silica	62

Accuracy Check

Ion Balance 1.052
TDS Balance 1.255
Conductance Balance 0.932

Stiff Diagram

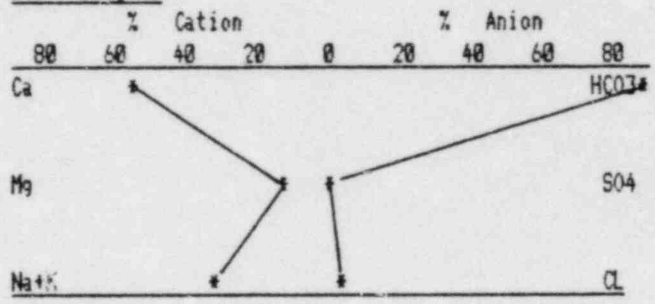


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. RC-4

Sample Date: 07/22/82 LAB NAME: NRL

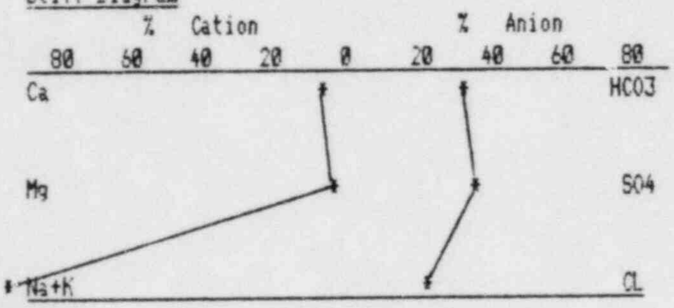
Major Constituents (mg/l)

Calcium	17	Carbonate	<2
Magnesium	3.7	Bicarbonate	400
Sodium	390	Sulfate	350
Potassium	9.3	Chloride	170
		Nitrate-N	0.02
		Fluoride	0.6
		Silica	10

Accuracy Check

Ion Balance	0.985
TDS Balance	0.956
Conductance Balance	0.994

Stiff Diagram



Sample Date: 09/30/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	18	Carbonate	<2
Magnesium	4.2	Bicarbonate	410
Sodium	380	Sulfate	340
Potassium	8.9	Chloride	160
		Nitrate-N	<0.01
		Fluoride	0.5
		Silica	10

Accuracy Check

Ion Balance	0.983
TDS Balance	0.976
Conductance Balance	0.987

Stiff Diagram

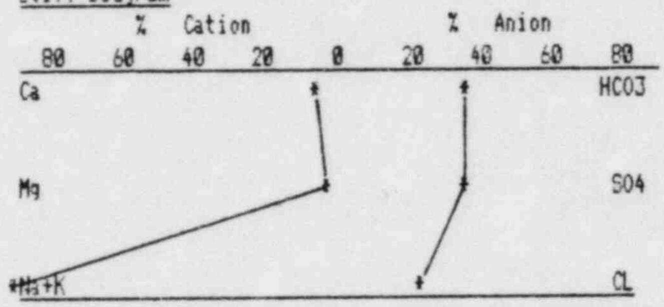


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. RC-5

Sample Date: 07/22/82 LAB NAME: NRL

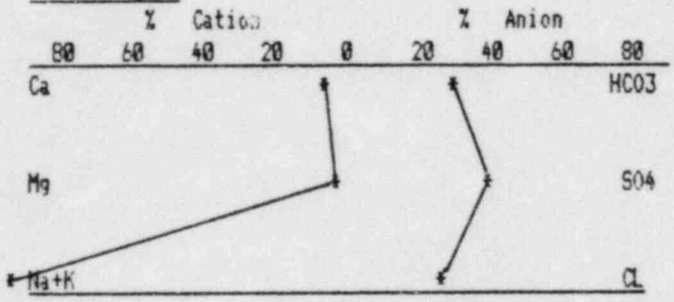
Major Constituents (mg/l)

Calcium	19	Carbonate	<2
Magnesium	3.2	Bicarbonate	370
Sodium	390	Sulfate	370
Potassium	11.	Chloride	180
		Nitrate-N	<0.01
		Fluoride	0.6
		Silica	13

Accuracy Check

Ion Balance	0.979
TDS Balance	0.939
Conductance Balance	1.005

Stiff Diagram



Sample Date: 09/30/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	18	Carbonate	2
Magnesium	3.0	Bicarbonate	350
Sodium	370	Sulfate	360
Potassium	10	Chloride	190
		Nitrate-N	<0.01
		Fluoride	0.5
		Silica	13

Accuracy Check

Ion Balance	0.938
TDS Balance	0.964
Conductance Balance	0.986

Stiff Diagram

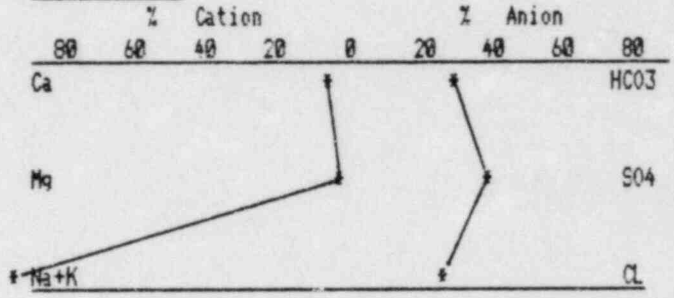


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. RC-6

Sample Date: 07/22/82 LAB NAME: NRL

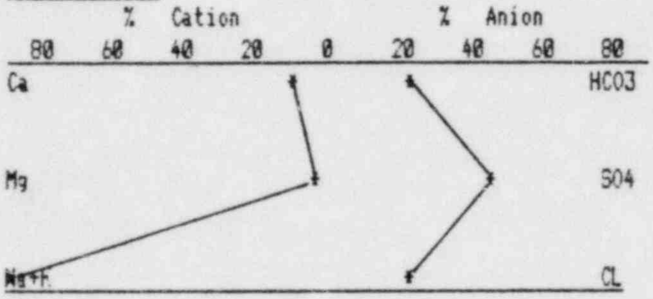
Major Constituents (mg/l)

Calcium	35	Carbonate	<2
Magnesium	6.8	Bicarbonate	330
Sodium	400	Sulfate	470
Potassium	14.	Chloride	190
		Nitrate-N	0.01
		Fluoride	0.7
		Silica	18

Accuracy Check

Ion Balance 0.976
TDS Balance 0.923
Conductance Balance 0.916

Stiff Diagram



Sample Date: 09/28/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	38	Carbonate	5
Magnesium	7.2	Bicarbonate	310
Sodium	440	Sulfate	460
Potassium	18	Chloride	250
		Nitrate-N	0.03
		Fluoride	0.6
		Silica	16

Accuracy Check

Ion Balance 1.019
TDS Balance 0.935
Conductance Balance 0.956

Stiff Diagram

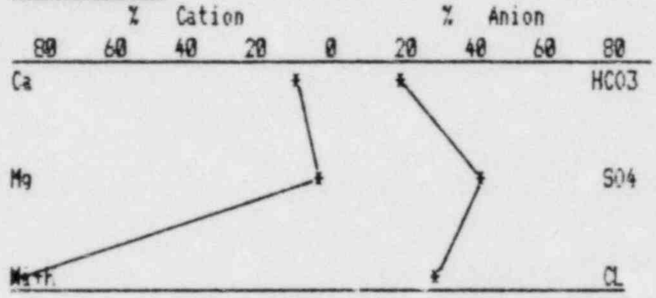


TABLE 2.11-A
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. RC-7

Sample Date: 07/21/82 LAB NAME: NRL

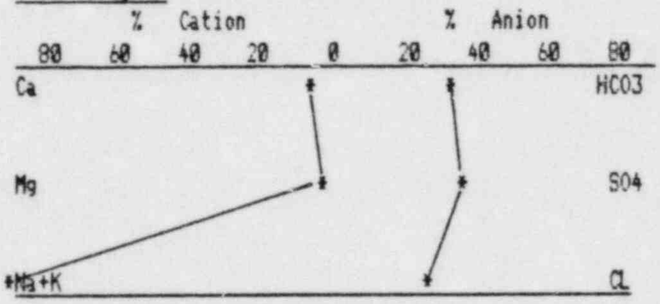
Major Constituents (mg/l)

Calcium	19	Carbonate	<2
Magnesium	3.1	Bicarbonate	360
Sodium	360	Sulfate	330
Potassium	11.	Chloride	170
		Nitrate-N	0.02
		Fluoride	0.8
		Silica	15

Accuracy Check

Ion Balance	0.976
TDS Balance	0.918
Conductance Balance	0.982

Stiff Diagram



Sample Date: 09/28/82 LAB NAME: NRL

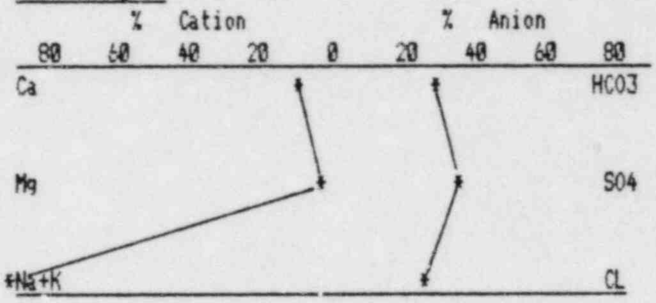
Major Constituents (mg/l)

Calcium	25	Carbonate	<2
Magnesium	3.5	Bicarbonate	340
Sodium	350	Sulfate	310
Potassium	11	Chloride	180
		Nitrate-N	0.01
		Fluoride	0.7
		Silica	16

Accuracy Check

Ion Balance	0.996
TDS Balance	1.032
Conductance Balance	0.950

Stiff Diagram



APPENDIX 2.11(B)
SURFACE WATER BASELINE DATA

CROW BUTTE PROJECT
SURFACE WATER BASELINE WATER QUALITY

Location Number: S-1 Sample Type: STREAM
Distance From Wellfield: 1980 m Water System: SQUAW CREEK

	EPA Standards	SAMPLE RESULTS				MINIUM	MAXIMUM	AVERAGE
Date Sampled		02/25/82	04/19/82	07/08/82	10/05/82			
Lab Name		NRL	NRL	NRL	NRL			
Calcium (mg/l)		64	65	64	61	61	65	64
Magnesium (mg/l)		9.7	9.4	9.8	9.5	9.4	9.8	9.6
Sodium (mg/l)		12	12	13	12	12	13	12
Potassium (mg/l)		3.4	3.5	3.8	3.7	3.4	3.8	3.6
Carbonate (mg/l)		<2	<2	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		270	270	260	270	260	270	268
Sulfate (mg/l)	250	<5	<5	8	5	5	8	7
Chloride (mg/l)	250	<2	<2	3	2	2	3	3
Ammonia-N (mg/l)		<0.05		<0.05		<0.05	<0.05	<0.05
Nitrite-N (mg/l)		<0.01	0.01	<0.01	<0.01	<0.01	0.01	0.01
Nitrate-N (mg/l)	10	0.57	0.33	0.10	0.17	0.10	0.57	0.29
Fluoride (mg/l)	1.4-2.4	0.6	0.6	0.5	0.5	0.5	0.6	0.6
Silica (mg/l)		53	52	55	51	51	55	53
TDS-180°C (mg/l)	500	280	270	290	320	270	320	290
Conductivity - Field (umhos)		420	380	390	330	330	420	380
Conductivity - Lab (umhos)		421	425	424	391	391	425	415
Conductivity - Dilute (umhos)		465	451	466	439	439	466	455
Alkalinity (mg/l)		210	210	220	220	210	220	215
pH - Field		7.71	7.30	8.3	7.8	7.3	8.3	7.8
pH - Lab		7.7	7.6	8.1	8.1	7.6	8.1	7.9
Aluminum (mg/l)		<0.1		<0.1		<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05	0.002		0.004		0.002	0.004	0.003
Barium (mg/l)	1	0.1		0.1		0.1	0.1	0.1
Cadmium (mg/l)	0.01	<0.001		<0.001		<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	<0.001		<0.001		<0.001	<0.001	<0.001
Cobalt (mg/l)				<0.001		<0.001	<0.001	<0.001
Copper (mg/l)	1	<0.001		0.001		<0.001	0.001	0.001
Iron (mg/l)	0.3	0.05		<0.05		<0.05	0.05	0.05
Lead (mg/l)	0.05	<0.005		<0.005		<0.005	<0.005	<0.005
Manganese (mg/l)	0.05	<0.1		<0.1		<0.1	<0.1	<0.1
Mercury (mg/l)	0.002	<0.0001		<0.0001		<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		<0.002		<0.002		<0.002	<0.002	<0.002
Nickel (mg/l)		<0.002		<0.002		<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002		<0.002		<0.002	<0.002	<0.002
Vanadium (mg/l)		0.005		0.006		0.005	0.006	0.006
Zinc (mg/l)	5	<0.002		0.004		<0.002	0.004	0.003
Boron (mg/l)		<0.5		<0.5		<0.5	<0.5	<0.5
Uranium (µg/l)		1	4	5		1	5	3.
Radium 226 (pCi/l)	5	0.4	0.3	0.4		0.3	0.4	0.4
Dissolved Oxygen (ppm)		12.0	11.9	8.5	10.5	8.5	12.0	10.7
Temperature (°C)		1	5	23	10	1	23	10

CROW BUTTE PROJECT
SURFACE WATER BASELINE WATER QUALITY

Location Number: S-2 Sample Type: STREAM
Distance From Wellfield: 6325 m Water System: SQUAW CREEK

	EPA Standards	SAMPLE RESULTS				MINIUM	MAXIMUM	AVERAGE
Date Sampled		02/25/82	04/19/82	07/08/82	10/05/82			
Lab Name		NRL	NRL	NRL	NRL			
Calcium (mg/l)		64	64	53	58	53	64	60
Magnesium (mg/l)		9.5	9.4	9.2	9.1	9.1	9.5	9.3
Sodium (mg/l)		12	12	14	12	12	14	13
Potassium (mg/l)		3.5	4.0	4.0	4.3	3.5	4.3	4.0
Carbonate (mg/l)		<2	<2	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		280	250	220	250	220	280	250
Sulfate (mg/l)	250	11	<5	10	<5	10	11	11
Chloride (mg/l)	250	<2	<2	2	2	2	2	2
Ammonia-N (mg/l)		<0.05		<0.05		<0.05	<0.05	<0.05
Nitrite-N (mg/l)		<0.01	0.02	<0.01	<0.01	<0.01	0.02	0.01
Nitrate-N (mg/l)	10	0.62	0.26	<0.01	<0.01	<0.01	0.62	0.22
Fluoride (mg/l)	1.4-2.4	0.6	0.6	0.5	0.5	0.5	0.6	0.6
Silica (mg/l)		53	51	50	48	48	53	51
TDS-180°C (mg/l)	500	300	240	260	280	240	300	270
Conductivity - Field (umhos)		430	390	350	300	300	430	368
Conductivity - Lab (umhos)		439	424	362	370	362	439	399
Conductivity - Dilute (umhos)		483	447	396	413	396	483	435
Alkalinity (mg/l)		230	200	180	200	180	230	203
pH - Field		7.78	7.73	7.5	7.85	7.5	7.8	7.7
pH - Lab		7.8	7.8	8.1	8.1	7.8	8.1	8.0
Aluminum (mg/l)		<0.1		0.1		<0.1	0.1	0.1
Arsenic (mg/l)	0.05	0.002		0.004		0.002	0.004	0.003
Barium (mg/l)	1	0.2		0.1		0.1	0.2	0.2
Cadmium (mg/l)	0.01	<0.001		<0.001		<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	<0.001		<0.001		<0.001	<0.001	<0.001
Cobalt (mg/l)				<0.001		<0.001	<0.001	<0.001
Copper (mg/l)	1	<0.001		0.001		<0.001	0.001	0.001
Iron (mg/l)	0.3	0.05		<0.05		<0.05	0.05	0.05
Lead (mg/l)	0.05	<0.005		<0.005		<0.005	<0.005	<0.005
Manganese (mg/l)	0.05	<0.1		<0.1		<0.1	<0.1	<0.1
Mercury (mg/l)	0.002	<0.0001		<0.0001		<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		<0.002		<0.002		<0.002	<0.002	<0.002
Nickel (mg/l)		<0.002		<0.002		<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002		<0.002		<0.002	<0.002	<0.002
Vanadium (mg/l)		0.004		0.006		0.004	0.006	0.005
Zinc (mg/l)	5	<0.002		0.002		<0.002	0.002	0.002
Boron (mg/l)		<0.5		0.6		<0.5	0.6	0.6
Uranium (µg/l)		2	2	4		2	4	3.
Radium 226 (pCi/l)	5	0.4	0.1	0.4		0.1	0.4	0.3
Dissolved Oxygen (ppm)		12.1	12.4	9.8	10.6	9.8	12.4	11.2
Temperature (°C)		1	7	24	10	1	24	11

CROW BUTTE PROJECT
SURFACE WATER BASELINE WATER QUALITY

Location Number: S-3
Distance From Wellfield: 610 m
Sample Type: STREAM
Water System: SQUAW CREEK

	EPA Standards	SAMPLE RESULTS				MINIUM	MAXIMUM	AVERAGE
Date Sampled		02/25/82	04/19/82	07/08/82	10/05/82			
Lab Name		NRL	NRL	NRL	NRL			
Calcium (mg/l)		65	66	49	57	49	66	59
Magnesium (mg/l)		9.7	9.6	9.0	9.4	9.0	9.7	9.4
Sodium (mg/l)		12	13	14	13	12	14	13
Potassium (mg/l)		4.0	4.5	4.0	4.5	4.0	4.5	4.3
Carbonate (mg/l)		<2	<2	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		270	270	220	240	220	270	250
Sulfate (mg/l)	250	5	<5	8	<5	5	8	7
Chloride (mg/l)	250	<2	<2	3	2	2	3	3
Ammonia-N (mg/l)		<0.05		<0.05		<0.05	<0.05	<0.05
Nitrite-N (mg/l)		<0.01	0.02	<0.01	<0.01	<0.01	0.02	0.01
Nitrate-N (mg/l)	10	2.4	0.21	<0.01	0.08	<0.01	2.4	0.68
Fluoride (mg/l)	1.4-2.4	0.6	0.6	0.5	0.5	0.5	0.6	0.6
Silica (mg/l)		51	48	44	48	44	51	48
TDS-180°C (mg/l)	500	290	280	260	280	260	290	278
Conductivity - Field (umhos)		430	398	340	305	305	430	366
Conductivity - Lab (umhos)		427	432	358	367	358	432	396
Conductivity - Dilute (umhos)		470	463	391	413	391	470	434
Alkalinity (mg/l)		220	210	180	200	180	220	203
pH - Field		7.83	7.80	8.4	7.8	7.8	8.4	8.0
pH - Lab		7.7	7.6	8.3	8.1	7.6	8.3	7.9
Aluminum (mg/l)		<0.1		<0.1		<0.1	<0.1	<0.1
Arsenic (mg/l)	0.05	0.002		0.004		0.002	0.004	0.003
Barium (mg/l)	1	0.2		0.1		0.1	0.2	0.2
Cadmium (mg/l)	0.01	<0.001		<0.001		<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	<0.001		<0.001		<0.001	<0.001	<0.001
Cobalt (mg/l)				<0.001		<0.001	<0.001	<0.001
Copper (mg/l)	1	<0.001		0.001		<0.001	0.001	0.001
Iron (mg/l)	0.3	0.05		<0.05		<0.05	0.05	0.05
Lead (mg/l)	0.05	<0.005		<0.005		<0.005	<0.005	<0.005
Manganese (mg/l)	0.05	<0.1		<0.1		<0.1	<0.1	<0.1
Mercury (mg/l)	0.002	<0.0001		<0.0001		<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		0.002		<0.002		<0.002	0.002	0.002
Nickel (mg/l)		<0.002		<0.002		<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002		<0.002		<0.002	<0.002	<0.002
Vanadium (mg/l)		0.005		0.005		0.005	0.005	0.005
Zinc (mg/l)	5	<0.002		0.002		<0.002	0.002	0.002
Boron (mg/l)		<0.5		0.5		<0.5	0.5	0.5
Uranium (µg/l)		12	4	4		4	12	7.
Radium 226 (pCi/l)	5	0.3	0.2	0.4		0.2	0.4	0.3
Dissolved Oxygen (ppm)		12.1	11.2	8.8	10.9	8.8	12.1	10.8
Temperature (°C)		1	8	25	11	1	25	11

CROW BUTTE PROJECT
SURFACE WATER BASELINE WATER QUALITY

Location Number: W-2 Sample Type: RIVER
Distance From Wellfield: 8305 m Water System: WHITE RIVER

	EPA Standards	SAMPLE RESULTS				MINIUM	MAXIMUM	AVERAGE
Date Sampled		02/24/82	04/21/82	07/08/82	10/05/82			
Lab Name		NRL	NRL	NRL	NRL			
Calcium (mg/l)		55	56	57	52	52	57	55
Magnesium (mg/l)		8.0	7.7	7.8	7.8	7.7	8.0	7.8
Sodium (mg/l)		17	16	20	18	16	20	18
Potassium (mg/l)		6.5	6.8	7.7	7.9	6.5	7.9	7.2
Carbonate (mg/l)		<2	<2	<2	<2	<2	<2	<2
Bicarbonate (mg/l)		230	230	240	230	230	240	233
Sulfate (mg/l)	250	12	<5	13	16	12	16	14
Chloride (mg/l)	250	4	4	6	6	4	6	5
Ammonia-N (mg/l)		<0.05		<0.05		<0.05	<0.05	<0.05
Nitrite-N (mg/l)		0.01	<0.01	0.01	0.40	<0.01	0.40	0.11
Nitrate-N (mg/l)	10	2.1	0.62	0.46	0.40	0.40	2.1	0.90
Fluoride (mg/l)	1.4-2.4	0.5	0.6	0.4	0.4	0.4	0.6	0.5
Silica (mg/l)		56	54	54	52	52	56	54
TDS-180°C (mg/l)	500	280	230	300	270	230	300	270
Conductivity - Field (umhos)		390	350	390	320	320	390	363
Conductivity - Lab (umhos)		394	413	420	377	377	420	401
Conductivity - Dilute (umhos)		436	431	459	422	422	459	437
Alkalinity (mg/l)		190	200	200	190	190	200	195
pH - Field		7.50	7.72	8.2	8.25	7.5	8.3	7.9
pH - Lab		7.5	7.7	7.9	8.2	7.5	8.2	7.8
Aluminum (mg/l)		<0.1		0.1		<0.1	0.1	0.1
Arsenic (mg/l)	0.05	0.002		0.004		0.002	0.004	0.003
Barium (mg/l)	1	0.2		<0.1		<0.1	0.2	0.2
Cadmium (mg/l)	0.01	<0.001		<0.001		<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	<0.001		<0.001		<0.001	<0.001	<0.001
Cobalt (mg/l)				<0.001		<0.001	<0.001	<0.001
Copper (mg/l)	1	<0.001		0.002		<0.001	0.002	0.002
Iron (mg/l)	0.3	0.05		<0.05		<0.05	0.05	0.05
Lead (mg/l)	0.05	<0.005		<0.005		<0.005	<0.005	<0.005
Manganese (mg/l)	0.05	<0.1		<0.1		<0.1	<0.1	<0.1
Mercury (mg/l)	0.002	<0.0001		<0.0001		<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		<0.002		<0.002		<0.002	<0.002	<0.002
Nickel (mg/l)		<0.002		<0.002		<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002		<0.002		<0.002	<0.002	<0.002
Vanadium (mg/l)		0.007		0.010		0.007	0.010	0.009
Zinc (mg/l)	5	<0.002		0.016		<0.002	0.016	0.009
Boron (mg/l)		<0.5		0.5		<0.5	0.5	0.5
Uranium (µg/l)		1	7	6		1	7	5.
Radium 226 (pCi/l)	5	3.0	0.4	0.5		0.4	3.0	1.3
Dissolved Oxygen (ppm)		12.1	13.9	9.1	10.4	9.1	13.9	11.4
Temperature (°C)		3	6	19	11	3	19	10

TABLE 2.11-8
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. S-1

Sample Date: 02/25/82 LAB NAME: NRL

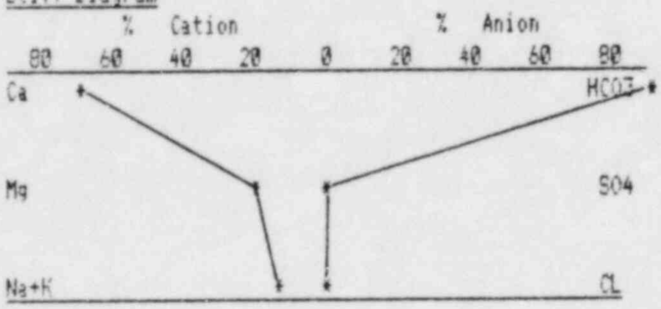
Major Constituents (mg/l)

Calcium	64	Carbonate	<2
Magnesium	9.7	Bicarbonate	270
Sodium	12	Sulfate	<5
Potassium	3.4	Chloride	<2
		Nitrate-N	0.57
		Fluoride	0.6
		Silica	53

Accuracy Check

Ion Balance 0.994
TDS Balance 0.982
Conductance Balance 1.050

Stiff Diagram



Sample Date: 04/19/82 LAB NAME: NRL

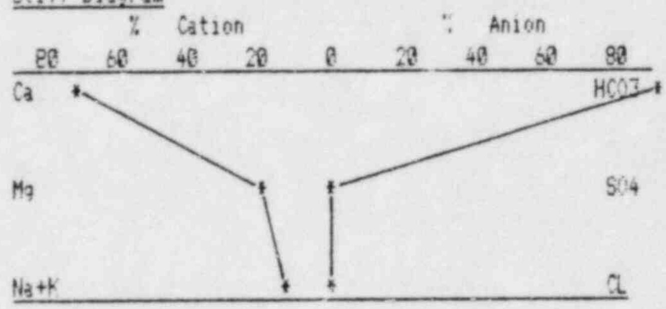
Major Constituents (mg/l)

Calcium	65	Carbonate	<2
Magnesium	9.4	Bicarbonate	270
Sodium	12	Sulfate	<5
Potassium	3.5	Chloride	<2
		Nitrate-N	0.33
		Fluoride	0.6
		Silica	52

Accuracy Check

Ion Balance 1.004
TDS Balance 0.948
Conductance Balance 1.018

Stiff Diagram



Sample Date: 07/08/82 LAB NAME: NRL

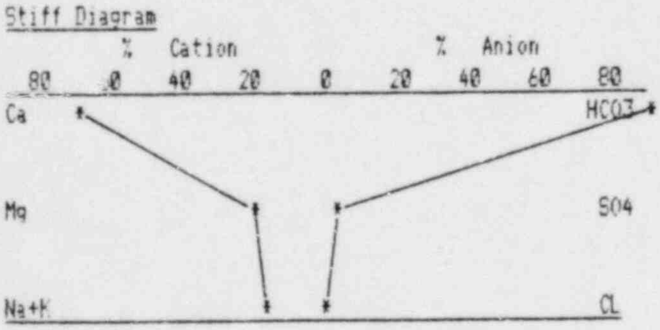
Major Constituents (mg/l)

Calcium	64	Carbonate	<2
Magnesium	9.8	Bicarbonate	260
Sodium	13	Sulfate	8
Potassium	3.8	Chloride	3
		Nitrate-N	0.10
		Fluoride	0.5
		Silica	55

Accuracy Check

Ion Balance 1.032
TDS Balance 1.010
Conductance Balance 1.051

Stiff Diagram



Sample Date: 10/05/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	61	Carbonate	<2
Magnesium	9.5	Bicarbonate	270
Sodium	12	Sulfate	5
Potassium	3.7	Chloride	2
		Nitrate-N	0.17
		Fluoride	0.5
		Silica	51

Accuracy Check

Ion Balance 0.966
TDS Balance 1.143
Conductance Balance 1.014

Stiff Diagram

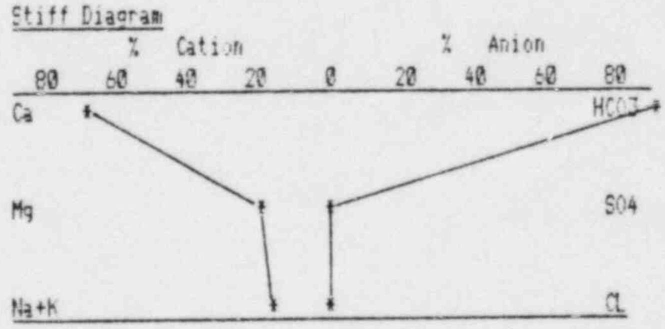


TABLE 2.11-B
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. S-2

Sample Date: 02/25/82 LAB NAME: NRL

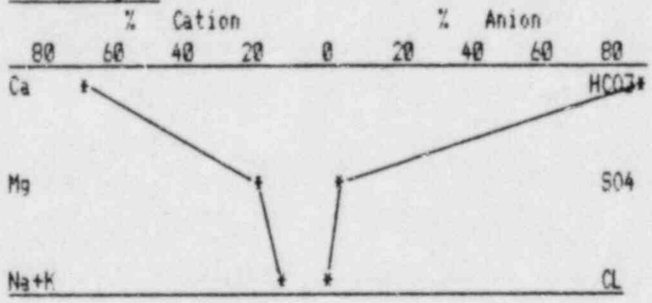
Major Constituents (mg/l)

Calcium	64	Carbonate	<2
Magnesium	9.5	Bicarbonate	280
Sodium	12	Sulfate	11
Potassium	3.5	Chloride	<2
		Nitrate-N	0.62
		Fluoride	0.6
		Silica	53

Accuracy Check

Ion Balance	0.932
TDS Balance	1.013
Conductance Balance	1.053

Stiff Diagram



Sample Date: 04/19/82 LAB NAME: NRL

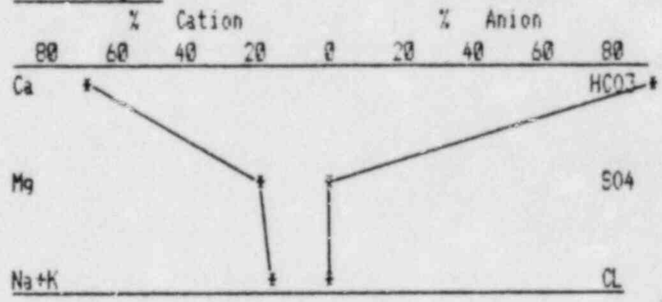
Major Constituents (mg/l)

Calcium	64	Carbonate	<2
Magnesium	9.4	Bicarbonate	250
Sodium	12	Sulfate	<5
Potassium	4.0	Chloride	<2
		Nitrate-N	0.26
		Fluoride	0.6
		Silica	51

Accuracy Check

Ion Balance	1.074
TDS Balance	0.878
Conductance Balance	1.047

Stiff Diagram



Sample Date: 07/08/82 LAB NAME: NRL

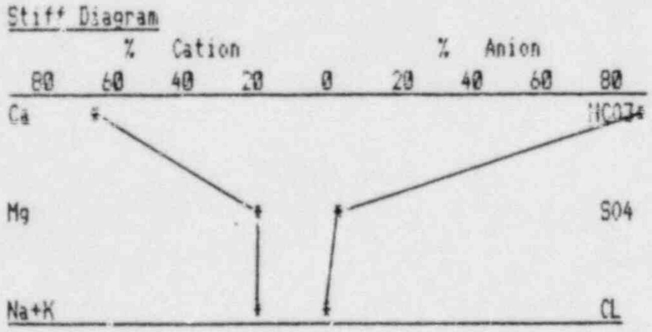
Major Constituents (mg/l)

Calcium	53	Carbonate	<2
Magnesium	9.2	Bicarbonate	220
Sodium	14	Sulfate	10
Potassium	4.0	Chloride	2
		Nitrate-N	<0.01
		Fluoride	0.5
		Silica	50

Accuracy Check

Ion Balance	1.063
TDS Balance	1.029
Conductance Balance	1.024

Stiff Diagram



Sample Date: 10/05/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	58	Carbonate	<2
Magnesium	9.1	Bicarbonate	250
Sodium	12	Sulfate	<5
Potassium	4.3	Chloride	2
		Nitrate-N	<0.01
		Fluoride	0.5
		Silica	48

Accuracy Check

Ion Balance	1.004
TDS Balance	1.061
Conductance Balance	1.009

Stiff Diagram

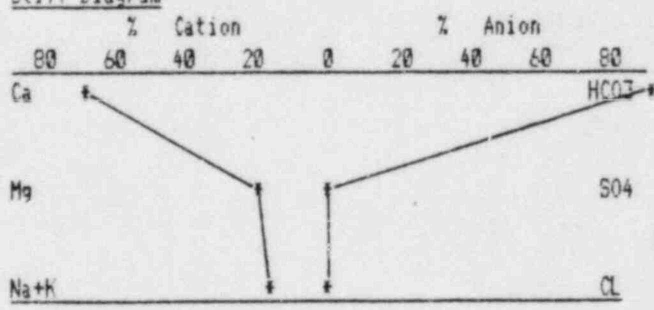


TABLE 2.11-B
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. S-3

Sample Date: 02/25/82 LAB NAME: NRL

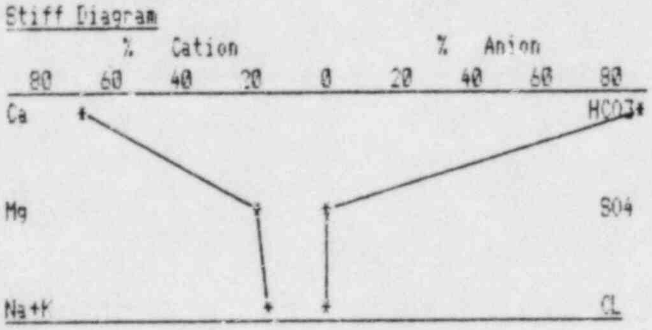
Major Constituents (mg/l)

Calcium	65	Carbonate	<2
Magnesium	9.7	Bicarbonate	270
Sodium	12	Sulfate	5
Potassium	4.0	Chloride	<2
		Nitrate-N	2.4
		Fluoride	0.6
		Silica	51

Accuracy Check

Ion Balance	0.[illegible]81
TDS Balance	1.012
Conductance Balance	1.031

Stiff Diagram



Sample Date: 04/19/82 LAB NAME: NRL

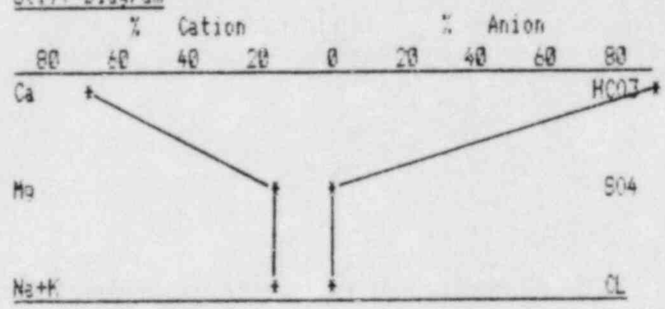
Major Constituents (mg/l)

Calcium	66	Carbonate	<2
Magnesium	9.6	Bicarbonate	270
Sodium	13	Sulfate	<5
Potassium	4.5	Chloride	<2
		Nitrate-N	0.21
		Fluoride	0.6
		Silica	48

Accuracy Check

Ion Balance	1.035
TDS Balance	0.986
Conductance Balance	1.029

Stiff Diagram



Sample Date: 07/08/82 LAB NAME: NRL

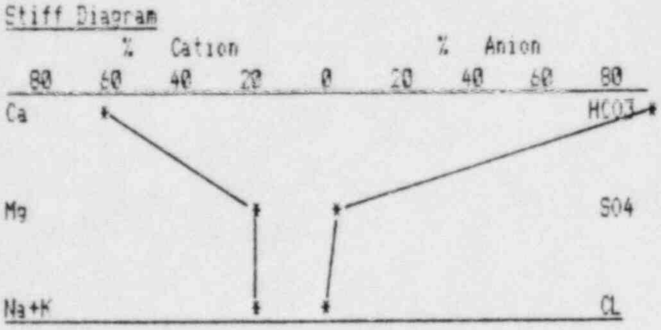
Major Constituents (mg/l)

Calcium	49	Carbonate	<2
Magnesium	9.0	Bicarbonate	220
Sodium	14	Sulfate	8
Potassium	4.0	Chloride	3
		Nitrate-N	<0.01
		Fluoride	0.5
		Silica	44

Accuracy Check

Ion Balance	1.010
TDS Balance	1.077
Conductance Balance	1.043

Stiff Diagram



Sample Date: 10/05/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	57	Carbonate	<2
Magnesium	9.4	Bicarbonate	240
Sodium	13	Sulfate	<5
Potassium	4.5	Chloride	2
		Nitrate-N	0.08
		Fluoride	0.5
		Silica	48

Accuracy Check

Ion Balance	1.048
TDS Balance	1.079
Conductance Balance	1.023

Stiff Diagram

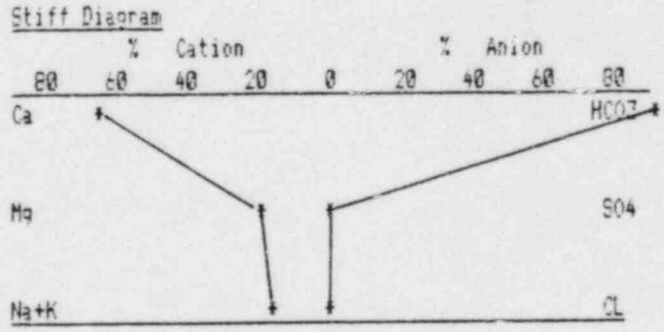


TABLE 2.11-B
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Well No. W-2

Sample Date: 02/26/82 LAB NAME: NRL

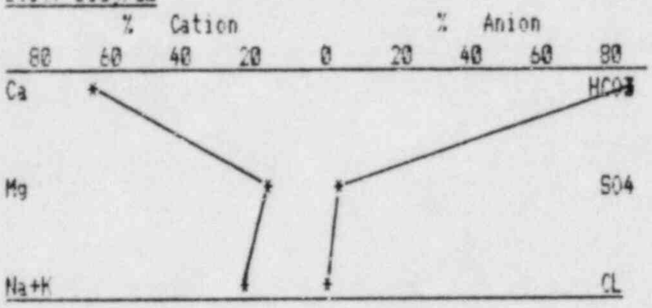
Major Constituents (mg/l)

Calcium	55	Carbonate	<2
Magnesium	8.0	Bicarbonate	230
Sodium	17	Sulfate	12
Potassium	6.5	Chloride	4
		Nitrate-N	2.1
		Fluoride	0.5
		Silica	56

Accuracy Check

Ion Balance	1.006
TDS Balance	1.014
Conductance Balance	1.029

Stiff Diagram



Sample Date: 04/21/82 LAB NAME: NRL

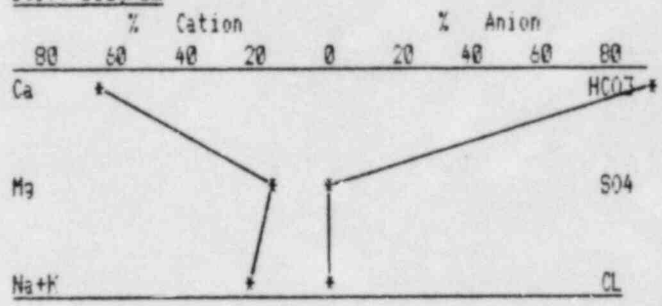
Major Constituents (mg/l)

Calcium	56	Carbonate	<2
Magnesium	7.7	Bicarbonate	230
Sodium	16	Sulfate	<5
Potassium	6.8	Chloride	4
		Nitrate-N	0.62
		Fluoride	0.6
		Silica	54

Accuracy Check

Ion Balance	1.066
TDS Balance	0.866
Conductance Balance	1.064

Stiff Diagram



Sample Date: 07/08/82 LAB NAME: NRL

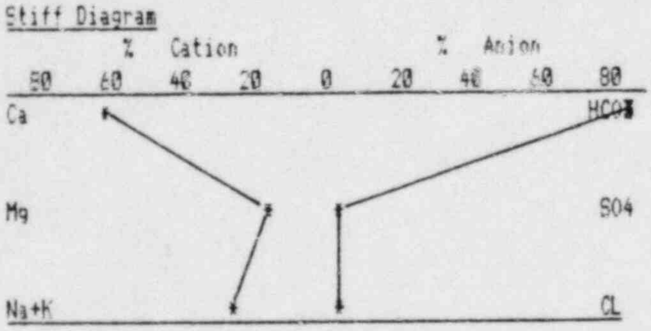
Major Constituents (mg/l)

Calcium	57	Carbonate	<2
Magnesium	7.8	Bicarbonate	240
Sodium	20	Sulfate	13
Potassium	7.7	Chloride	6
		Nitrate-N	0.46
		Fluoride	0.4
		Silica	54

Accuracy Check

Ion Balance	1.033
TDS Balance	1.048
Conductance Balance	1.040

Stiff Diagram



Sample Date: 10/05/82 LAB NAME: NRL

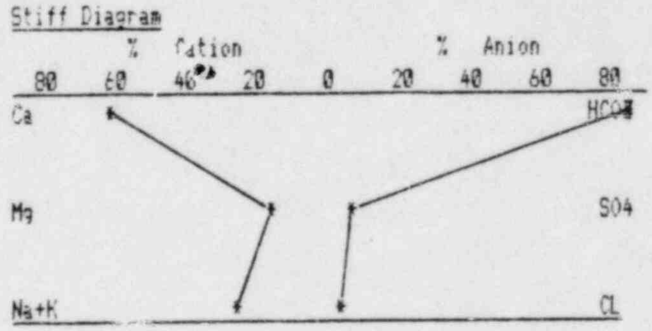
Major Constituents (mg/l)

Calcium	52	Carbonate	<2
Magnesium	7.8	Bicarbonate	230
Sodium	18	Sulfate	16
Potassium	7.9	Chloride	6
		Nitrate-N	0.40
		Fluoride	0.4
		Silica	52

Accuracy Check

Ion Balance	0.982
TDS Balance	0.980
Conductance Balance	1.001

Stiff Diagram



CROW BUTTE PROJECT
SURFACE WATER BASELINE WATER QUALITY

Location Number: I-1 — Sample Type: IMPOUNDMENT

Distance From Wellfield: 1905 m — Water System: SQUAW CREEK

	EPA Standards	SAMPLE RESULTS	MINIUM	MAXIMUM	AVERAGE
Date Sampled		06/24/82			
Lab Name		NRL			
Calcium (mg/l)		24	24	24	24
Magnesium (mg/l)		1.9	1.9	1.9	1.9
Sodium (mg/l)		0.50	0.5	0.5	0.5
Potassium (mg/l)		4.7	4.7	4.7	4.7
Carbonate (mg/l)		<2	<2	<2	<2
Bicarbonate (mg/l)		86	86	86	86
Sulfate (mg/l)	250	<5	---	---	---
Chloride (mg/l)	250	<2	---	---	---
Ammonia-N (mg/l)					
Nitrite-N (mg/l)		<0.02	<0.02	<0.02	<0.02
Nitrate-N (mg/l)	10	<0.02	<0.02	<0.02	<0.02
Fluoride (mg/l)	1.4-2.4	0.1	0.1	0.1	0.1
Silica (mg/l)		9.4	9.4	9.4	9.4
TDS-180°C (mg/l)	500	87	87	87	87
Conductivity - Field (umhos)		120	120	120	120
Conductivity - Lab (umhos)		147	147	147	147
Conductivity - Dilute (umhos)		147	147	147	147
Alkalinity (mg/l)		71	71	71	71
pH - Field		8.6	8.6	8.6	8.6
pH - Lab		7.5	7.5	7.5	7.5
Aluminum (mg/l)		0.1	0.1	0.1	0.1
Arsenic (mg/l)	0.05	0.002	0.002	0.002	0.002
Barium (mg/l)	1	0.1	0.1	0.1	0.1
Cadmium (mg/l)	0.01	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	0.001	0.001	0.001	0.001
Cobalt (mg/l)		<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	1	0.001	0.001	0.001	0.001
Iron (mg/l)	0.3	<0.05	<0.05	<0.05	<0.[illegible]
Lead (mg/l)	0.05	<0.005	<0.005	<0.005	<0.005
Manganese (mg/l)	0.05	<0.1	<0.1	<0.1	<0.1
Mercury (mg/l)	0.002	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		<0.002	<0.002	<0.002	<0.002
Nickel (mg/l)		<0.002	<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		0.001	0.001	0.001	0.001
Zinc (mg/l)	5	0.002	0.002	0.002	0.002
Boron (mg/l)		0.5	0.5	0.5	0.5
Uranium (µg/l)					
Radium 226 (pCi/l)	5				
Dissolved Oxygen (ppm)		10	10	10	10
Temperature (°C)		18	18	18	18

CROW BUTTE PROJECT
SURFACE WATER BASELINE WATER QUALITY

Location Number: I-3
Distance From Wellfield: 2820 m

Sample Type: IMPOUNDMENT
Water System: ENGLISH CREEK

	EPA Standards	SAMPLE RESULTS	MINIUM	MAXIMUM	AVERAGE
Date Sampled		06/24/82			
Lab Name		NRL			
Calcium (mg/l)		74	74	74	74
Magnesium (mg/l)		12	12	12	12
Sodium (mg/l)		25	25	25	25
Potassium (mg/l)		7.2	7.2	7.2	7.2
Carbonate (mg/l)		<2	<2	<2	<2
Bicarbonate (mg/l)		350	350	350	350
Sulfate (mg/l)	250	<5	---	---	---
Chloride (mg/l)	250	<2	---	---	---
Ammonia-N (mg/l)					
Nitrite-N (mg/l)		<0.02	<0.02	<0.02	<0.02
Nitrate-N (mg/l)	10	<0.02	<0.02	<0.02	<0.02
Fluoride (mg/l)	1.4-2.4	0.7	0.7	0.7	0.7
Silica (mg/l)		31	31	31	31
TDS-180°C (mg/l)	500	350	350	350	350
Conductivity - Field (umhos)		430	430	430	430
Conductivity - Lab (umhos)		558	558	558	558
Conductivity - Dilute (umhos)		586	586	586	586
Alkalinity (mg/l)		280	280	280	280
pH - Field		7.6	7.6	7.6	7.6
pH - Lab		7.9	7.9	7.9	7.9
Aluminum (mg/l)		0.1	0.1	0.1	0.1
Arsenic (mg/l)	0.05	0.003	0.003	0.003	0.003
Barium (mg/l)	1	0.4	0.4	0.4	0.4
Cadmium (mg/l)	0.01	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	<0.001	<0.001	<0.001	<0.001
Cobalt (mg/l)		<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	1	<0.001	<0.001	<0.001	<0.001
Iron (mg/l)	0.3	0.05	0.05	0.05	0.05
Lead (mg/l)	0.05	<0.005	<0.005	<0.005	<0.005
Manganese (mg/l)	0.05	0.2	0.2	0.2	0.2
Mercury (mg/l)	0.002	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		<0.002	<0.002	<0.002	<0.002
Nickel (mg/l)		<0.002	<0.002	<0.002	<0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		<0.001	<0.001	<0.001	<0.001
Zinc (mg/l)	5	0.012	0.012	0.012	0.012
Boron (mg/l)		0.5	0.5	0.5	0.5
Uranium (µg/l)					
Radium 226 (pCi/l)	5				
Dissolved Oxygen (ppm)		2.6	2.6	2.6	2.6
Temperature (°C)		12	12	12	12

CROW BUTTE PROJECT
SURFACE WATER BASELINE WATER QUALITY

Location Number: I-4
Distance From Wellfield: 3660 m

Sample Type: IMPOUNDMENT
Water System: ENGLISH CREEK

	EPA Standards	SAMPLE RESULTS	MINIUM	MAXIMUM	AVERAGE
Date Sampled		06/24/82			
Lab Name		NRL			
Calcium (mg/l)		30	30	30	30
Magnesium (mg/l)		11	11	11	11
Sodium (mg/l)		38	38	38	38
Potassium (mg/l)		12	12	12	12
Carbonate (mg/l)		<2	<2	<2	<2
Bicarbonate (mg/l)		250	250	250	250
Sulfate (mg/l)	250	<5	---	---	---
Chloride (mg/l)	250	<2	---	---	---
Ammonia-N (mg/l)					
Nitrite-N (mg/l)		<0.02	<0.02	<0.02	<0.02
Nitrate-N (mg/l)	10	<0.02	<0.02	<0.02	<0.02
Fluoride (mg/l)	1.4-2.4	0.7	0.7	0.7	0.7
Silica (mg/l)		9.7	9.7	9.7	9.7
TDS-180°C (mg/l)	500	230	230	230	230
Conductivity - Field (umhos)		335	335	335	335
Conductivity - Lab (umhos)		432	432	432	432
Conductivity - Dilute (umhos)		446	446	446	446
Alkalinity (mg/l)		200	200	200	200
pH - Field		8.8	8.8	8.8	8.8
pH - Lab		7.9	7.9	7.9	7.9
Aluminum (mg/l)		0.1	0.1	0.1	0.1
Arsenic (mg/l)	0.05	0.003	0.003	0.003	0.003
Barium (mg/l)	1	0.1	0.1	0.1	0.1
Cadmium (mg/l)	0.01	<0.001	<0.001	<0.001	<0.001
Chromium (mg/l)	0.05	0.001	0.001	0.001	0.001
Cobalt (mg/l)		<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	1	0.002	0.002	0.002	0.002
Iron (mg/l)	0.3	0.05	0.05	0.05	0.05
Lead (mg/l)	0.05	<0.005	<0.005	<0.005	<0.005
Manganese (mg/l)	0.05	<0.1	<0.1	<0.1	<0.1
Mercury (mg/l)	0.002	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/l)		<0.002	<0.002	<0.002	<0.002
Nickel (mg/l)		0.002	0.002	0.002	0.002
Selenium (mg/l)	0.01	<0.002	<0.002	<0.002	<0.002
Vanadium (mg/l)		0.002	0.002	0.002	0.002
Zinc (mg/l)	5	0.004	0.004	0.004	0.004
Boron (mg/l)		<0.5	<0.5	<0.5	<0.5
Uranium (µg/l)					
Radium 226 (pCi/l)	5				
Dissolved Oxygen (ppm)		15	15	15	15
Temperature (°C)		18	18	18	18

TABLE 2.11-B
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Surface Sample No. I-1

Sample Date: 06/24/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	24	Carbonate	<2
Magnesium	1.9	Bicarbonate	86
Sodium	0.50	Sulfate	<5
Potassium	4.7	Chloride	<2
		Nitrate-N	<0.02
		Fluoride	0.1
		Silica	9.4

Accuracy Check

Ion Balance	0.953
TDS Balance	0.960
Conductance Balance	0.963

Stiff Diagram

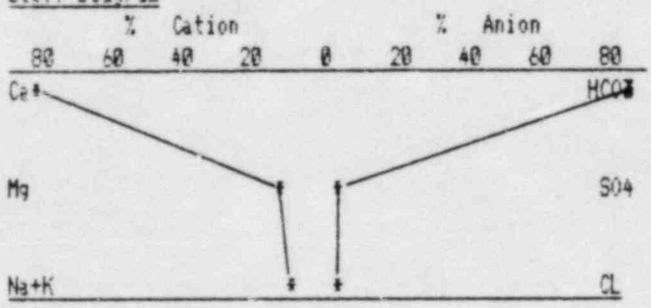


TABLE 2.11-B
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Surface Sample No. I-3

Sample Date: 06/24/82 LAB NAME: NRL

Major Constituents (mg/l)

Calcium	74	Carbonate	<2
Magnesium	12	Bicarbonate	350
Sodium	25	Sulfate	<5
Potassium	7.2	Chloride	<2
		Nitrate-N	<0.02
Accuracy Check		Fluoride	0.7
Ion Balance	1.009	Silica	31
TDS Balance	1.055		
Conductance Balance	1.034		

Stiff Diagram

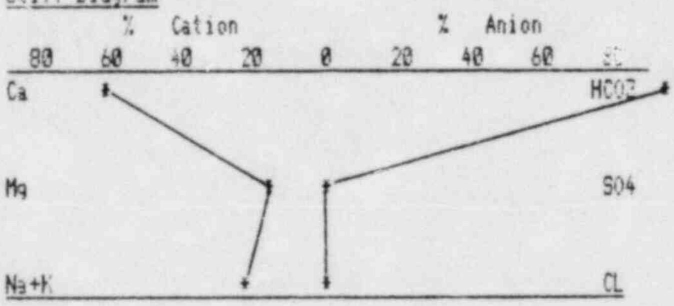


TABLE 2.11-B
CROW BUTTE PROJECT
WATER QUALITY SUMMARY
Surface Sample No. I-4

Sample Date: 06/24/82 LAB NAME: NRL

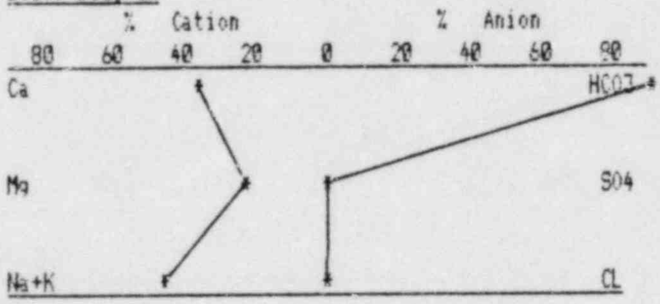
Major Constituents (mg/l)

Calcium	30	Carbonate	<2
Magnesium	11	Bicarbonate	250
Sodium	38	Sulfate	<5
Potassium	12	Chloride	<2
		Nitrate-N	<0.02
		Fluoride	0.7
		Silica	9.7

Accuracy Check

Ion Balance	1.024
TDS Balance	0.985
Conductance Balance	1.079

Stiff Diagram



SECTION 3.1 to 3.3

DESCRIPTION OF PROPOSED FACILITY

TABLE OF CONTENTS

DESCRIPTION OF PROPOSED FACILITY

The proposed Crow Butte R&D in situ leach facility has been designed to accomplish three objectives: (1) to evaluate the feasibility of different well spacings in the in situ extraction of uranium from the Chadron formation; (2) to demonstrate restoration of the aquifer; and (3) to test potential leach chemistries which could be used in a commercial operation.

The operational plan outlined in this section is based on the best information and projections currently available to Wyoming Fuel Company. The intent of this plan and application is to allow adequate flexibility in the R&D operation to allow research into all viable aspects of commercial development and aquifer restoration within the limitations of existing regulations.

3.1 Solution Mining Process and Equipment

3.1.1 R&D Ore Body

As discussed in Section 2.7, Geology, the ore body in the vicinity of the R&D wellfield is in the Basal Chadron sand at a depth of approximately 650 ft (197.6m). The overall width of the mineralization in this area ranges from less than 100 to greater than 250 ft. The Basal Chadron sand in the area of the R&D ore body has a total thickness of about 40 ft (12.2m). The area chosen for the R&D wellfields is believed to be representative of the ore body in this area.

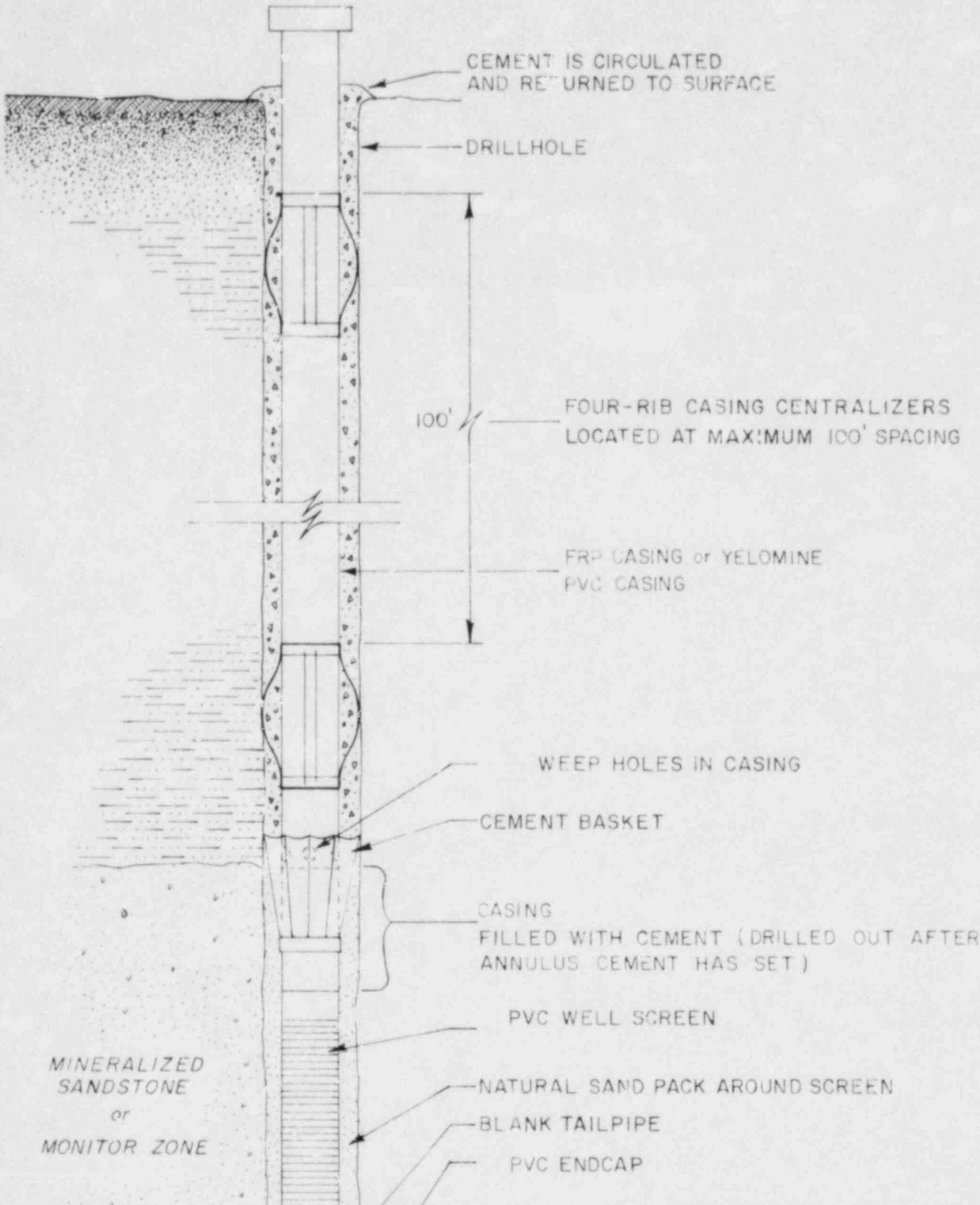
3.1.2 Well Construction and Integrity Testing

Two well construction methods and casing materials may be used during the R&D test for installation of production and injection wells. The methods of well construction which will receive the greatest attention are shown in the Ground Water section of this application, Figures 3.1-1 and 3.1-2. As these well construction methods are used, summaries of the well completion data for each well will be kept on site and maintained as needed for documentation of project activities (Figure 3.1-4). The well construction methods are not necessarily described in the order of their preferred use. Either of these methods could be used for monitor wells. PVC casing may also be used in monitor wells only.

Method No. 1, Figure 3.1-1, involves the setting of an integral casing/screen string. The method consists of drilling a pilot hole, geophysically logging the pilot hole to define the desired screen interval, and reaming the pilot hole to the desired depth. Next, a string of casing with the desired length of screen attached to the lower end is placed in the hole. A cement basket is attached to the blank casing just above the screen to prevent blinding of the screen interval during cementing. The cement is then pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weep holes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement has cured sufficiently, the residual cement and plug are drilled out, and the well is developed by air lifting or pumping.

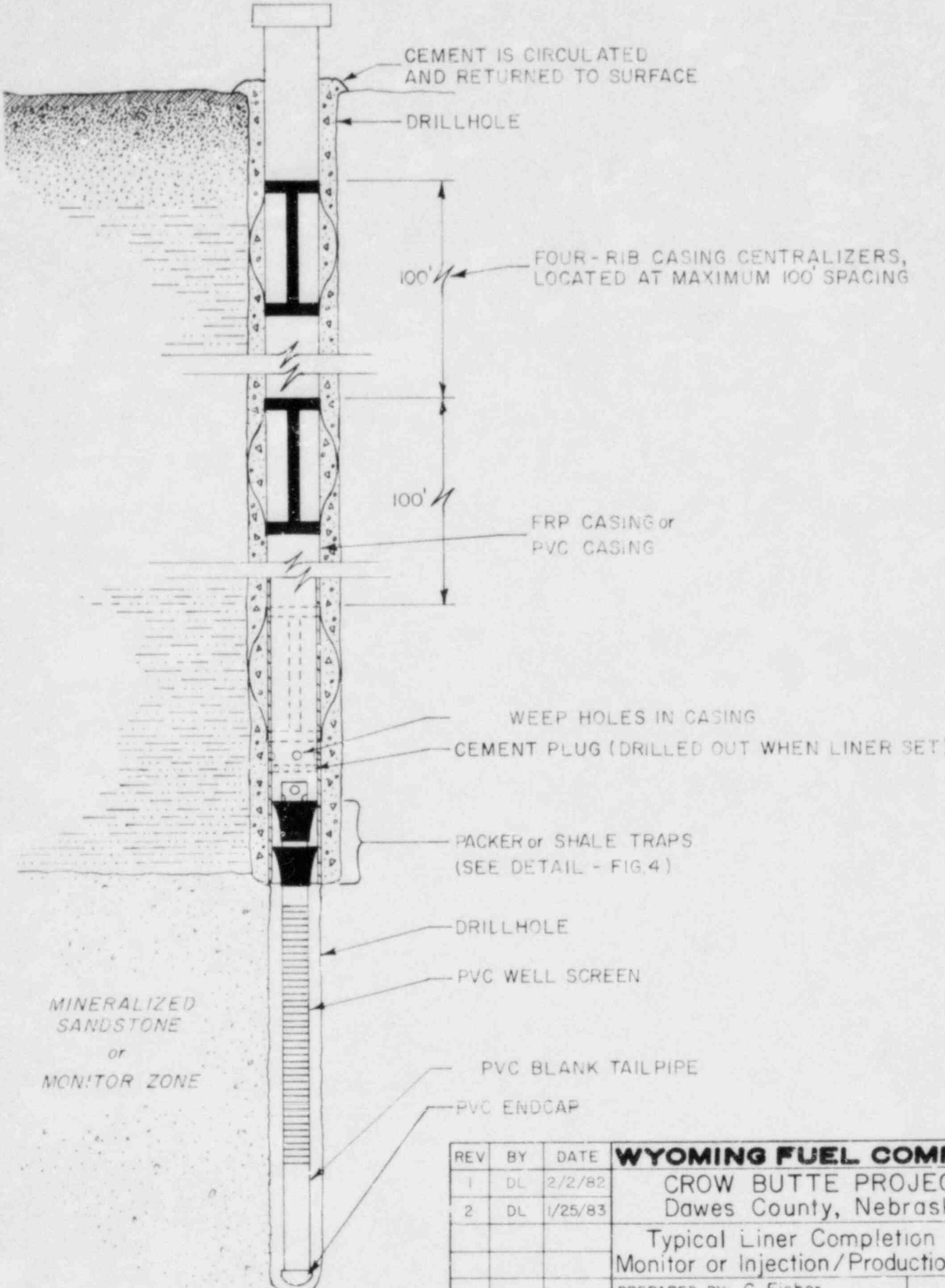
The second construction method shown in Figure 3.1-2 uses a screen telescoped down inside the cemented casing. As in the first method, a pilot hole is drilled and geophysically logged, to locate the desired screen interval. The pilot hole is then reamed only to the top of the desired screen interval. Next a string of casing with a plug at the lower end and weep holes just above the plug is set in the reamed hole. Cement is then pumped down the casing and out the weep holes. Cuttings prevent the cement from going down the pilot hole and the cement goes back to the surface through the annulus. After the cement has cured, the residual cement in the casing and the plug are drilled out and the drilling continues through the desired production zone. The screen with a packer or shale traps (Figure 3.1-3) is then telescoped through the casing and set in the desired interval. The packer or shale traps serve to hold the screen in the desired position while acting as a fluid seal. Well development is again accomplished by air lifting or pumping.

WELL COMPLETION METHOD No. I

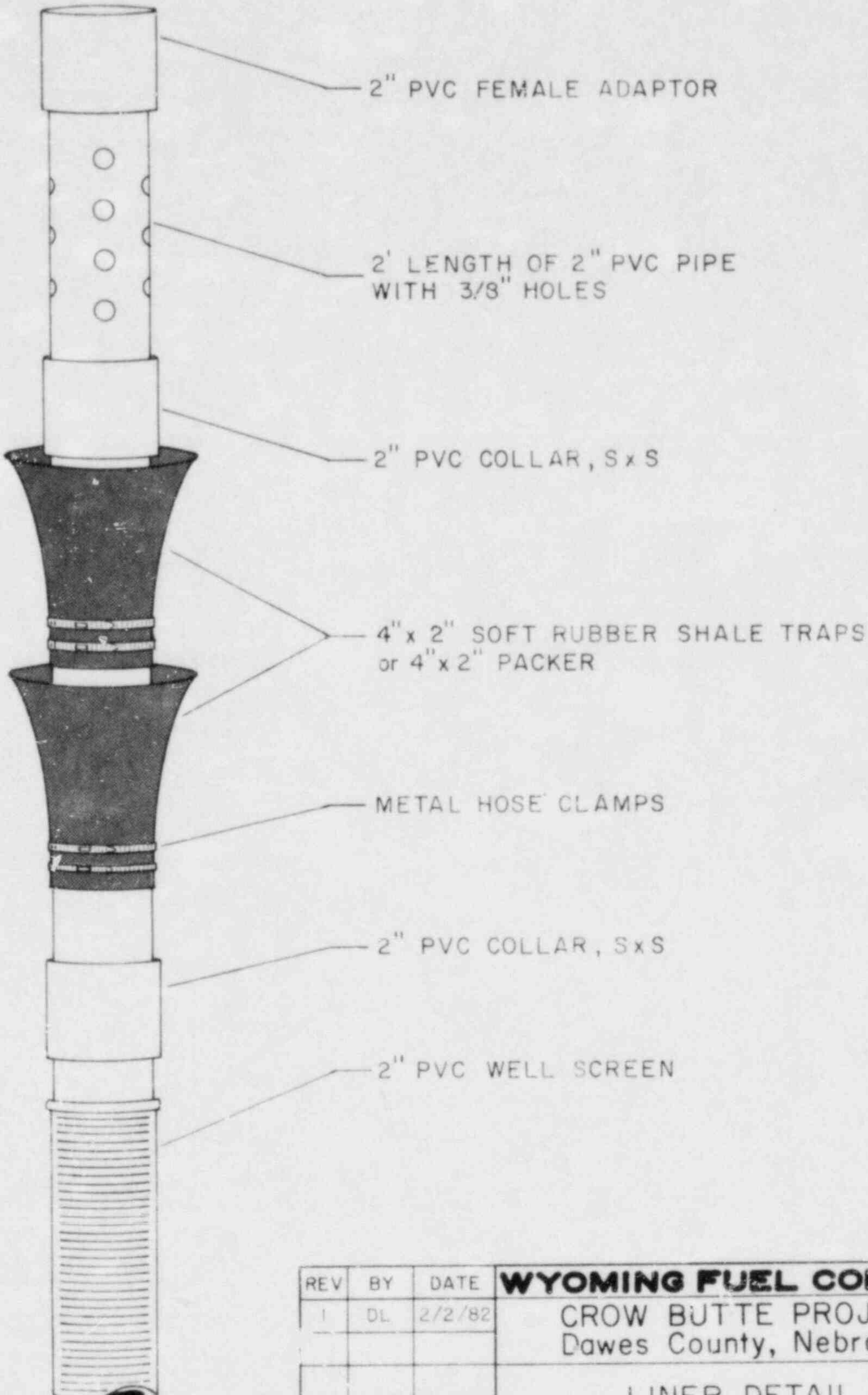


REV	BY	DATE	WYOMING FUEL COMPANY
1	DL	2/2/82	CROW BUTTE PROJECT
2	DL	1/25/83	Dawes County, Nebraska
			Typical Cement Basket Completion for Monitor or Injection/Production Wells
			PREPARED BY: C Fisher
			DWN BY: D Lewis — DATE: 1-23-82 — FIG. 3.1-1

WELL COMPLETION METHOD No. 2



REV	BY	DATE	WYOMING FUEL COMPANY	
1	DL	2/2/82	CROW BUTTE PROJECT	
2	DL	1/25/83	Dawes County, Nebraska	
			Typical Liner Completion for Monitor or Injection / Production Wells	
			PREPARED BY: C. Fisher	
			DWN BY: DLewis — DATE: 1-23-82	FIG. 3.1-2



REV	BY	DATE	WYOMING FUEL COMPANY	
1	DL	2/2/82	CROW BUTTE PROJECT Dawes County, Nebraska	
			LINER DETAIL	
			PREPARED BY: C. FISHER	
			DWN BY: D. LEWIS	DATE: 1-19-82
			FIG. 3.1-3	

Prior to leach solution injection, field testing of injection and recovery wells will be performed to demonstrate the mechanical integrity of the well casing. This testing will be performed either using pressure-packer tests or another acceptable method. Initially, the mechanical integrity tests will use the following procedure:

1. The well will be tested after the casing cement has cured and prior to drilling out the cement plug at the bottom of the casing. Prior to the test, the top of the casing will be sealed with a water tight nipple at the well head.

2. Fluid will then be injected into the casing at a pressure which simulates the maximum anticipated operating pressure of the well.

3. The well will then be "closed in" and the pressure observed for a minimum of 10 minutes.

4. If more than 10% of the pressure is lost during this period, the well will be deemed unacceptable for use as an injection well.

When possible, the well will be repaired and the integrity tests will be repeated. If the well casing leakage cannot be repaired or corrected, the well will be plugged and reclaimed as described in Section 6.0, Groundwater Quality Restoration, Surface Reclamation and Plant Decommissioning of this application.

Wyoming Fuel will have available on site the results of all mechanical integrity tests for regulatory review. An example form is included as Figure 3.1-5. Initially, Wyoming Fuel proposes to test all wells for mechanical integrity. However, once an adequate data base of the mechanical integrity tests is compiled and it can be demonstrated to the regulatory authority that the well construction methods are sound, Wyoming Fuel will propose an alternate plan not requiring the testing of all wells for mechanical integrity.

3.1.3 Wellfield Operation

A wellfield area of approximately 6.9 acres is located north of the process plant (Figure 2.1-2, Section 2.1 Site Location and Layout). Within this area, two wellfields will be constructed on smaller areas not to exceed 1 acre. Injection and recovery wells in both wellfields will be open to the mineralized part of the Chadron sand. The production zone ranges between approximately 640 and 670 ft (195 and 204m) in depth below the land surface. The injection and recovery wells will be selectively screened at the ore depth within this interval. The generalized well locations are given in Figure 2.1-2. The geologic unit comprising the production zone has been previously delineated in Figure 2.7-2 and Cross Sections 2.7-1 through 2.7-5. A significant factor in the final siting of the wells in the area designated on Figure 2.1-2 will be the cre distribution encountered during the drilling of the initial wells. Specific access routes to and within the wellfields have been designated in Figure 2.1-2, Section 2.1 Site Location and Layout, and vehicular traffic will be limited to these routes.

Within the wellfield area two separate wellfields will be tested simultanteously. Each wellfield will be a single five spot pattern with additional wells drilled in the larger wellfield to allow operation of a different size five spot using the same production well. Although initially designated as either injection or recovery wells, all of the wells will be capable of functioning for either purpose throughout the test. Piping will be arranged to allow individual flow measurements and sampling from each of the two wellfield patterns. The smaller five spot will be used to investigate the leaching response of the formation over a complete leaching cycle. This will include ore recovery and restoration. The larger well pattern will be used to investigate the effect of different well spacings on ore recovery.

Piping from the plant building to the wellfield building and from the wellfield building to the individual wells will be buried below the frost line. Either high density polyethylene or PVC pipe will be used for the underground service. At the wells,

WELL COMPLETION REPORT

COMPANY: ______________________ PROJECT: ______________________

WELL NO: ______________________ GROUND ELEV: ______________________

COORDINATES: ______________________ WELL HEAD ELEV: ______________________

Drill Contractor: ____________

Rig No: ____________

Driller: ____________

Mud Type: ________ Amt: ______

Bit Size: ____________

Date Started: ____________

Date Completed: ____________

Casing Size: ________ Type: ______

Drilled Depth: ____________

Casing Depth: ____________

Centralizer Depths: ____________

Basket Depth: ____________

Screen Interval: ____________

Cement Contractor: ____________

Operator: ____________

Cement Vol: ________ Wt: ______

Water Amt: ____________

Additives: ____________

Cement Circulated to Surface: ______

Logging Contractor: ____________

Unit: ________ Probe #: ______

Operator: ____________

Pipe Tally (Casing)

Describe drilling problems, drilling time, lost circulation, any difficulty with casing, cementing, crooked hole, junk in hole, etc.

Drill Technician: Date: Well No:

FIGURE 3.1-4

CASING INTEGRITY TEST REPORT FORM

WELL NO ________ DATE ____________

WELLFIELD __________________________

CASING TYPE __________________________ DIAMETER __________________

TOTAL DEPTH ____________________ TOP OF SCREEN ______________

TEST PACKER(S) DEPTH ______________ TEST DURATION __________

COMMENTS ____

____

____

____

____

TIME	ELAPSED TIME (MIN)	PRESSURE (psig)		TIME	ELAPSED TIME (MIN)	PRESSURE (psig)	

TEST PERFORMED BY: __________________

DATE: ____________

FIGURE 3.1-5

pitless adapters will be used to eliminate any above ground piping. All underground piping will be leak tested prior to use.

The anticipated wellfield operating schedule is as follows: for the first six months both well patterns will operate in a leaching mode; the smaller five spot will then go into restoration while the larger pattern is still leaching; after restoration of the smaller pattern is completed, restoration of the larger pattern will begin.

The exact dimensions of the wellfield will vary depending on conditions encountered in the field. Current plans are for the smaller cell to consist of four injection wells, spaced on a 35 x35 ft (10.7 m) square with a single production well in the center. The larger pattern consists of four injection wells on the corners of a 132x132 ft (40.2 m) square with a production well in the center of the square. Another pattern oriented 45° from the 132 ft (40.2 m) pattern will also be drilled, having dimensions of 186x186 ft. (56.7 m). This array can then be operated at well spacings of both 93 and 132 ft (28.4 and 40.2 m).

If new investigations are found desirable during the operation of the wellfields, Wyoming Fuel may desire to install additional wells within the large pattern. The anticipated resulting pattern would be four 93x93 ft (28.4 m) five spots adjacent to one another within the original 186x186 ft (56.7x56.7 m) pattern.

Monitor wells will be placed in the Chadron sand. In addition to the Chadron sand, monitor wells will also be placed in the first Brule sand above the Chadron sand. All monitor wells will be completed and developed prior to leach solution injection.

Computations have indicated the maximum pressure at the injection well head will be 100 psi. This pressure is required in order to keep the oxidant (oxygen) in solution. The injection pressure will be limited to keep from fracturing the formation. Fracture pressure is usually considered to be approximately 1 psi/ ft. of well depth. This figure is based on the overburden pressure of rock and tensile strength of the formation. The 1 psi/ft, however, does not consider the weight of the water column that will be in the well above the piezometric surface. The 100 psi limit provides a factor safety of approximately 4 to 5 to avoid fracturing the formation at the depths and peizometric surfaces encountered in the vicinity of the R&D wellfield.

3.1.4 Uranium Recovery Process

Sodium and carbonate species along with an oxidizer (oxygen or hydrogen peroxide) will be added to the formation water for dissolution of uranium.

Theoretically, uranium dissolution is a process involving an oxidation step and a dissolution step. The reactions representing these steps at a neutral pH are:

Oxidation:

$$UO_2 + H_2O_2 \rightleftharpoons UO_3 + H_2O$$

$$UO_2 + 1/2O_2 \rightleftharpoons UO_3$$

(solid) (in solution) (at solid surface)

Dissolution:

$$UO_3 + 2\ HCO_3^- + H_2O \rightleftharpoons UO_2(CO_3)_2\ 2H_2O^{-2}$$

$$UO_3 + CO_3^= + 2HCO_3^- \rightleftharpoons UO_2(CO_3)_3^{-4} + H_2O$$

The principal uranyl carbonate complex ions formed as illustrated above, are uranyl dicarbonate, $(UO_2)(CO_3)_2.2H_2O^{-2}$ (UDC), and uranyl tricarbonate $(UO_2)(CO_3)_3^{-4}$, (UTC). The relative abundance of each is a function of pH and total carbonate strength.

Various cations can be used to carry carbonates and bicarbonates in solution, but for economic reasons, sodium or ammonium systems are normally used for in situ extractions. Sodium is a naturally occuring groundwater constituent. For this reason, a sodium system was selected for the R&D test.

In addition to the complexing agent, sodium bicarbonate, an oxidant is added to the injection solution to carry out the oxidation reaction shown above. Although several oxidants could be used, the common choices are hydrogen peroxide (H_2O_2) or gaseous oxygen (O_2). Both of these oxidants revert to naturally occurring substances.

At the R&D site a sodium bicarbonate lixivant will be used. The sodium bicarbonate will be used at a strength of from 0.5 to 5.0 grams per liter with 0.1 to 1.5 grams per liter H_2O_2, or oxygen equivalent. From the results of these leaching tests, Wyoming Fuel may determine that it will be desirable to use another lixivant. However, prior approval from the regulatory authority would be obtained before use of another lixivant.

Uranium bearing solution resulting from the leaching of uranium underground will be recovered and the uranium will be extracted in the processing plant. The plant process will utilize the following steps:

a. Loading of uranium complexes onto an ion exchange resin;
b. Reconstitution of the leach solution by addition of sodium, bicarbonate, and oxygen;
c. Elution of uranium complexes from the resin using a sodium chloride/sodium bicarbonate eluant;
d. Precipitation of uranium using H_2O_2.

The process flow sheet for the above steps is shown in Figure 3.1-6. The anticipated R&D process plant layout is shown in Figure 3.1-7. The plant will be designed to operate at a maximum capacity o 100 gallons per minute.

The process flow sheet and plant layout as shown are based upon use of a particular set of used uranium recovery equipment. If this equipment is not available, or other equipment is found to be more suitable, the details of the layout may change; however, the general process will remain the same. The effluents will remain approximately the same and the space requirements will be approximately as shown.

Recovery of uranium will take place in ion exchange columns. The uranium bearing leach solution will enter the column and as it passes through the uranium complexes in solution will be loaded onto resin in the column. The loading process can be represented by the following chemical reaction.

$$2\ RCl + UO_2(CO_3)_2 \cdot 2H_2O^{-2} \rightleftharpoons R_2UO_2(CO_3)_2 + 2Cl^- + 2H_2O$$

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride ions.

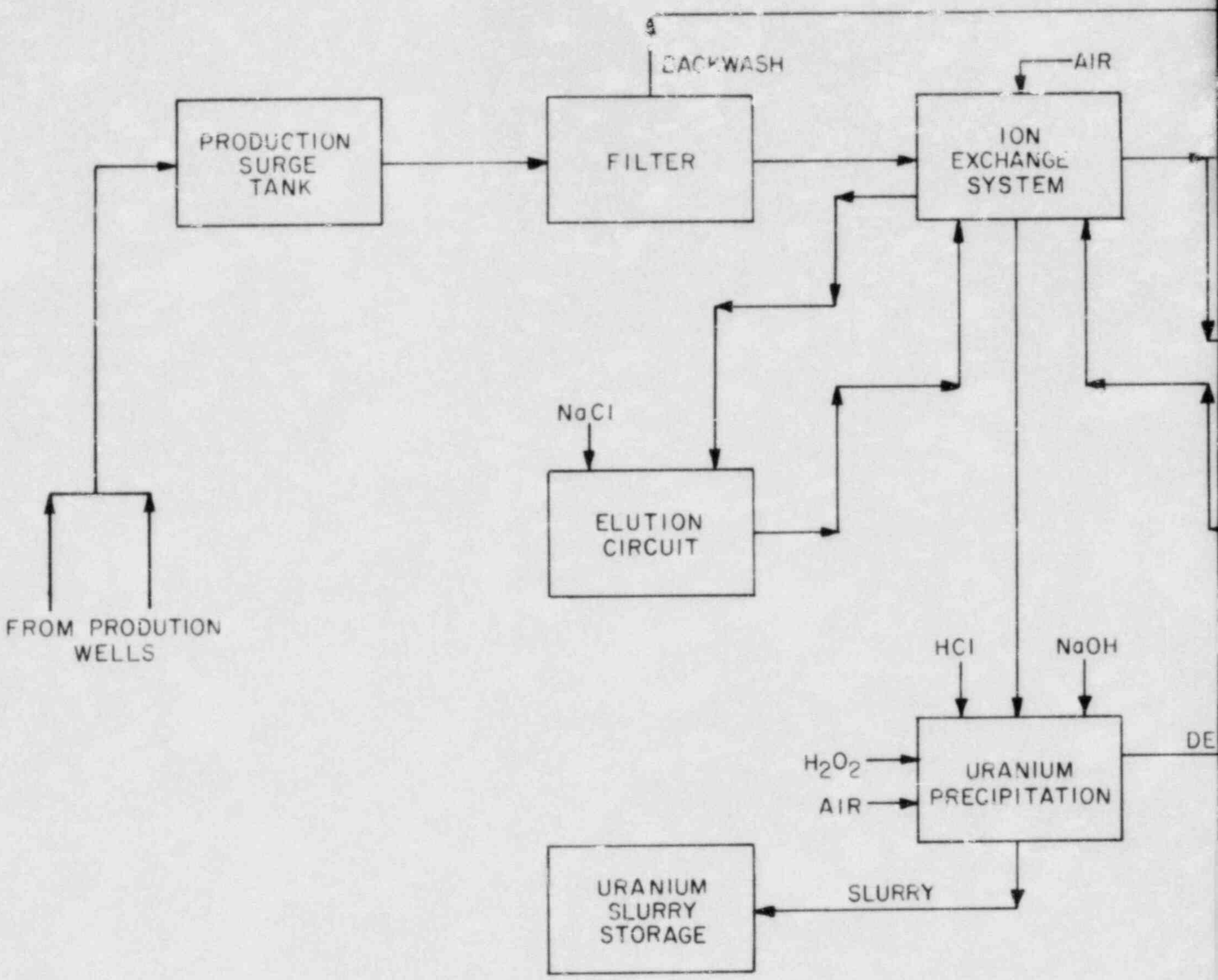
The now-barren leach solution passes to a barren lixivant surge tank. At this point the solution is refortified with sodium and carbonate chemicals as required and pumped to the wellfield for reinjection into the formation.

Since this is a research and development effort the lixivant concentration and composition will vary as different chemistries are investigated. Such variability results not only from modification of the plant chemistry, but also from different chemical reaction rates within the host sand. As a result, only anticipated lixivant composition, with ranges of concentrations, can be given. These expected ranges are shown in Table 3.1-1. A more detailed expected material balance is presented in Figure 3.1-8.

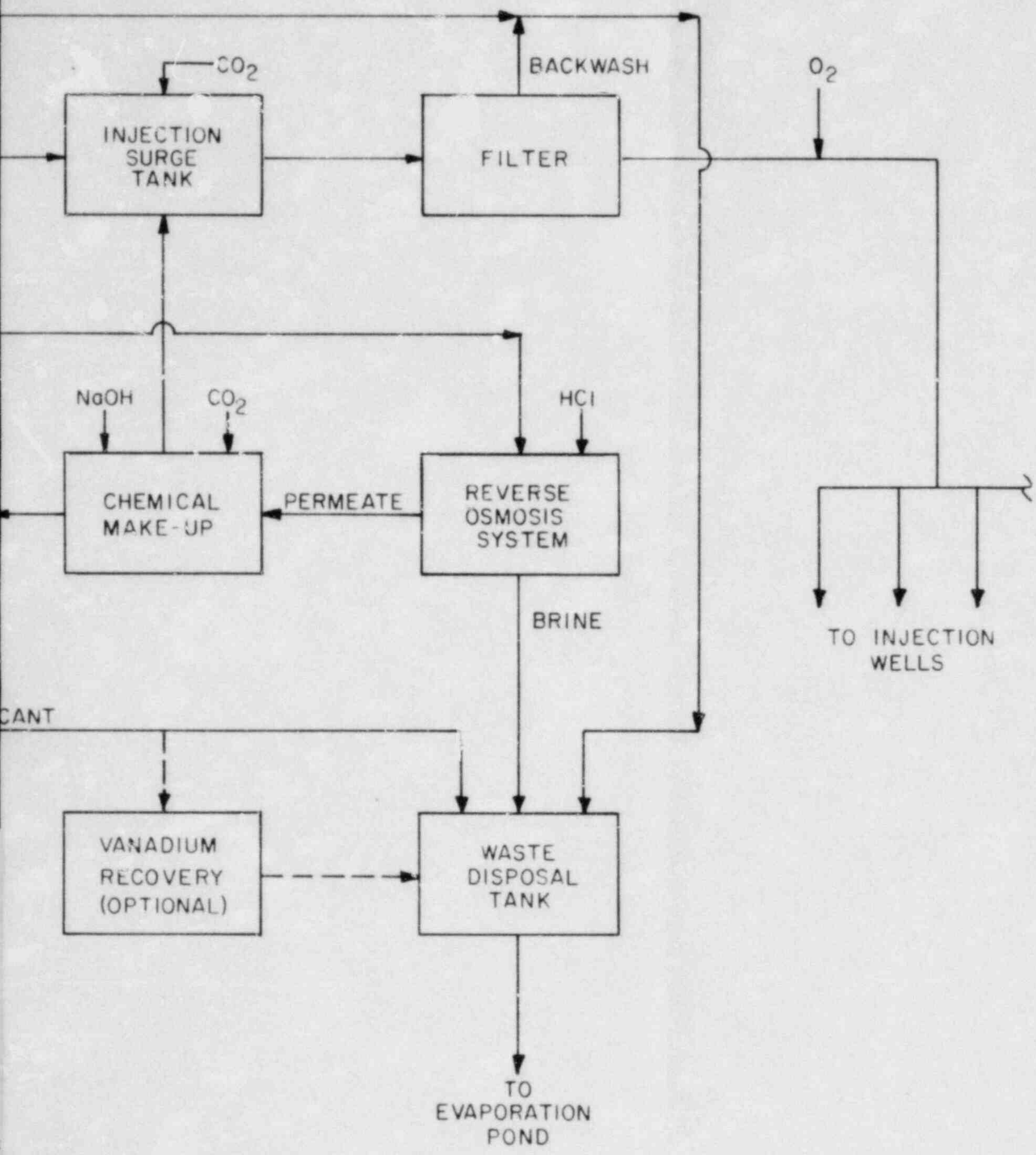
Once all ion exchange sites on the resin are filled with uranium, the particular column is taken off stream. The loaded resin is then stripped of uranium in place through an elution process based on the following chemical reaction:

$$R_2UO_2(CO_3)_2 + 2Cl^- + CO_3 \rightleftharpoons 2\ RCI + UO_2(CO_3)_3^{-4}$$

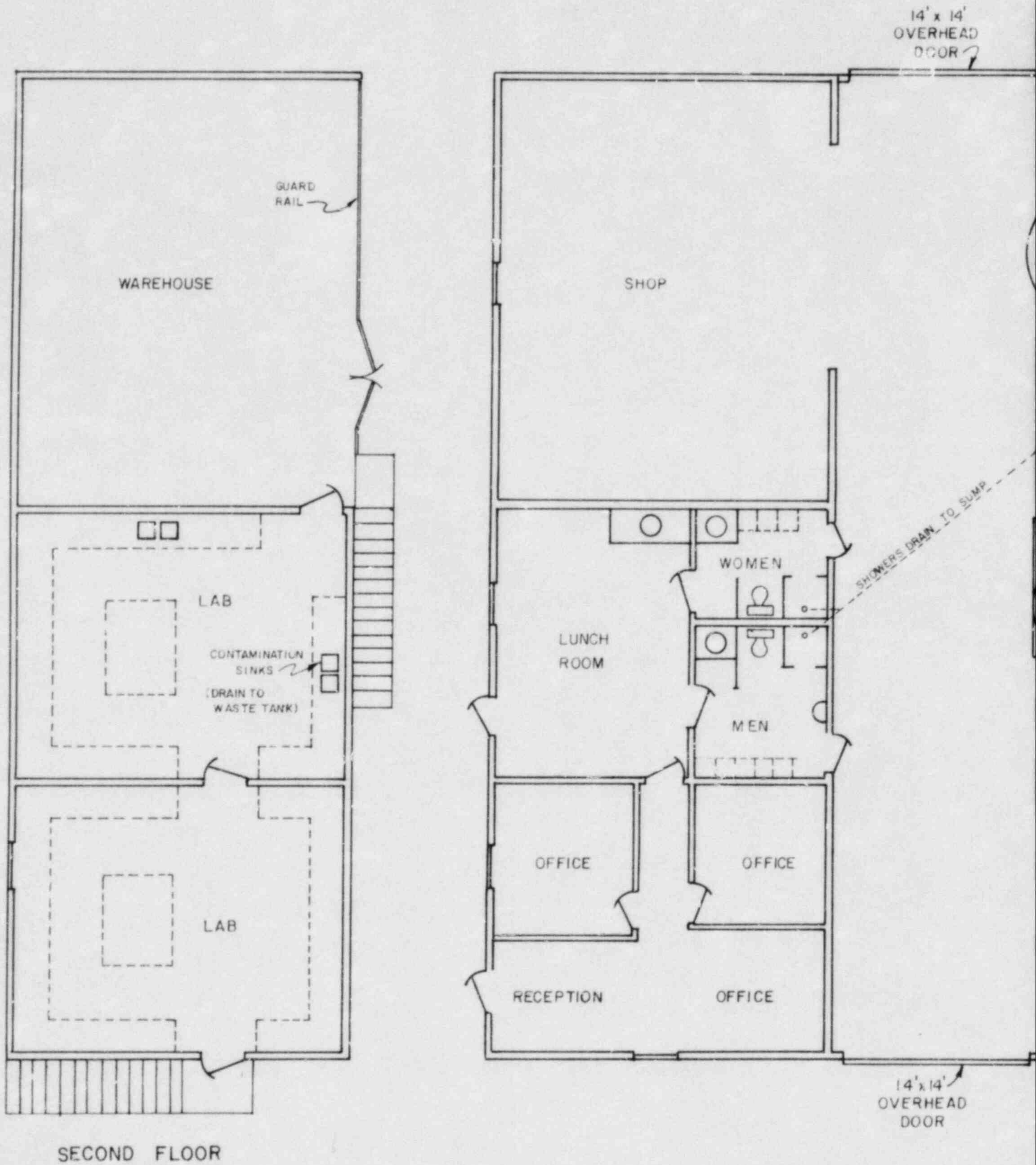
During the elution process, the first half of the pregnant eluate will be transfered to the precipitation tank. The second half of the eluant volume, which is lower in uranium content, will be stored in the intermediate eluant storage tank to be used on the first half of the next elution cycle.



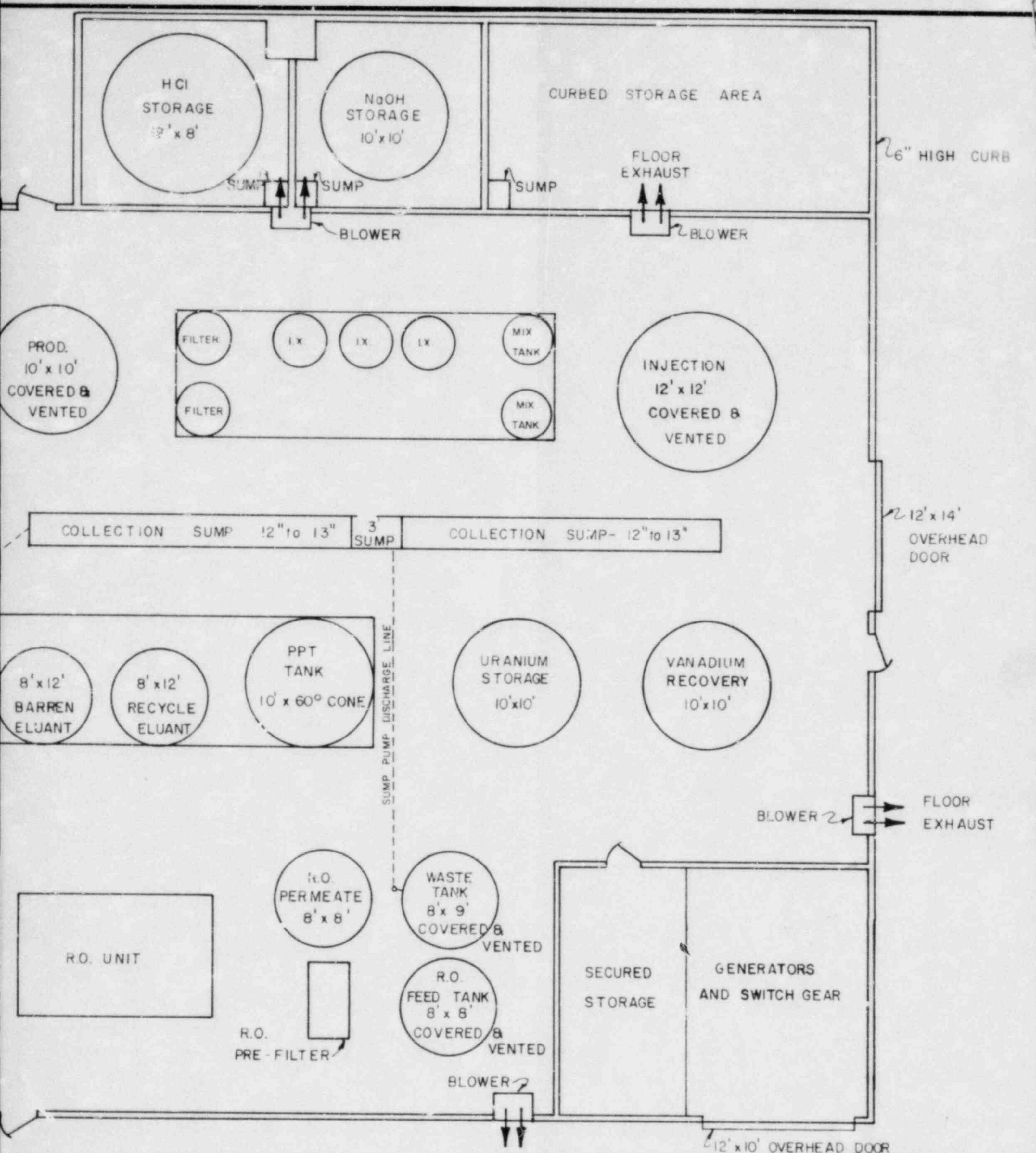
BACKWASH
AIR
PRODUCTION
SURGE
TANK
FILTER
ION
EXCHANGE
SYSTEM
NaCl
ELUTION
CIRCUIT
FROM PRODUTION
WELLS
HCl
NaOH
H_2O_2
AIR
URANIUM
PRECIPITATION
DE
URANIUM
SLURRY
STORAGE
SLURRY



REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			PROCESS FLOW SHEET
			PREPARED BY: JAKrebs
			DWN BY: SADavis — DATE: Jan19,1983 — FIG. 3.1-6

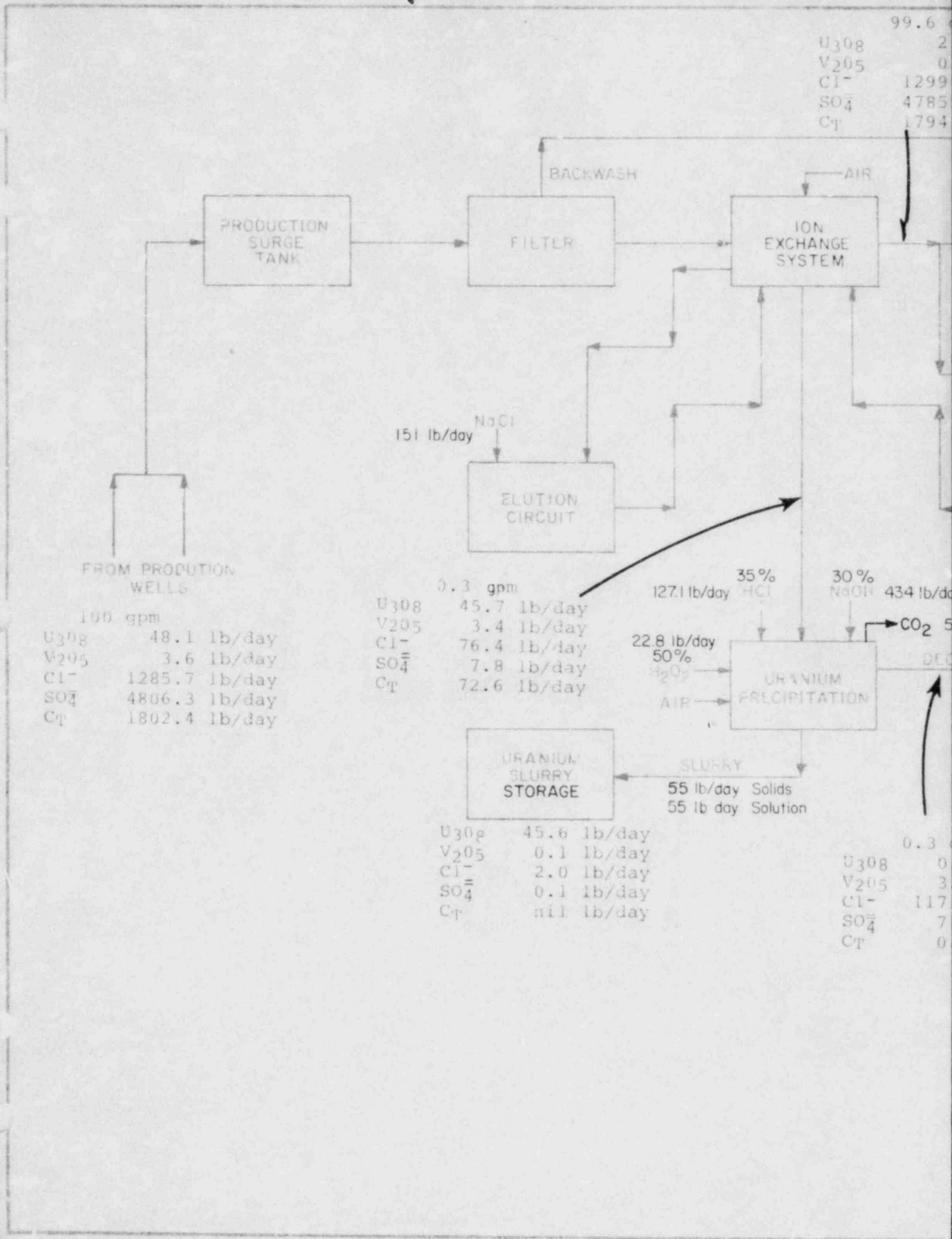

14' x 14'
OVERHEAD
DOOR
GUARD
RAIL
WAREHOUSE
SHOP
SHOWERS DRAIN TO SUMP
WOMEN
LAB
CONTAMINATION
SINKS
(DRAIN TO
WASTE TANK)
LUNCH
ROOM
MEN
OFFICE
OFFICE
LAB
RECEPTION
OFFICE
14'x14'
OVERHEAD
DOOR
SECOND FLOOR

SCALE: 1"=10'

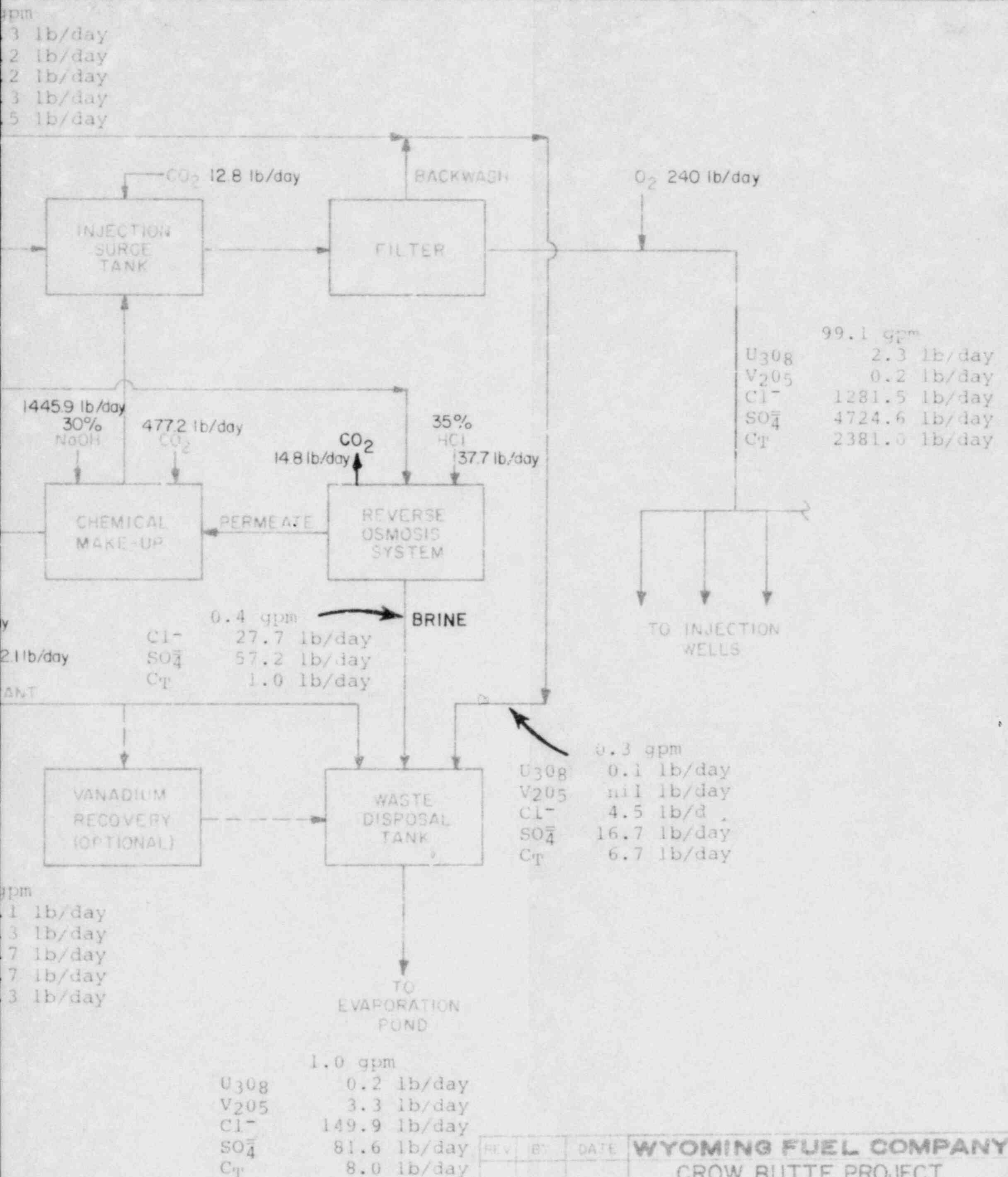


FIRST FLOOR

REV	BY	DATE	
			WYOMING FUEL COMPANY CROW BUTTE PROJECT Dawes County, Nebraska
			PLANT EQUIPMENT LAYOUT
			PREPARED BY
			DWN BY: R.E. Larson DATE: 12-16-82 FIG. 3.1-7



99.6
U_3O_8
V_2O_5
Cl^- 1299
$SO_4^=$ 4785
C_T 1794
BACKWASH
AIR
PRODUCTION SURGE TANK
FILTER
ION EXCHANGE SYSTEM
NaCl
151 lb/day
ELUTION CIRCUIT
FROM PRODUTION WELLS
100 gpm
U_3O_8 48.1 lb/day
V_2O_5 3.6 lb/day
Cl^- 1285.7 lb/day
$SO_4^=$ 4806.3 lb/day
C_T 1802.4 lb/day
0.3 gpm
U_3O_8 45.7 lb/day
V_2O_5 3.4 lb/day
Cl^- 76.4 lb/day
$SO_4^=$ 7.8 lb/day
C_T 72.6 lb/day
35 %
127.1 lb/day HCl
30 %
NaOH
434 lb/
CO_2
22.8 lb/day
50%
H_2O_2
AIR
URANIUM PRECIPITATION
URANIUM SLURRY STORAGE
SLURRY
55 lb/day Solids
55 lb day Solution
U_3O_8 45.6 lb/day
V_2O_5 0.1 lb/day
Cl^- 2.0 lb/day
$SO_4^=$ 0.1 lb/day
C_T nil lb/day
0.3
U_3O_8
V_2O_5
Cl^-
$SO_4^=$
C_T



REV	BY	DATE

WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Dawes County, Nebraska

PROCESS FLOW SHEET
Material Balance

PREPARED BY: JAKrebs
DWN BY: SADavis DATE: Jan 19, 1983 **FIG. 3.1-8**

TABLE 3.1-1

LIXIVANT CONCENTRATION AND COMPOSITION

SPECIES	RANGE* LOW	HIGH
Na	500	6000
Ca	20	500
Mg	3	100
K	15	300
CO_3	0.5	2500
HCO_3	350	5000
Cl	200	5000
SO_4	500	5000
U_3O_8	.01	500
V_2O_5	.01	100
TDS	1650	12000
pH	6.5	10.5

* All values in mg/l except pH.

After the uranium has been stripped from the resin, the resin will be rinsed with a sodium bicarbonate solution. This rinse will remove the high chloride eluant physically entrained in the resin and will partially convert the resin to bicarbonate form. In this way, chloride ion buildup in the leach solution can be reduced.

When a sufficient volume of pregnant eluant is held in storage it will be acidified with hydrochloric acid to destroy the uranyl carbonate complex ion and air will be sparged through the solution to assist in removal of the resulting CO_2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \rightleftharpoons UO_2^{++} + 3\ CO_2 + 3H_2O$$

Hydrogen peroxide will then be added to the solution to precipitate the uranium according to the following reaction:

$$UO_2^{++} + H_2O_2 + 2H_2O \rightleftharpoons UO_4.2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry will be allowed to settle and the clear solution will be decanted. The decant solution will probably contain enough vanadium to preclude its reuse. Therefore, it will be pumped to the waste storage tank for transfer to the evaporation ponds. A tank will be provided to accumulate some of this low uranium, high vanadium solution which will allow testing of various vanadium recovery techniques. The thickened uranium slurry will be transfered to tanks or other suitable containers for storage. The product eventually will be shipped to a licensed milling or converting facility in a slurry form.

3.1.5 Process Wastes

The operation of the process plant will result in three sources of liquid waste. They are (1) filter backwash, (2) eluant bleed, and (3) reverse osmosis brine (see Figure 3.0-8). Since this is a research and development operation, the composition of process wastes will vary as the leach chemistry varies and also as efforts are made to improve the process. The currently anticipated compositions of the liquid wastes and their expected volumes are shown in Table 3.1-2. The wastes will be discharged into the lined evaporation ponds. During leaching, the total amount of solution wastes from the process plant, Items 1 and 2 above, are not expected to exceed 1% of the pregnant solution recovered from the wellfield. A water balance diagram for the entire system, including the waste streams, is shown in Figure 3.1-9.

For the leaching portion of the test, the total plant waste is estimated to be 394,500 gallons (1,493,200 liters). During restoration of the smaller five spot, the waste produced is estimated to total 103,600 gallons (392,100 liters) while restoration of the larger pattern is expected to produce 2,702,000 gallons (10,227,100 liters) of waste.

3.2 Recovery Plant Equipment

As referenced earlier, the proposed layout of the processing plant is shown in Figure 3.1-2. All tankage used in the plant will be of fiberglass reinforced plastic (FRP) or lined steel construction. The ion exchange columns used will be of lined carbon steel construction with a protective coating on the exterior surfaces. The columns will be operated in an upflow fixed bed manner, that is to say that the solution will travel through the resin from bottom to top through each vessel. The three vessels will be operated using a conventional "merry-go-round" system whereby two columns are loading while the third is on the elution cycle. The resin will be eluted and rinsed in place and will never leave the column. While the resin loading is a continuous process, resin elution will be carried out batch wise.

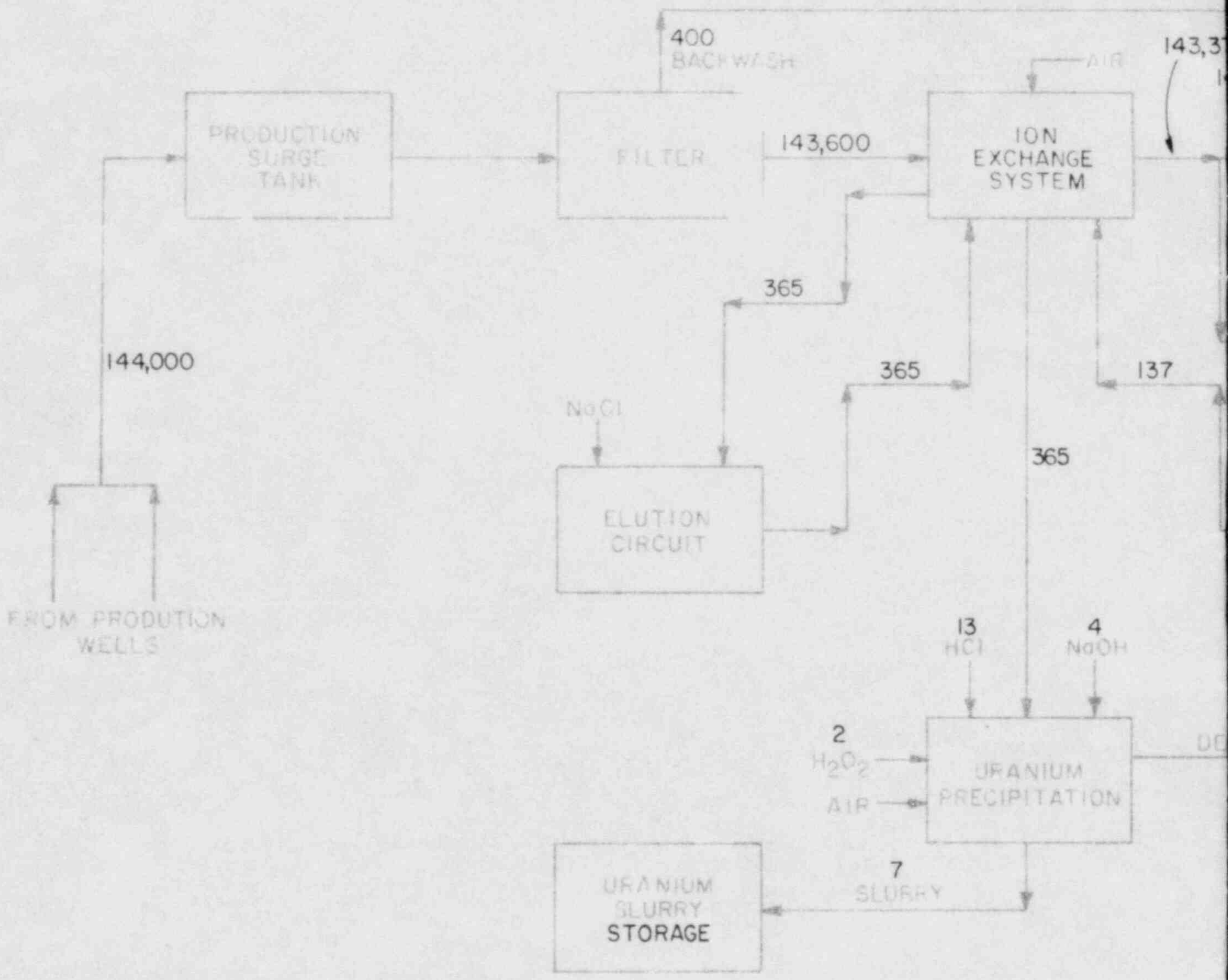
Reagent makeup will be affected by the use of gaseous or liquid reagents wherever possible. It may be, however, that solid sodium carbonate, sodium bicarbonate, or sodium sesquicarbonate may be used for reagent makeup in either the injection or eluant makeup circuits. Widespread use of solid reagents, however, is not anticipated.

TABLE 3.1-2

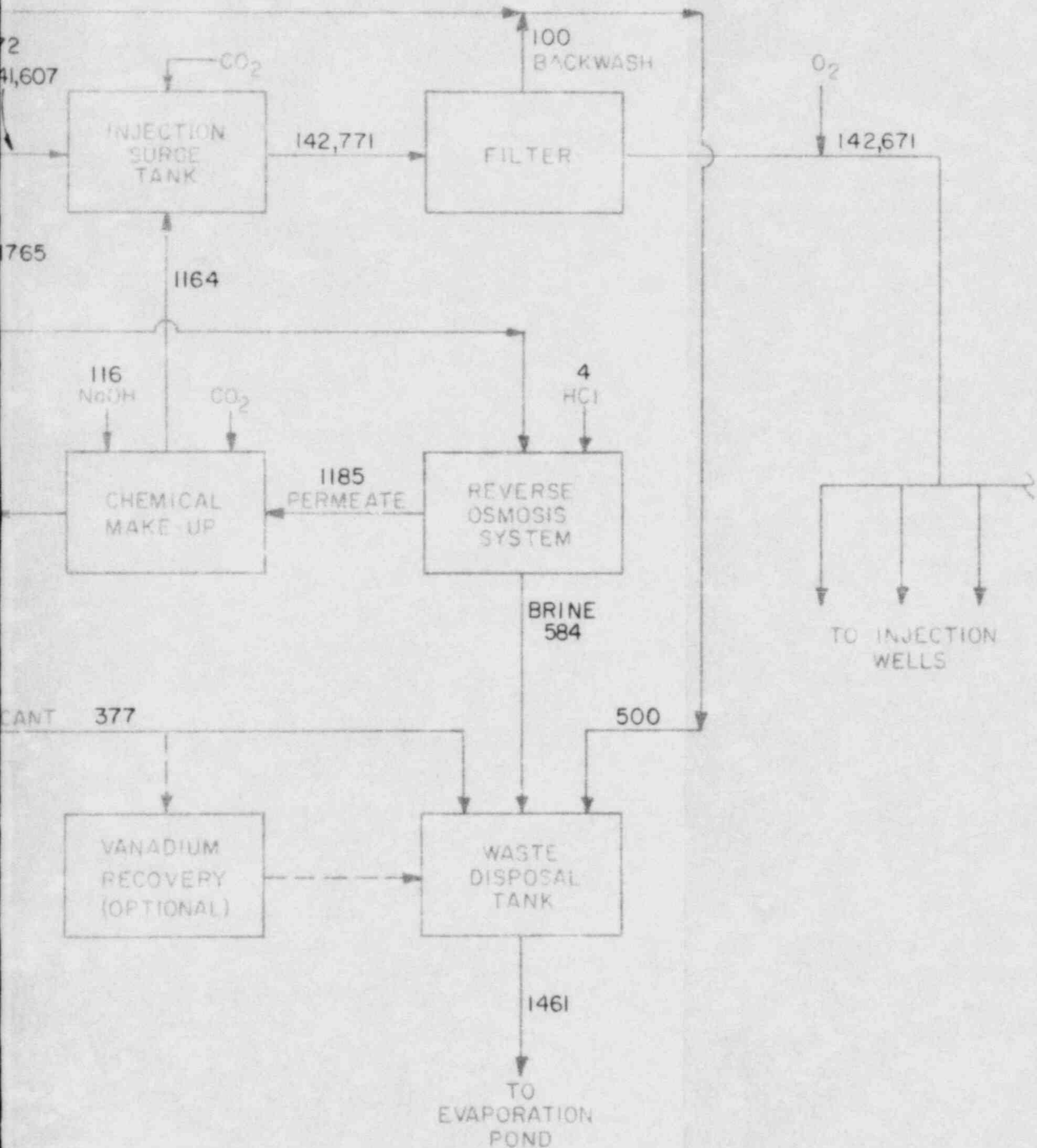
ESTIMATED WASTE VOLUMES AND COMPOSITIONS
(mg/l except as noted)

PARAMETER	FILTER BACKWASH*	ELUANT BLEED	REVERSE OSMOSIS BRINE*
Flow Rate (gpm)	0.3	0.3	0.4
U_3O_8	0.2 to 500	0.2 to 100	5 to 20
V_2O_5	0.02 to 100	0.1 to 1500	.02 to 30
Na	50 to 6000	20000 to 30000	1000 to 15000
Ca	20 to 500	10 to 200	60 to 400
Cl	200 to 3000	20000 to 40000	600 to 8000
Total Carbonates	350 to 5000	10 to 100	$<$ 100
SO_4	500 to 5000	1000 to 8000	1500 to 17000
Solids	0 to 5% (by wt)	nil	nil

* Intermittent Stream - flow averaged over 24 hours.



*ALL FIGURES IN GALLONS PER DAY



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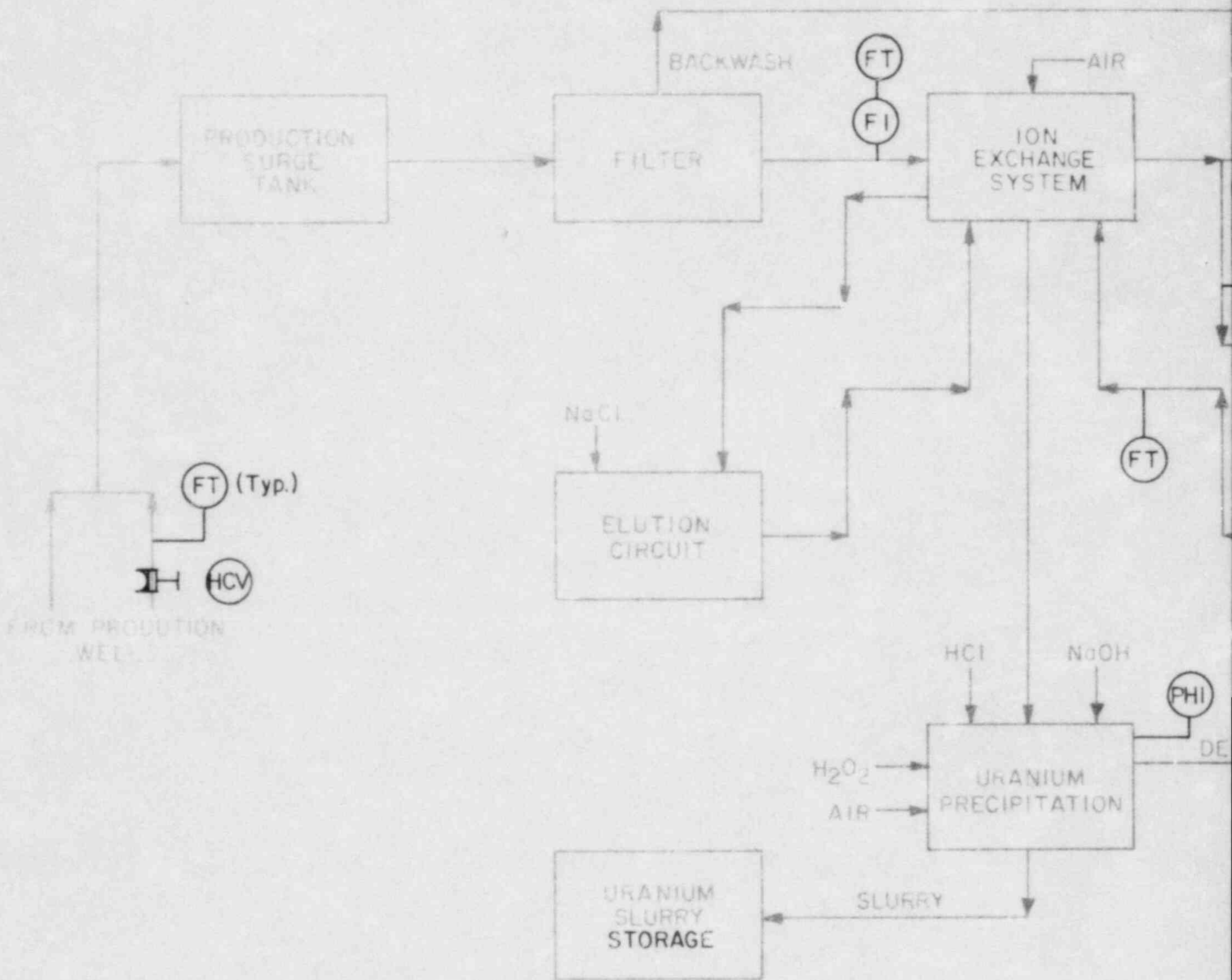
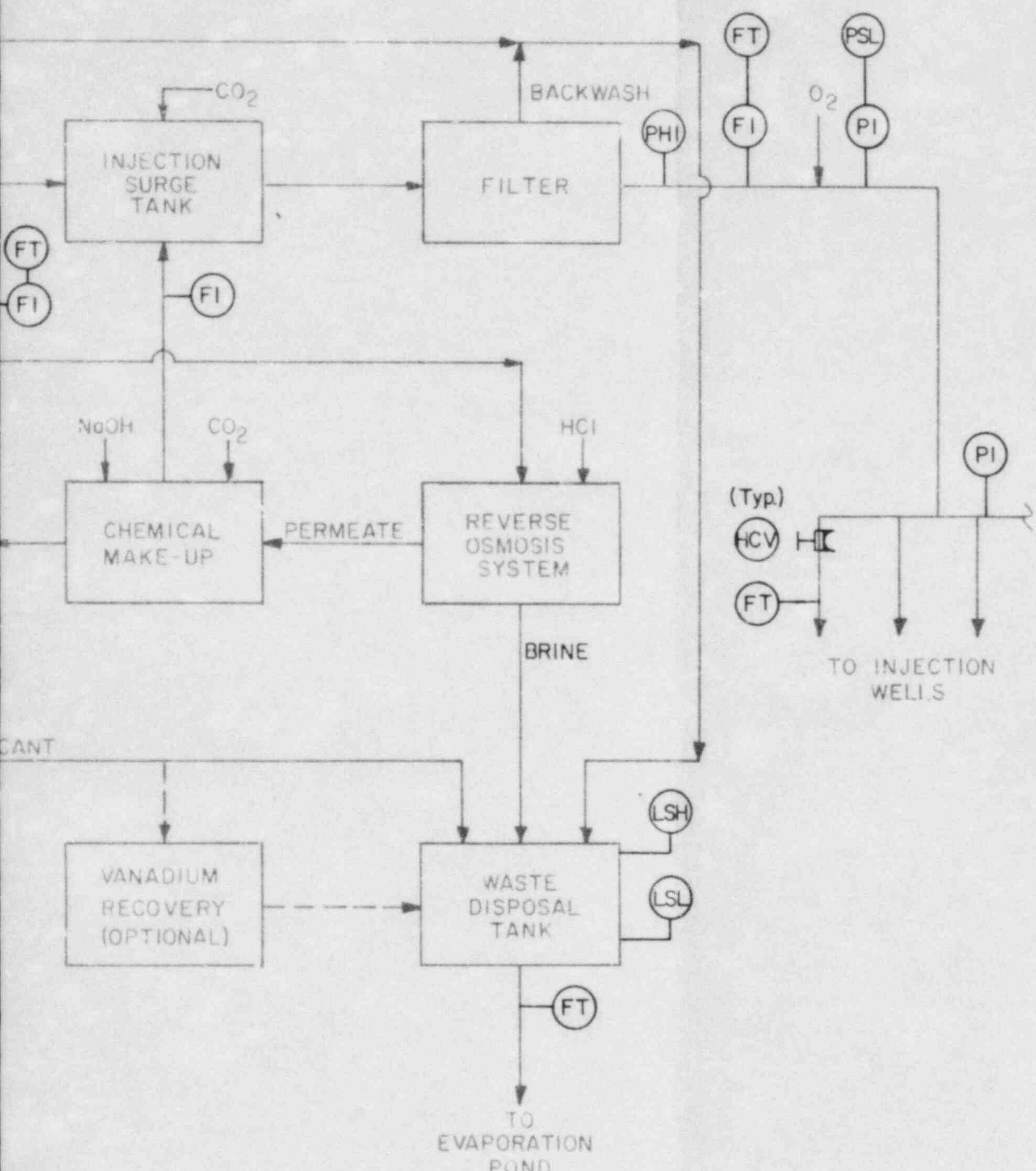
			WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			PROCESS FLOW SHEET **Water Balance**
			PREPARED BY JAKrebs
			DWN BY SADavis — DATE Jan.19,1983 — **FIG. 3.1-9**



LEGEND

FI	FLOW INDICATOR
FT	FLOW TOTALIZER
PI	PRESSURE INDICATOR
PSL	PRESSURE SWITCH, LOW
PHI	pH INDICATOR
LSH	LEVEL SWITCH, HIGH
LSL	LEVEL SWITCH, LOW
HCV	HAND CONTROL VALVE



REV	BY	DATE

WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Dawes County, Nebraska

PROCESS FLOW SHEET
Instrumentation Diagram

PREPARED BY JAKrebs

DWN BY SADavis DATE Jan. 19, 1983 **FIG. 3.1-10**

A discussion of the areas in the proposed plant layout where fumes or gases could be generated can be found in Section 7.3. The production solution surge tank is a possible source of radon and CO_2 gases and will be vented to the atmosphere by a turbine ventilator or fan. The injection surge tank will be similarly vented for radon and CO_2 removal. The reverse osmosis feed tank will also be ventilated for removal of any radon which may be liberated at that point as well as CO_2 which will be released from the tank. The precipitation tank will be ventilated in anticipation of release of CO_2 and a small amount of acid mist anticipated to occur during the precipitation process. Building ventilation in the process equipment area will be accomplished by the use of fans at floor level in the walls of the building. These fans will draw fresh air in from ventilators at the peak of the building and help to sweep radon, which will accumulate near the floor of the building, out to the atmosphere.

3.3 Instrumentation

Wellfield instrumentation will be provided to measure total flow to the injection wells, total flow from each production well, and flows to individual wells. In addition, instrumentation will be provided to indicate the maximum pressure which is being applied to any of the injection wells. Flow and pressure instrumentation will be calibrated on a schedule that is consistent with good operating practice.

In the plant, instrumentation will be provided to monitor the total flow into the plant, the total injection flow leaving the plant, the total waste flow leaving the plant, and the eluant flow to the ion exchange columns. In addition to the above mentioned flow instrumentation, pressure instrumentation will be provided on the injection transfer pump to shut the pump down in the event of low pressure which would indicate a rupture in the injection transfer line going from the plant to the wellfield. The pump will be sized so that it is incapable of producing pressures high enough to exceed the design pressure of the injection lines or the maximum pressure to be applied to the injection wells.

Other instrumentation such as pressure gauges, pH indicators, and flow indicators will be provided at various places in the process where required. The instrumentation, in conjunction with the samples which will be collected, will be sufficient to allow a material and water balance around the plant and wellfield on a daily basis. Typical instrumentation for the wellfield and plant is shown in Figure 3.1-10.

SECTION 4.1

GASEOUS AND AIRBORNE PARTICULATES

4.1 GASEOUS AND AIRBORNE PARTICULATES

The Crow Butte R&D Project is an in-situ operation and as such, many of the sources of particulate effluents normally associated with conventional mills will not exist. Uranium ore will not be handled and there will be no tailings. The product will be stored and shipped as a slurry, and as a result there will be no product dryer which is a potential source of particulate emissions. The only possible source of radioactive particulates is in the precipitation circuit.

After the ion exchange resin has been eluted, the uranium in the concentrated eluant will be precipitated. The process requires acid to be added to the eluant to remove the carbonate ion and lower the pH of the solution. At this point in the process carbon dioxide will be evolved. Care will be taken to add the acid slowly to prevent an excessively vigorous reaction and minimize the possibility of creating a mist that may contain uranium. This neutralization will be conducted in a cone bottom tank with high sides. The level of liquids in the tank will be kept low to further alleviate any problem with misting that might occur.

Radon-222 is a radioactive gaseous effluent and control of this gas will be of primary importance. The estimated concentration of radon-222 in the leach solution is 6.43×10^{-7} Ci/l. The calculations used to arrive at this figure are included in Appendix 7.3(A). The radon will emanate from solution when it is pumped to the surface. The pump discharge lines are closed therefore the gas will not escape in the wellfield. The solution is pumped from the wellhead to a production surge tank housed in the plant building. It is in this tank that a majority of the radon-222 will be released from solution. From the surge tank the solution passes through filters and the ion exchange train both of which are pressurized. The release of appreciable amounts of radon-222 from this part of the process is unlikely. The solution is then transferred to an injection surge tank before being pumped back to the wellfield. The potential exists for radon-222 to be released from this surge tank. The injection wells are sealed and pressurized and radon escaping from them is unlikely.

Both the production and injection surge tanks are the primary locations for release of radon-222. Two secondary sources of radon may be two smaller tanks, one used to store feed solution for the R.O. unit and the other for storage of liquid waste collected in the sump and the reject stream from the R.O. unit. The R.O. feed also receives the solution bleed stream when it is produced.

Two possible alternatives exist for minimizing the exposure to radon-222 1) keep the gas in solution or 2) control the release of the gas. If the entire process circuit were pressurized, radon could be contained in solution and recirculated. The concentration of the gas in the solution would quickly reach very high levels. Small leaks in the circuit, as well as the solution bleed would release radon at concentrations that would be much greater than a conventional nonpressurized circuit. Control of the radon-222 would prove to be very difficult and result in the potential for increased radiation doses to plant operators due to the greater concentrations of the gas when releases occur.

The second alternative is to control the release of the gas at the two surge tanks. This is the method selected to be applied at the Crow Butte R&D Project. The method of control will be to release the radon-222 through a vent in each of the surge tanks. The vents will be approximately 0.20 m (8 in) in diameter and will extend through the roof of the plant. On top of each vent a rotary roof ventilator will be attached to continually exhaust the air in the tank. This procedure should allow for the removal of most of the radon and permit the release of the gas at a safe and controlled location. The two smaller tanks, the R.O. feed and the waste tank will also be vented through the roof. This should remove any radon that may emanate from the solutions in these tanks. The effect of this planned radon-222 release on the environment and population surrounding the Crow Butte R&D Project is discussed in Section 7.3.

Venting the radon-222 out of the building, will also minimize the possibility of radon daughter concentrations in the building exceeding prescribed levels. There will be four exhaust fans mounted in the exterior walls of the building and a system of ventilators in the building roof to allow air to enter. These fans will be of sufficient size to permit a minimum of four complete plant air exchanges per hour. The number of required air exchanges was calculated assuming the primary source of radon-222 in the plant was from process solutions exposed to the plant atmosphere and that all of the radon-222 was released from this solution. The volume of solution exposed was estimated to be 0.5 percent of the plant's production flow rate. The radon was further assumed to only reach 50% of equilibrium with its daughters. From these assumptions it can be shown in the four air exchanges per hour will maintain the working levels at 10% MPC. It should be noted that this estimate does not allow for the increased air circulation through the plant building due to open doors and windows.

SECTION 4.2

LIQUIDS AND SOLIDS

4.2 LIQUIDS AND SOLIDS

Descriptions of liquids and solids waste management facilities are provided as required in Regulatory Guide 3.46 (Task FP 818-4). Design, inspection and monitoring have been developed under the guidance of NRC Technical Position Papers WM-8101, "Design, Installation, and Operation Natural and Synthetic Liners at Uranium Recovery Facilities," WM-8201. "Hydrologic Design Criteria for Tailings Retention Systems," Regulatory Guide 3.11 and Regulatory Guide 3.11.1.

Waste Ponds

The waste storage ponds are designed to totally contain the anticipated waste stream produced from the proposed R&D test, the impinging annual rainfall less annual evaporation and the 6 hour probable maximum precipitation (U.S. Dept. of the Interior, 1977). The ponds are to be membrane lined with an underdrain system placed on compacted soil.

The waste pond design, installation and operation criteria used in the design of these waste ponds are those which were found to be applicable in NRC Regulatory Guidelines 3.11, 3.11.1 and Staff Technical Position Paper WM-8101.

Pond Location. The waste ponds are located at approximately 42°38'34" north latitude and 103°20'50" longitude (see Figure 2.1-2, Section 2.1, Site Location and Layout). A more detailed location of the ponds is shown in Figure 4.2-1.

Pond Capacities. The two waste storage ponds will have total depth of 17 ft (5.18m). The volume at 10 ft (3.05m) of depth is designated as the maximum operating pool depth. The emergency volume is from the 10 ft (3.05m) depth to the 16 ft (4.88m) depth and is to be retained in the event of excessive precipitation and/or for an upset in plant operations requiring additional waste storage capacity. The minimum freeboard is designed as 1.0 ft (0.3m). The pond volumes are tabulated in Table 4.2-1.

The required total maximum operating pool volume is given in Section 3.1 as 12,112,400 liters (3,200,100 gallons). The emergency volume was based on the probable maximum precipitation for a six hour period of 20 in (50.8m) (U.S. Dept. of the Interior, 1977). The 6 hour PMP falling on the area of the membrane liners results in a volume of 1,211,200 gallons (4,584,300 liters). The 6 hour PMP is considered as a highly conservative and unlikely situation since the 24 hour maximum precipitation recorded in the area is 3.18 in (8.08 cm), and the maximum monthly precipitation is 10.38 in (26.37 cm). Therefore, the emergency volume is considered as also being available for unforeseen upsets in operation that may result in additional volumes of waste solution.

Design Considerations. The waste storage pond design considered hydrologic conditions, site soil conditions and the proposed operating conditions. The hydrologic conditions involved in calculating the pond capacity requirements included average annual rainfall, average annual evaporation rate and a 6 hour probable maximum precipitation. The location and elevation of the ponds have eliminated the effects of the probable maximum flood or other excessive run-off conditions when considering the capacities of the waste ponds. The only potential for erosion of the pond structure is due to run-off. The native soil is a highly erodible loess which is loosely consolidated. In order to help control this erosion, banks on cut and fill slopes in the immediate area of the ponds will not have slopes exceeding 3H:1V and they will be completed in a manner to prevent erosion as much as possible. It is intended for the duration of the proposed project that any damage to the pond structure will be repaired in a timely manner. Since the ponds will be removed upon closure of the site no further measures to control erosion are required.

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TABLE 4.2-1

POND CAPACITIES

Description	Depth	Pond 1 Capacity	Pond 2 Capacity	Total Capacities
Operating Pool	0 to 3.1 m	5,662,320 l	5,662,320 l	11,324,720 l
	(0 to 10 ft)	(1,496,000 gal)	(1,496,000 gal)	(2,992,000 gal)
Emergency Volume	3.1 to 4.9 m	6,288,800 l	6,288,800 l	12,577,600 l
	(10 to 16 ft)	(1,661,500 gal)	(1,661,500 gal)	(3,323,000 gal)
Freeboard Volume	4.9 to 5.2 m	1,286,900 l	1,286,900 l	2,573,800 l
	(16 to 17 ft)	(340,000 gal)	(340,000 gal)	(680,000 gal)
TOTALS		13,238,000 l	13,238,000 l	26,476,000 l
		(3,497,500 gal)	(3,497,500 gal)	(6,995,000 gal)

The pond site soil conditions were evaluated by five test borings and one bulk sample. The results of the boring and the subsequent laboratory test work are provided in Table 4.2-2.

The data given in Table 4.2-2 represent samples taken at the surface and to a depth of 12 ft (3.7m) from the surface. One boring was continued to a depth of 20 ft (6.1m) from surface and it was visually determined that the materials from 12 ft (3.7m) to 20 ft (6.1m) of depth did not significantly vary from those materials found from the surface to 12 ft (3.7m) of depth. Based on the data in Table 4.2-2 it was determined that a structure the size of the proposed waste ponds could be satisfactorily erected using the native soils.

The operating conditions are such that the ponds will receive small amounts of waste during the leaching segments of the R&D test and the majority of the waste during aquifer restoration. It is intended that during all portions of the test a reverse osmosis or other water purification unit be used to minimize the amount of waste produced and placed into the ponds. In addition, it is intended that the naturally high evaporation rate be enhanced as much as possible through the experimental use of spray systems, solar heating or other means which have some potential for providing accelerated evaporation rates. The results of accelerating the evaporation rate were not factored into the pond volume requirements due to the experimental approach being taken.

Stability Analysis. Once the soil tests and preliminary pond design were completed it was determined that the stability of a lined structure of this size located at this site is good. This assumes that in no case shall cut slopes or compacted fill slopes exceed a slope of 3H:1V, that the ponds are largely below the natural surface elevation and the height of any compacted fill shall not exceed 20 ft (6.1m) (Bureau of Reclamation, 1977). Wyoming Fuel

TABLE 4.2-2

POND SITE SOIL CONDITIONS

Soil Type	Silty Loess
Soil Conservation Service Designation*	Busher loamy very fine sands
Unified Soil Classification	SM-ML
Inplace density (average)	75.5 lb/cu ft
Inplace moisture content (average)	8.6% dry basis
Color	Dark yellow brown to tan
Color when wetted	" dark brown to brown
Maximum dry density	104.3 lb/cu ft
Optimum moisture content	15.6% dry basis
Permeability of sample compacted to 103.8 lb/cu ft @ 15.9% moisture	1.0×10^{-6} cm/sec

* USDA, SCS, 1977

Company will, however, be conducting additional soil testing to determine the optimum slopes using native soils. At present, Wyoming Fuel Company intends to adhere to the slope design as presented.

Settlement Analyses. It is anticipated that any settlement which may occur at this site will occur primarily during the construction phase. During this time the density of the unexcavated soil will be increased by thoroughly wetting the soil and beginning the compaction process prior to backfilling. The backfill will then be compacted to within 95% of optimum which will cause some additional settlement of the underlying soil. Once the structure is in place, additional loading resulting from use is limited to the maximum 17 ft (5.2 m) of head produced by filling the structure completely with waste solutions. If the density of the solution is assumed to be 70 lb/cu ft (1.12 g/cc) then the maximum additional load is limited to approximately 8.3 lb/sq in (583.6 g/sq cm). The total load to the subsurface under the ponds is estimated to be approximately 12.3 lb/sq in (864.8 g/sq cm) while the load under the maximum thickness of compacted soil is estimated to be approximately 16.1 lb/sq in (1132.0 g/sq cm).

Some post-construction settlement of the waste ponds may occur if the supporting soils are allowed to become saturated. The potential for saturating the supporting soils by leakage through the pond's membrane liner is minimized by the underdrain system. This system serves the dual purpose of monitoring for leakage and collecting any solution in the system before the compacted soil liner can be penetrated and the supporting soils saturated. Natural saturation of the supporting soils is unlikely since the soil is naturally well drained and it is greater than 40 ft (12.2m) to the water table from the bottom of the pond structure.

Pond Design Specifications. In general, the waste storage ponds will consist of a compacted soil underliner overlain by a sand blanket or fabric underdrain system which in turn is covered by a high density polyethylene or hypalon membrane liner. The compacted soil underliner is to be approximately 3 ft (1m) thick and compacted to 95% of optimum density. This soil compaction level produces a relatively impermeable material with a permeability less than 3.9×10^{-6} in/sec (1×10^{-5} cm/sec). The underdrain system is to be placed on the graded sloping surface of the compacted soil underliner. The washed sand or geotextile fabric underdrain will allow any leakage to drain down-slope to a "French" drain with a perforated collection pipe where the solution can be collected, sampled and removed. The high density polyethylene (HDPE) membrane liner will be at least 80 mils thick with extrusion welded seams. If reinforced hypalon is used, it will be at least 36 mils thick. Construction details for the sand and HDPE system are shown in Figure 4.2-2.

The compacted soil layer will be constructed by first excavating the native soil and stockpiling it below the pond area. Once the soil is excavated to the dimensions indicated in Figures 4.2-1 and 4.2-2 the moisture content of the in-place soil shall be increased to approximately 25% moisture at a depth of approximately 3 ft (1m). This wetting process will initiate settling and consolidation of the subsoil. Once the soil is wetted, the surface will be allowed to drain and dry to approximately 16% moisture, dry basis. At this point the surface of the subsoil will be slightly wetter than optimum and compaction can begin. The subsoil is to be compacted using a sheeps foot type compaction unit making numerous passes over the area until no additional settling occurs. Once the subsoil surface is compacted, then the excavated soil is to be backfilled in lifts not to exceed 6 in (15.3 cm) when compacted. The backfill material is to be maintained wetter than optimum and compacted to 95% of maximum dry density, i.e., 16 to 16.5% moisture on a dry basis and 99.1 lb/cu ft (+1.59 g/cc) compacted dry density. The compacted soil is to be placed such that 6 in (15.3 cm) to 8 in

(20.3 cm) of compacted soil will have to be graded from the surface to attain the final graded surface dimensions. The procedure outlined above will produce a compacted soil underliner with a permeability of approximately $3.9x10^{-6}$ in/sec ($1x10^{-5}$ cm/sec) and a nominal minimum thick ness of 3 ft (1m). The wetting and preconsolidation of the subsoil is intended to prevent any significant settling of the pond structure after construction.

If a sand blanket underdrain is used, it will provide both a bedding surface for the membrane liner and an integral portion of the leak detection system. The washed sand is to contain less than 0.5% fines passing 75 um (ASTM 200 mesh) and provide a permeability of less than $3.9x10^{-6}$ in/sec ($1x10^{-2}$ cm/sec) when tested in a laboratory permeameter. A minimum of 6 in (0.15m) of sand is to be placed on compacted soil which has been graded smooth and to the dimensions indicated in Figure 4.2-2. In the pond bottoms a grade of 1% is to be maintained across the compacted soil surface to the collection system. The collection system will drain into a stand pipe from which any leakage can be collected, removed and analyzed. The collection system will consist either of well screen with a 10 mil slot size or perforated pipe wrapped with PVC filter cloth.

If a geotextile fabric underdrain is used, it will only provide a limited amount of bedding for the liner. Therefore, the surface of the compacted fill will be examined for rocks and rolled prior to the installation of the fabric. The fabric to be used will be a non-woven product designed to allow maximum horizontal conductance of liquid. It will be placed evenly over the entire pond including side slopes and anchored to prevent subsequent movement. The collection system used with the fabric underdrain will consist of a lined trench containing a perforated pipe wrapped with geotextile fabric or well screen surrounded by pea gravel. This entire "French" drain system will be covered with at least two layers of geotextile fabric for liner protection. The collection and inspection pipes will be the same as for the sand underdrain system.

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Either high density polyethylene (HDPE) or hypalon is suitable for the pond lining. High density polyethylene lining material is chemically resistant to the anticipated waste solutions as well as to each of the chemical reagents that are to be used on the site (Chasis, 1976, Manufacturers Bulletin 1). A membrane thickness of 80 mil is being specified due to the remote possibility of settlement of the subsoils in the event of their saturation. The 80 mil thickness provides for 500 to 800% elongation prior to reaching the breaking point with tensile strengths at the breaking point of 235.5 to 3,350 to 3,400 lb/sq in (239.1 kg/sq cm). (Manufacturers Bulletins 2 and 3, 1979). The thickness and physical strength of this material also greatly increase the trafficability of the liner which minimizes the potential for tears and punctures due to equipment movement, foot traffic and hooved animals. The installation methodology of high density polyethylene provides for a thermal extrusion weld joint which can be non-destructively tested through the use of ultrasonic testing (Manufacturers Bulletin 3). Manufacturers of this lining material provide turnkey installation services including liner placement, welding and inspection as recommended in the NRC staff technical position paper WM-8101. Repair of the liner is performed by the manufacturer using the thermal extrusion welding equipment.

Reinforced hypalon has been used almost exclusively at in situ mining test facilities for pond liners during the last several years. As with HDPE, hypalon is chemically resistant to any anticipated waste solutions and chemical reagents to be used on site. As an alternate to HDPE, a 36 mil reinforced hypalon material is specified, as it is the material most used and recommended by the manufacturer. Field seaming of the liner is accomplished using a bonding adhesive on an overlapped seam. The physical properties of the reinforced hypalon are a minimum tensile strength at break of 1,500 lb/sq in (105.4 kg/sq cm) and a minimum of 300% elongation at break. The material is reasonably durable and can be patched by operating personnel using surplus liner material and adhesive. The liner manufacturer's representative would be on site inspecting and assisting the personnel doing the actual installation.

Installation, Testing and Quality Assurance. The monitoring and testing of the pond installation is divided into four groupings. These are 1) wetting of the subsoil, 2) compaction and grading of the backfill, 3) installation of the underdrain and 4) installation of the membrane liner. It is anticipated that wetting of the subsoil shall be done through the use of a sprinkler system or water truck. Once the wetting process has begun, periodic hand borings will be made to obtain samples at the 3 ft (1m) depth in order to determine the moisture content at that depth. Once it is found that the specified moisture content has been reached in a random sample, then a minimum of six regularly spaced borings shall be made in the excavated area to confirm uniformity of the moisture content. This process will be repeated until the entire excavated area under the ponds is at or has had the specified moicture content at 3 ft (1m) of depth.

Compaction of the excavated area begins when the subsoil has been allowed to drain and the top 6 in (15.3 cm) has a moisture content of 16 to 16.5% as shown by random sampling and confirmed by a minimum of six regularly spaced samples across the excavated area. The subsoil surface will be compacted using a sheeps foot compactor and multiple passes until no obvious additional subsidence occurs. The first lift of backfill soil will then be placed and compacted. At this point three in-place compaction measurements will be made at random to a depth of approximately 18 in (0.5m) and the density and moisture contents determined. The sampling locations and depths are to be recorded along with the resulting densities and moisture contents. A minimum of three in-place compaction measurements shall be taken at random every 2nd or 3rd lift. No samples will be taken from the final lift. All sample holes will be refilled and compacted. In-place compaction measurements for density and moisture shall be made according to ASTM standard method D1556-64 (1974) "Test for Density of Soil in place by the Sand-Cone Method" or ASTM method D2167-66 (1977) "Test for Density of Soil in place by the Rubber-Balloon Method" (ASTM, 1981). If at any time it is found that the compacted soil is not of the specified density and moisture content, the soil shall be scarified to the depth of the sampling, the moisture content adjusted and recompacted to the specified density. Once the compacted surfaces are approximately 6 in (15.3 cm) above the final grade elevations, the compacted soil is to be graded to the specified dimensions and elevations and the excess soil removed from the pond liner area. The graded surface is then to be rolled and sterilized prior to placement of the underdrain and membrane materials.

Prior to placement of the underdrain material the leak detection system will be placed in the ponds as shown in Figure 4.2-2 in the case of the sand underdrain. The placement of the collection pipes at the intersection of the bottom slope and side slope takes advantage of the natural leakage collection area and helps to insure that any membrane leakage is detected. The collection pipes will drain to a small sump from which solutions can be sampled and removed when necessary. All piping in the drain collection system will be butt fusion welded HDPE, Schedule 40 PVC or equal, with chemically welded joints. The sand to be used in the sand blanket underdrain is to be inspected and sampled prior to placement in the ponds. The sand sample is to be sieved and the amount of material passing 200 mesh (75 um) must be less than 0.5% of the sand's contents. As the sand is placed, the on-site engineer will monitor the sand for changes in fines content and sieve additional samples if deemed necessary. Once the sand is in place, three samples of the sand shall be taken from the bottom of each pond, their locations recorded and sieve analyses performed. If the six sand samples do not meet the specifications then the sand will be removed and sand of the proper specification shall be placed in the ponds.

In the case of the geotextile fabric underdrain system, a trench approximately 8"x8" (20x20 cm) will be excavated in the compacted fill at the low end of the pond bottom. The trench will be fully lined with a 10 mil PVC membrane and one layer of geotextile fabric, and a 1 inch thick bed of pea gravel will be placed in the bottom of the lined trench. The perforated pipe wrapped with geotextile fabric or the well screen will be placed in the trench and connected to the collection pipe system. The remainder of the trench will then be backfilled with pea gravel even with the pond bottom and at least two layers of the fabric will be placed over the gravel.

The rest of the compacted soil will then be covered with the geotextile fabric. The fabric will be anchored in such a way to prevent its subsequent movement while preventing puncture should some settling take place.

Once the underdrain system is installed it will be tested for effectiveness. In general, this test will be performed in each pond by simulating a small liner failure at a distance greater than 50 ft from the drain collection pipe. A constant volume of water shall be allowed to seep into the underdrain at a single point and the time required for the water to reach the collection system will be determined. The underdrain test will be performed and evaluated by a competent hydrologist or engineer.

Installation of the membrane liner will be directly supervised by a representative of the liner manufacturer. In the case of the high density polyethylene liner, the supplier will also provide the extrusion welder and ultrasonic testing unit for the seams as well as the technical personnel required to operate the welder and the testing unit.

Upon completion of the pond installation a report will be submitted to the NRC staff. This report will include tabulations of any tests performed during construction, a description of the construction process indicating any problems which were encountered and as built drawings of the structure indicating final dimensions and elevations.

Fencing. Access to the pond area will be controlled by fencing. General access will be controlled by fencing as described in Section 2.1 pertaining to the overall site. The immediate pond area will be protected by a game proof fence located as shown in Figure 4.2-2.

Pond Inspection Program. The waste ponds will be inspected quarterly for signs of settlement and erosion. Daily inspections will be performed to determine if any damage has occurred to the liner, liner slopes or earthwork, and to check for signs of leakage into the underdrain. Quarterly reports will be prepared in order to tabulate the daily inspection results and the quarterly inspection. These reports shall be kept at the project site for reference and inspection by regulatory authorities.

Contingency Plans. Contingency plans have been considered for the 6 hour probable maximum rainfall, embankment failure and membrane liner leakage. The volume required for the 6 hour probable maximum rainfall has been allowed for in the sizing of the ponds. The potential effect of the probable maximum flood on the pond capacities has been eliminated by the location of the ponds. With the effects of the 6 hour PMP and the PMF considered, no additional contingency plans were proposed for these two events.

Embankment failure of one or both ponds could result in the release of a limited amount of contaminated solution into Squaw Creek. The amount is limited since only some 3.0 million gallons (11.36 million liters) of solution will be in the ponds at any one time. In addition, upon failure of an embankment a considerable, but unknown, amount of the solution would be absorbed by the soil prior to reaching Squaw Creek. In the event of such a failure, the area contacted by the solutions would be immediately surveyed with a gamma meter and soil samples collected. The soils would be analyzed for U, Ra-226, Pb-210 and Th-230. The event would be immediately reported to the NRC. Based upon the soil samples, their analysis and the gamma survey, the appropriate clean-up steps, as recommended by the NRC staff, would be taken. Operations at the site would be halted until provisions for the disposal of waste solutions could be made.

Membrane liner leakage would be determined by the detection of waste solutions in the underdrain system. In the event of leakage in one pond, the contents of that pond would be pumped into the adjacent pond and the leak located and repaired under the supervision of the lining manufacturers representative using the recommended repair methodology. It is also intended that, in the event of a liner leak, the entire liner will be inspected and the seams retested by the manufacturers representative as deemed necessary. The discovery of membrane liner leakage would immediately be reported to the appropriate NRC staff member. Upon correction of the problem, a report on the corrective measures and possible additional preventive measures would be submitted to the NRC.

Domestic Liquid Waste

Domestic liquid wastes from restrooms and the lunchroom shall be disposed of in a septic system. The size, design and installation of the septic system shall be as specified by the State of Nebraska Department of Health. The approximate location of the septic system is shown in Figure 2.1-1 (see Section 2.1, Site Location and Layout).

Solid Wastes

Solid wastes generated at the site will consist of spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. These wastes will be classified as contaminated or non-contaminated waste according to their contact with radioactive materials.

Contaminated Solid Waste. Contaminated solid waste will be separated into two categories. The first category will be waste which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include piping, valves, instrumentation, equipment and any other item which may be decontaminated. Decontaminated materials shall have radiation levels lower than those specified in NRC Branch Technical Position "Guidelines for

Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source, or Special Nuclear Material" (NRC, 1976). Inspection of decontaminated wastes shall be the responsibility of the radiation safety officer or radiation safety technician.

The second category of contaminated waste shall include all items not yet decontaminated or which cannot be decontaminated. These materials shall be stored on a bermed concrete pad until such time as they can be decontaminated or they are shipped to a by-product waste disposal site.

Non-Contaminated Solid Waste. Non-contaminated solid waste shall be collected at the site on a regular basis and disposed of in the nearest sanitary landfill.

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SECTION 4.3

CONTAMINATED EQUIPMENT

4.3 CONTAMINATED EQUIPMENT

Due to the relatively small size of the Crow Butte R&D Project, the amount of contaminated solid waste generated during operation is not expected to present problems. The R&D plant will only be operated for a short duration and the original equipment should last the life of the project, therefore problems with obsolete and worn-out contaminated equipment should not occur. At the end of the project the decision to decommission the facility will be made and the procedures for removal of contaminated equipment, if the plant is decommissioned is included in Section 6.

During normal operations some contaminated non-reusable items will be generated. Examples of these items may be filter media, scrap pipe, and resin fines. These materials will be decontaminated if possible and disposed by conventional methods. If decontamination is possible, records of the residual surface contamination will be made by the health physics technician, prior to releasing the material for final disposal. If the material can not be adequately decontaminated then it will be stored on a curbed pad until a sufficient waste volume has been generated to warrant transportation to an NRC licensed disposal area. The most likely disposal facility would be a conventional uranium mill tailings impoundment in Wyoming. The wastes will be transported in a manner acceptable to the U.S. Department of Transportations.

SECTIONS 5.1 to 5.6

OPERATIONS

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5.0 OPERATIONS

INTRODUCTION

The following sections address Wyoming Fuel Company's operational plan for the Crow Butte Research and Development facility. This operational plan defines the basic management policies and programs to achieve the objective of maintaining radiation exposures to employees "As Low As Reasonably Achievable" (ALARA). Wyoming Fuel Company understands statements, representations, and procedures provided in this chapter will normally be made a specific condition of the NRC source material license.

5.1 Corporate Organization and Administrative Procedures

Wyoming Fuel Company's organization for the Crow Butte Research and Development facility is presented on Figure 5.1-1. Levels of management are corporate and production (on site). The corporate level is responsible for monitoring production safety for the purpose of detecting any activity which may result in radiation health/safety hazards or actions which may result in significant impacts on the environment. The production level is responsible for implementation of all radiation safety and health programs. Responsibilities with regard to development, review, approval, implementation, adherence to operating procedures, radiation safety programs, environmental groundwater monitoring programs, quality assurance, routine and non-routine maintenance activities, and changes in any of the above are defined through the first supervisory level below.

5.1.1 President

The President of Wyoming Fuel Company has overall responsibility for the radiation, environmental, and safety activities of the Crow Butte Research and Development facility.

The President has direct lines of communication to the Site Manager, Manager of Uranium, Environmental Coordinator and Corporate Radiation Safety Officer.

5.1.2 Manager of Uranium

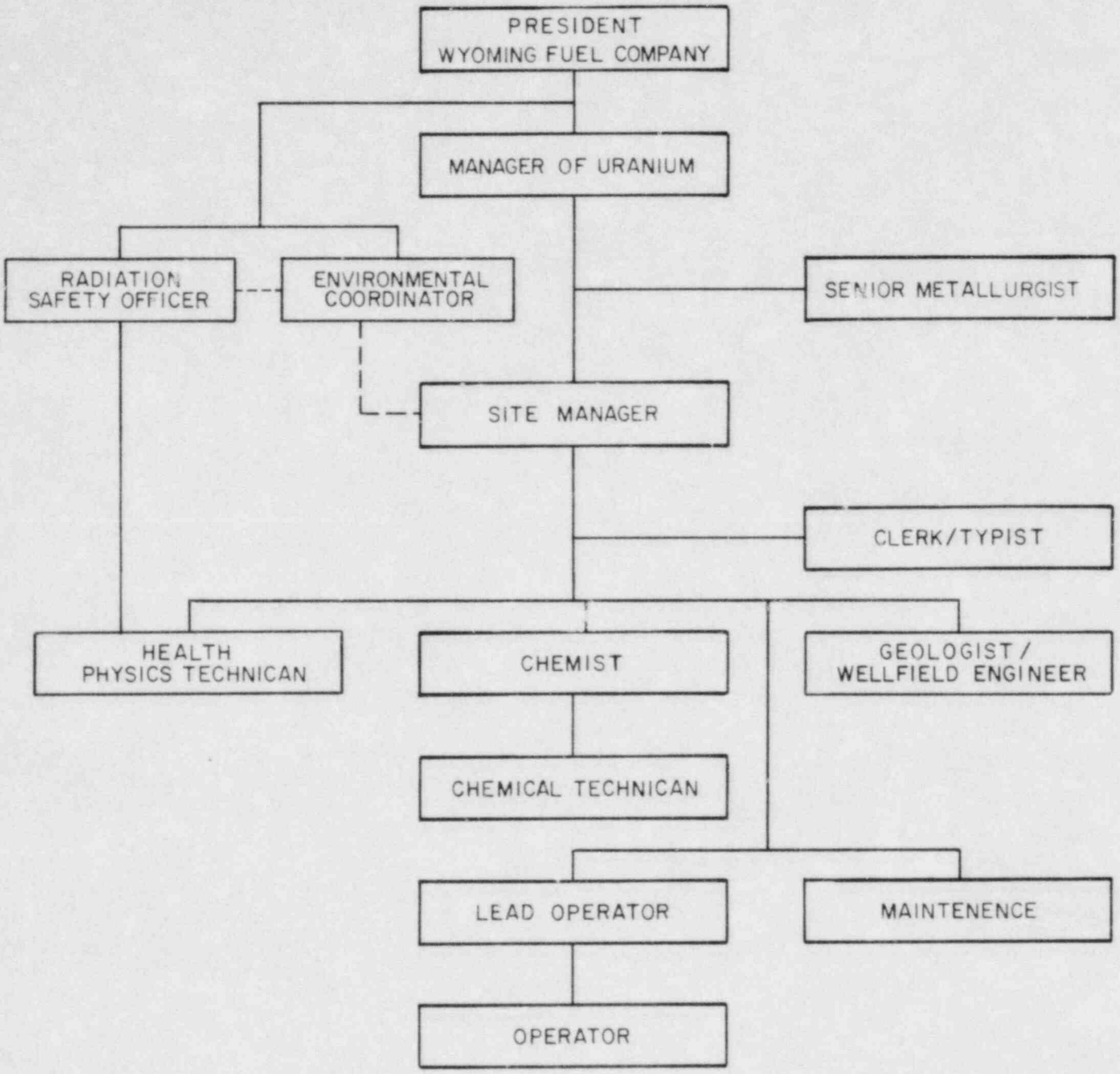
The Manager of Uranium is responsible for all Crow Butte Research and Development production facilities, reporting directly to the President. He is directly responsible for the radiation safety programs and nonradiological programs at the production facility. The Manager of Uranium works closely with the Environmental Coordinator and Corporate Radiation Safety Officer in seeing these programs are conducted in a manner consistent with the regulatory requirements.

5.1.3 Site Manager

The Site Manager is responsible for all uranium production activity at the site. He is responsible for implementing any safety and/or monitoring programs associated with operations, including yellowcake handling procedures. The Site Manager is authorized to immediately implement any action to correct or prevent radiation safety hazards. He cannot, however, modify or eliminate any radiation safety program without prior consultation with the Corporate Radiation Safety Officer. The Site Manager will insure through direct communication with the Health Physics Technician, all radiation monitoring and control is carried out according to regulations and/or stipulations addressed in the source material license.

5.1.4 Corporate Radiation Safety Office (CRSO)

The CRSO is responsible for the development, administration and enforcement of all radiation safety programs. The CRSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The CRSO reports



REV	BY	DATE

WYOMING FUEL COMPANY

CROW BUTTE PROJECT
Dawes County, Nebraska

RESEARCH AND DEVELOPMENT
Organizational Chart

PREPARED BY: DMStout — 82-3401-041 A

DWN BY: SADavis — DATE: 12/20/82 — FIGURE 5.1-1 directly to the President. The qualifications of the CRSO are presented in Section 5.A.

5.1.5 Environmental Coordinator

The Environmental Coordinator is responsible for the development, administration and enforcement of nonradiological environmental programs. The Environmental Coordinator is responsible for nonradiological licensing development including modifications to existing licenses. The Environmental Coordinator works closely with other supervisory personnel to insure compliance with license provisions are maintained.

5.1.6 Health Physics Technician (HPT)

The HPT will be responsible for the implementation of all on site environmental and safety programs, including emergency procedures. The HPT will personally inspect facilities to verify compliance with all applicable requirements in the areas of radiological health and safety as well as industrial health and safety. The HPT will work closely with all supervisory personnel to ensure established programs are maintained. The HPT will be responsible for collection and interpretation of employee exposure related monitoring data, including data from industrial safety and radiological safety. The HPT will recommend as necessary, to improve any and all safety related controls. The HPT will report directly to the Site Manager and also be responsible to the Corporate Radiation Safety Officer for technical guidance.

5.2 Management Control Program

Wyoming Fuel Company will establish standard operating procedures (SOP's) for all operational activities involving radioactive materials that are handled, processed or stored. Standard operating procedures for operational activities will include pertinent radiation safety practices. Additionally written procedures will be established for nonoperational activities including health physics and environmental monitoring, sampling analysis and instrument calibration. An up-to-date copy of each written procedure will be kept in each area of the R&D facility where it is used.

Operational and nonoperational procedures will be reviewed and approved by the Corporate Radiation Safety Officer. The CRSO will review written procedures annually and implement necessary changes in procedures to insure no violation of newly established radiation practices have or will occur.

For work on non-routine maintenance jobs, where the potential for exposure to radioactive material exists and for which no standard written operating procedure already exists, a radiation work permit (RWP) will be used (see Figure 5.2-1 for example RWP). At a minimum, RWP will describe the following:

1. The details of the job to be performed,

2. Any precautions necessary to reduce exposure to uranium and its daughters, and

3. The radiological monitoring and sampling necessary during and following completion of the job.

The HPT shall indicate by signature, the review of each RWP prior to initiation of work, and the work will be carried out in strict adherence to the conditions of the RWP. When the HPT is not available, e.g., during off-shifts, the HPT will designate a member of the supervisory production protection training to review and sign RWP's in the HPT's absence

5.3 Management Audit and Inspection Program

5.3.1 General

Wyoming Fuel Company will develop a Management Audit and Inspection of worker health protection practices at the

RWP No:	Date of Issue:		Date of Expiration:
Requested by:	Date of Request:	Est. No Days to Complete:	Work Location:

Description of work to be performed:

Names of personnel performing work:

Time of Entry:	Time of Departure:	Total Time:

RADIOLOGICAL DATA

Radiation levels ______________________ mr/hr

Radon daughters ______________________ WL

Surveyed by, ______________ Date ___/___/___

PROTECTIVE EQUIPMENT REQUIRED

- ☐ TLD Badge
- ☐ Hood
- ☐ Gloves
- ☐ Shoe Covers
- ☐ Plastic Suit
- ☐ Respiratory Protection
- ☐ Face Sheild
- ☐ Goggles

SPECIAL INSTRUCTIONS:

Approved by ( ) Signature, ______________ Date ___/___/___

Terminated for: ☐ Completion of Job ☐ Expiration of RWP ☐ Cancellation of RWP ☐ Change in Radiological Conditions

Signature, ______________ Date ___/___/___

REV	BY	DATE	WYOMING FUEL COMPANY
			CROW BUTTE PROJECT Dawes County, Nebraska
			RADIATION WORK PERMIT FORM
			PREPARED BY: DMS'out — 82-3401-041 8
			DWN BY: SADavis — DATE: 12/20/82 — FIG. 5.2-1

R&D facility. This program will provide management with the information necessary to conduct an appropriate ALARA program.

5.3.2 Daily and Weekly Inspections

The HPT and lead operator will conduct a daily walk through (visual) inspection of all areas of the plant and working areas to insure proper implementation of good safety practices, including good housekeeping and clean-up practices that will minimize unnecessary contamination and insure adherence to the SOP's. Problems observed will be noted in writing in a daily inspections log book. The entries will be dated, signed and maintained on file for at least one year. The HPT will review each day's findings of violations of radiation safety procedures or other potentially hazardous problems with the Site Manager and other site employees who have authority to correct the problem. The HPT will also review the daily work order and shift logs on a regular basis to determine that all jobs in operation having a potential for exposing personnel to uranium, especially those jobs which will require a radiation survey and monitoring were approved in writing by the HPT or his designee prior to initiation of work.

A weekly inspection will be made by the HPT of all work and storage areas and a report submitted to the CRSO on any items of noncompliance with SOP's, license requirements or safety practices affecting radiological safety.

5.3.3 Monthly Inspections

On a monthly basis, the HPT will conduct an inspection of all work and storage areas and will review all monitoring and exposure data for the month. The HPT will provide to the Site Manager and all department heads for their review, a written summary of the month's significant work protection activities containing at a minimum, (1) a summary of personnel exposure data, including bioassays and time weighted calculations, and (2) a summary of all perti.ent radiation survey records. In addition, the monthly inspection will specifically address any trends or deviations from the ALARA program, including an evaluation of the adequacy of the implementation of licensed conditions regarding the ALARA The summary will provide a description of the unresolved problems and will propose corrective measures. The monthly summary inspection report will be maintained on file and accessible for at least five years. A copy of the Monthly Summary Inspection Report, initialled by the Site Manager, will be forwarded to the Manager of Uranium.

5.3.4 ALARA Program Audit

The CRSO will perform a formal semi-annual audit of the ALARA program and submit a detailed written report on the audit to the Site Manager. The primary purpose of this audit will be to evaluate the overall effectiveness of the R&D ALARA program. The audit report will summarize the results of the following data:

1. Employee exposure records (external and time weighted calculations),
2. Bioassay results
3. Inspection log entries and summary reports of daily, weekly and monthly inspections
4. Documented training program activites
5. Safety meeting reports
6. Radiological survey and sampling data
7. Radioactive effluent and environmental monitoring data
8. Reports on overexposure of workers submitted to NRC, MSHA or the designated state regulatory authority
9. Operating procedures that were reviewed during this time period.

The report on the semi-annual ALARA audit will specifically discuss the following:

1. Trends in personnel exposure for identifiable categories of workers and types of operational activities

2. Trends in effluent releases

3. Whether equipment for exposure control and effluent control is being properly used, maintained and inspected

4. Recommendations on ways to further reduce personnel exposures to effluent releases of uranium and its daughters.

A copy of this report, initialled by the Site Manager, will be forwarded to the Manager of Uranium and the President of Wyoming Fuel Company.

5.4 Qualifications

For discussion of qualifications of the Radiation Safety Officer and Health Physics Technician, please refer to Section 5.7.9, Quality Assurance.

5.5 Training

5.5.1 General

The on site HPT will be responsible for administering the radiation protection training program at the R&D facility. Responsibility will include the implementation of the program, training materials, reviews and documentation. The CRSO will provide health physics assistance in program development and administration and conduct a semi-annual evaluation. The objectives of the radiation protection training program are to:

1. Develop a basic understanding of the biological effects of exposures to radiation so that the potential risk of radiation doses will be understood and can be evaluated.

2. Develop an understanding of the radiation hazards associated with each portion of the plant.

3. Develop the expertise necessary to insure individual effort in maintaining exposures as low as reasonably achievable.

Note: Female workers and those supervisors who work with them will be given specific instruction about prenatal exposure risks to the developing embryo and fetus.

5.5.2 Employee Radiation Protection Training

Basic indoctrination in radiation protection will be given to all plant employees before starting work. The basic indoctrination training will include:

1. Fundamentals of health protection

   a. What are the radiological and toxic hazards of exposure to uranium and its daughters.

   b. How uranium and its daughters enter the body (inhilation and injestion)

   c. Why exposures to uranium and its daughters should be kept as low as reasonably achievable (ALARA)

2. Personal hygiene at uranium mills

   a. Wearing protective clothing

   b. Using respirators when appropriate

   c. Eating, drinking and smoking only in designated areas

   d. Using proper methods for decontamination

3. Facility provided protection

   a. Cleanliness of working space

   b. Safety designed features for process equipment

   c. Ventilation systems and effluent controls

   d. Standard operating procedures

   e. Security and access control to designated areas

4. Health protection measurements

   a. Measurement of airborne radioactive material

   b. Bioassays to detect uranium (urinalysis and invivo counting)

   c. Surveys to detect contamination of personnel and equipment

   d. Personnel dosimetry

5. Radiation protection regulations

   a. Regulatory authority of NRC, MSHA and state

   b. Employee rights in 10 CFR Part 19

6. Emergency procedures

A written test with questions directly relevant to the principles of radiation safety and health protection in the R&D facility covered in the training course shall be given to each worker. The instructor will review the test results with each worker and will discuss incorrect answers to the questions with the worker until worker understanding is achieved. Workers who fail the exam shall be retested and test results will remain on file. Each permanent worker at the R&D facility will be provided with an abbreviated retraining course annually. The successful completion of the retraining course will also be maintained on file. Retraining shall include relevant information that has become available during the previous year, a review of safety problems that have arisen during the year, and changes in regulations and license conditions, exposure trends and other current topics.

In addition, all new workers, including supervisors, will be given specialized instruction on the health and safety aspects of the specific jobs they will perform. This instruction will be done in the form of individualized on the job training. Supervisors will be provided with additional specialized training on their supervisory responsibilities in the area of worker radiation protection. Retraining will be done annually and documented. All employees will sign a statement that they received job specific training. Their statement will indicate the dates the training was received and it will be cosigned by the instructor. Every two months all workers will attend a general safety meeting with at least 30 minutes of meeting devoted to radiation safety matters.

Visitors who have not received training will be escorted by on site personnel properly trained and knowledgable about the hazards of the facility. As a minimum, visitors will be instructed specifically on what they should do to avoid possible hazards in the area of the facility they will be visiting.

Any contractors having work assignments at the facility will be given appropriate training and safety instruction. Contract workers who will be preforming work on heavily contaminated equipment will receive the same training instruction normally required of all permanent workers. In the event contract workers have received full training on prior work assignments at the facility only job specific safety instruction will be necessary.

5.6 Security

Access to the R&D facility will originate along the northern boundary of the NW4 of Section 19, Township 31 North, Range 51 West off the east-west county road (see insert on Figure 2.1-2). A cattle guard will be placed at this location. The road will continue in a southerly direction and enter the RA in the N2SE4 of Section 19, Township 31 North, Range 51 West. Access to the RA will be limited to authorized personnel only. Appropriate signs will be posted identifying the RA.

All visitors (any person not permanently assigned to the project site) will be required to register at the office and will not be permitted inside the plant areas without proper authorization from designated supervisory personnel. No visitors vehicles will be allowed beyond the office parking lot, unless authorized by designated supervisory personnel.

The plant will operate 24 hours per day and 7 days per week, so Wyoming Fuel Company employees will always be on site. All plant personnel will be instructed to immediately report any unauthorized person or persons to their supervisors. The supervisor will contact the reported unauthorized person or persons and make sure that the person has been authorized for entry. If the person is unauthorized, and has no business on the property, he or she will be escorted to the main entrance for departure.

SECTION 5.7

RADIATION SAFETY CONTROLS & MONITORING

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5.7.1 Effluent Control Techniques

The only radioactive airborne effluent at the Crow Butte R&D Project will be radon-222 gas. The particulate emissions usually associated with a conventional uranium mill will not be present at this facility. The solid product will be stored and shipped as a slurry and therefore particulate emissions from a product drier will not have to be considered.

Radon-222 will not escape in the wellfield since both the injection and production wellheads will be sealed. This gas will be carried in solution to the recovery facility. As the solution encounters the first process vessel, the production surge tank, the gas will emanate from the liquid, due to substantial turbulence in the tank and a decrease in the partial pressure of radon gas. A large percentage of the gas originally present in solution will be released in this tank.

From the production surge tank the solution passes through filters and the ion exchange columns. These vessels are closed and pressurized and therefore the possibility of releasing radon-222 from them is thought to be minimal. From the ion exchange columns the solution passes to the injection surge tank before being pumped back to the wellfield. The injection surge tank is also considered a likely source of radon-222. The process bleed stream will be diverted from the normal process flow at some point between the last ion exchange column and the injection surge tank. The bleed stream will normally be directed to the R.O. feed tank to be processed through the R.O. unit. The reject stream of the R.O. unit is stored in the waste tank. When this tank is filled, its contents will be transferred to the ponds for evaporation. Plant wash down water and any spills are collected in the sumps and pumped to either the R.O. feed tank or the waste tank. Both of these tanks are potential release points for radon-222.

The four tanks identified above as being sources of radon gas will be vented through the roof to release the radon gas outside of the plant building. The vents will be 20 cm (8 in) in diameter and extend approximately 7 m (23 ft) above the floor of the plant. A rotary ventilator will be placed on top of each vent to continually remove air from the tank. This should prevent the increase of radon in the tanks atmosphere.

The slow, controlled release of radon should prevent the inadvertent release of the gas in the plant area. The vents described above should control the majority of the gas in the process vessels but there will be other minor sources throughout the plant. The most significant contribution of these minor sources is from process solution that is exposed to the plant air. This exposure occurs during resin elution, precipitation, filter maintenance or small leaks in the plant. To control radon from these sources four exhaust fans will be installed in the exterior walls of the plant building and ventilators will be placed in the roof. The fans will be sized to permit four air exchanges per hour.

The required air exchanges were estimated based on the following assumptions;

1. The quantity of solution exposed to plant air was 0.5 percent of plant throughout.
2. The radon concentration in the leach solution is 6.43×10^{-7} Ci/l and it is all released from solution.

3. Fifty percent of equilibrium exists between radon-222 and its daughters (60 pCi/l Rn-222 = 0.33 working levels).

4. The plant air will be maintained at 10% of MPC.

5. The plant building has a volume of 3,140 m^3

The above considerations do not allow for contributions from doors and windows.

The exhaust fans will be maintained according to manufacturers specifications and inspected periodically to insure proper operation. The air in the plant will be sampled for the concentrations of radon and radon daughters. The sampling programs are detailed in Section 5.7.3. If the working levels in the plant exceeds 25% MPC then the action level will have been exceeded. This will require efforts to reduce the concentrations to acceptable levels by opening the doors and windows in the plant to allow better ventilation. The radiation safety technician will begin an investigation to determine the source of the increased levels and work with plant personnel to prevent future occurrences.

There will be two sources of nonradioactive gaseous effluents, the hydrochloric acid storage tank and the precipitation tank. The emissions from the hydrochloric acid tank will be controlled by a standard scrubber. Periodic maintenance and inspection of the hydrochloric acid scrubber will be performed to insure proper operation. The carbon dioxide liberated during the precipitation process will not present a problem due to the ventilation system designed for control of radon-222.

The only nonradioactive particulate emissions at the facility other than dust will emissions from a back-up diesel generator. When in operation the generator will produce particulate and gaseous (CO, NO_x and hydrocarbons) emissions. Such emissions will be vented outside the building through an exhaust manifold. The generator will be fitted with the required emission controls and their proper operation will be maintained. It should be noted that the generator is a back-up unit to be used only in the event of an electrical failure. As such, its operation and emissions will occur very infrequently.

The radioactive liquid effluents associated with the Crow Butte R&D Project can be classified as follows 1) plant waste water, 2) laboratory waste water 3) solution bleed and 4) restoration waste solution. There will be no routine release to the environment of any radioactive liquids from the plant. These effluent solutions will be collected and their volumes reduced by evaporation and reverse osmosis.

The contaminated liquids generated in the laboratory will be poured into a special sink which drains to the plant sump. The water used in the plant for equipment wash down and the employee showers all collect in the sump. From the sump the liquid can be pumped to the waste tank or R.O. feed tank. The process solution bleed is diverted to the R.O. feed tank. After processing these solutions through the R.O., the permeate will be used as plant water and the reject stream will go to the waste tank. Intermittently the waste tank's contents will be pumped to the evaporation ponds.

The evaporation ponds will be used to contain the small amount of liquid effluents produced during the production phase of the project. During the restoration phase substantial increases in liquid wastes are anticipated. Volume reduction will be accomplished through the use of the R.O. and reinjection of the permeate. Complete restoration is estimated to generate two pore volumes of liquid wastes. The evaporation ponds have been sized to contain the volume required for restoration. Volume reduction in the ponds will be accomplished by evaporation. The remaining solids or slurry in the pond bottoms will be transported to a USNRC licensed disposal facility in U.S. Department of Transportation approved vehicles and containers.

The effects of spills in both the wellfield and the plant have been discussed in Section 7.5. The methods of preventing and controlling the spills was discussed. Briefly, spills in the plant will be contained on the curbed concrete pad. The spill material will be washed to the collection sumps. From the sumps, the solution may be placed back in the process flow or pumped to the waste tank. Spills in the wellfield will be readily absorbed by the soil. If the results of the soil sampling indicate radioactive contamination above approved limits the soil will be removed and treated as contaminated solid waste.

5.7.2 External Radiation Exposure Monitoring Program

This section is required in the U.S. Nuclear Regulatory Guide 3.46 (1982). The objective of this section is to detail how Wyoming Fuel Company proposes to monitor employee exposure to external radiation. The methods proposed conform to §20.101 of 10 CFR Part 20 and an action level of 25% of the maximum permissible exposure will be enforced. Employee exposure will be monitored using area dosimeters and compared with exposure estimates calculated from area gamma surveys and occupancy times.

Employees' exposure to external radiation will be monitored in two ways, gamma radiation surveys and area dosimeters. Gamma surveys will be performed on a routine schedule throughout the plant. The results of these surveys together with the predicted employee occupancy time will provide an estimate of the whole-body exposure. Area dosimeter results will be evaluated to insure that no person is likely to receive a dose in any calendar quarter in excess of 25 percent of the maximum permissable exposure (0.31 rem).

Gamma surveys will be conducted on a monthly basis at specific locations in the plant. During the initial start-up of the plant more frequent surveys will be performed to determine areas of elevated gamma radiation. Some of these areas can be predicted on the basis of previous experience. Areas expected to be elevated are near filters, ion exchange columns, precipitation circuit and the product storage area. These areas are easily identified since the source of the radiation, uranium and its daughters, will be present at each of the locations.

The offices, laboratory, shop, and wellfield will be surveyed in addition to the locations chosen for monitoring in the plant areas. These measurements will be made with a properly calibrated survey meter, held approximately at waist level and twelve inches from any surface. The results of the surveys will be recorded along with the date, name of the inspector, survey instrument serial number, and calibration date.

The results of the surveys will then be used in conjunction with the predicted employee occupancy times to arrive at an estimate of employee exposure to external radiation. The occupancy times will be expressed as the number of hours of occupancy for a particular location during a five day work week. Initially these occupancy times will be conservatively estimated but as the pilot plant's operations become more routine a more realistic estimate of occupancy times will be determined.

As a second means of monitoring employee exposure to external radiation, area dosimeters will be positioned to monitor all areas of the plant. The dosimeters to be used at the Crow Butte R&D Project will be thermoluminescence dosimeters (TLD). This form of detection has many advantages over using a film emulsion, the primary advantage being its superior response at the low dose rates encountered in in-situ uranium plants. The TLD dosimeters will be provided by Eberline Instruments Corporation of Santa Fe, New Mexico and will be exchanged on a quarterly basis. The specifications for these dosimeters are given in Table 5.7-1.

TABLE 5.7-1

SPECIFICATIONS FOR THE EBERLINE INSTRUMENTS CORPORATION DOSIMETERS

Detector	LiF TLD chips
Detector Shields	One 10 mg/cm^2 One 285 mg/cm^2
Sensitivity	1 mR
Range	1 mR - 1000R
Exchange Frequency	Quarterly

The results reported from Eberline Instrument Corporation are in millirem of penetrating radiation and millirem of nonpenetrating radiation. Each report will include the cumulative exposure for the quarter. An investigation into the cause of any high reading can then be initiated and any abnormal situation corrected.

The exposures recorded by area dosimeters are assumed to be the actual dose received by an individual in that area constantly. After factoring for the occupancy time an action level of 25% of the maximum permissible exposure (MPE) will be enforced at the Crow Butte R&D Project. Exposures above the action level will be investigated by the radiation safety office and the cause of the exposure identified. Any exposures that are above those estimated from area gamma surveys and the occupancy times will be investigated. Any exposures above allowable limits will be reported to the Nuclear Regulatory Commission.

Based on the experience acquired at a number of other in-situ pilot and production facilities using similar processes and equipment area dosimetry is being proposed in lieu of personnel dosimetry.

The results of the area radiation surveys and exposure calculations will be kept on file at the plant along with the area dosimeter reports. These files will be reviewed by representatives of the radiation safety office and the management during periodic audits of the entire radiation safety program.

If in any area the radiation level is sufficiently elevated so that the possibility exists that an employee may receive a dose in excess of five millirem in any hour to a major portion of his body or a dose in excess of 100 millirem during any five consecutive days, then the area will be designated a "Radiation Area" as defined in Title 10 Part 20.202 (b)(2) of the Code of Federal Regulations. In the unlikely event that this situation occurs it would be considered an action level. Once this level of exposure is determined the cause for the radiation will be investigated and corrective measures will be taken to reduce the level, if practicable. Should reduction of the radiation levels not be possible, employee work time in the area will be controlled, to insure that exposures will not exceed the action level. It should be noted that this situation is not expected to arise at a facility of this type since the concentration of gamma emitting isotopes will remain relatively low.

5.7.3 Airborne Radiation Monitoring Program

This section details the methods Wyoming Fuel Company proposes to employ to monitor the airborne radionuclides at the Crow Butte R&D Project. Uranium, radon, and radon daughters are the three primary radionuclides that will be monitored during the R&D plant operation. The type of instrumentation as well as the analytical procedures are presented. Also discussed are the proposed action levels and corrective action requirements.

The airborne radiation monitoring program at the Crow Butte R&D Project is designed to monitor employee exposure to airborne uranium dust and radon daughters. This will be accomplished by taking periodic air samples in specified work areas and analyzing the samples for the concentration of various radionuclides. From the employee's occupancy records and the measured airborne concentrations, the employee's exposure may be determined.

During the plant start up, locations suspected of having elevated levels of airborne radionuclides will be sampled regularly to insure that the levels do not exceed license conditions. When the plant operations become more routine the frequency of sampling and number of locations may be decreased as the sources of airborne radionuclides are identified, and control of these sources is demonstrated.

The plant design is typical of other in-situ facilities. Through experience gained at the existing facilities the sources of uranium particulates and radon gas can be predicted with a relatively high degree of certainty. The uranium particulates will be monitored closely at the precipitation circuit and storage facilities. Radon gas will be most prevalent in plant surge tanks and ion exchange columns. The surge tanks provide the first opportunity for the radon to off-gas. Adequate control and monitoring will be provided at these locations to ensure that the levels of radon or its daughters will not increase above the acceptable limits in the plant area.

Other areas such as the offices, laboratory, lunch room and maintenance shop will also be monitored, in addition to those in the plant. This will ensure that all employees are adequately protected.

During routine operations specified locations will be sampled for the concentrations of airborne radionuclides on a regular basis. Depending on the location and the potential for release, the sampling interval will vary from weekly to quarterly. These values will be kept on record and used in conjunction with the employee occupancy records to determine the individual employee's exposure.

If any analysis indicates airborne concentrations above 25% of the Maximum Permissible Concentration (MPC) for a particular radionuclide, a confirming sample will be taken to determine if the occurrence was transient, steady state, or representative of an increasing trend. The 25% MPC level will represent the action level and occurrences above this limit will require an investigation by the health physics technician. The cause of the increase will be investigated and corrective action taken to prevent future occurrences. Documentation of the employees in the areas at the time of occurrence will be required.

The results of all air monitoring samples will be kept on file at the facility. The employee exposure records and all required instrument calibration records will also be maintained at the site. Examples of these forms are in Appendix 5.7(A). Periodic audits will be performed by the radiation safety office to insure proper operation of the program and adequate protection of the employees. Annual audits will be performed by representatives of the radiation safety office in conjunction with management personnel.

Uranium particulates will be monitored by drawing a specified volume of air through a filter with a properly calibrated vacuum pump. The alpha activity collected on the filter paper will then be measured using a scintillation detector and scaler. The sampling and counting procedures will ensure a minimum detection limit of 0.05 MPC. Appendix 5.7(A) includes detailed instrument specifications. Also included are the sampling and analytical procedures.

Radon daughters will be determined using the modified Kusnetz method. At least 10 liters of air will be drawn through a high efficiency membrane filter with a calibrated vacuum pump. The alpha activity on the filter will be determined after a delay of 40 to 90 minutes. The resulting concentration will be expressed in working levels (WL). One working level is represented by any combination of radon daughters whose total alpha activity is equal to 1.3×10^5 MeV. The sample size and scintillation detector efficiency will ensure a minimum detection limit of 0.03 working levels. The procedure and equipment calibration techniques for radon daughter measurements are included in Appendix 5.7(A). The specific instrument characteristics are also given in the appendix.

Radon gas will be measured on a less frequent basis than the radon daughter measurements. The hazard associated with radon gas is the ingrowth of the radon daughters which when attached to particles in the air can be inhaled and retained in the lungs. Therefore, radon gas monitoring will be used primarily to determine the sources of the gas and possible methods of reducing its evolution. The radon daughter concentration can be reduced by control the radon gas emission.

Radon gas will be monitored using a Lucas cell. The Lucas cell is filled with a filtered air sample and the radon daughters are allowed to in-grow until equilibrium is reached, normally three hours. The alpha activity in the cell is then determined using a scintillation detector and scaler. The results are expressed as microcuries of radon per milliter of air. The minimum detection limit for this method of analysis will be at least 2×10^{-10} μCi Rn/ml. The procedures and calibration techniques are included in Appendix 5.7(A). Also included are the instrument specifications for the detector and scaler.

The procedures and techniques described above are to be employed during routine plant operations. Procedures during nonroutine operations, such as maintenance and clean-up activities will be adjusted to accommodate the particular circumstances.

An example of nonroutine operations is the entry into a process vessel, such as an ion exchange column. This operation will require notification of the health physics technician. Prior to actually entering the vessel, the air in the vessel will be sampled for airborne radionuclides and the gamma radiation level will be measured. A radiation work permit will then be issued. The permit will state the necessary safety apparel such as coveralls, rubber boots, gloves, respirator, etc., and any time limitations, if required. The permit will have space for the employee to sign his/her name and the length of time spent in the vessel. This information will be used to calculate the employees exposure. If conditions in the vessel are judged to be unacceptable for entry, procedures designed to lower the airborne radionuclides will be employed. The vessel will then be retested. Entry will not be allowed until acceptable levels are obtained.

All nonroutine operations will require review of the procedure by the health physics technician. If monitoring is deemed necessary it will be performed before work commences.

In the plant, breathing zone air samples will be collected periodically. These air samples are collected using a low volume, battery powered vacuum pump with a filtered inlet. The filter is attached to the individual's lapel and the pump is clipped to his belt. The sample is collected for an entire work shift which results in a composite sample of the air actually inhaled by the employee while performing his normal duties. The filter is then analyzed for uranium by alpha counting. The result of this type of sample more accurately reflects the exposure of the individual than does the area air particulate sample. The breathing zone sample is used as a means of judging the adequacy of the area air monitoring-occupancy time method of estimating exposures.

5.7.4 Exposure Calculations

In this section Wyoming Fuel Company presents the method and equations it proposes to use to calculate employee intake and exposure to airborne uranium and radon daughters. The action levels are presented and the corrective action requirements are detailed.

There will be only two sources of airborne radioactivity at the Crow Butte Project, yellowcake and radon daughters. A third normally anticipated source of airborne radioactivity, that of uranium ore dust, will not be present since this is an in-situ operations and the ore grinding facilities are not required at this type of operation.

As described in previous sections the concentration of yellowcake and radon daughters in the air will be monitored on a routine schedule, the frequency to be based on the concentration present and the propensity for change. These values will be used in conjunction with occupancy times to determine employee exposure. The occupancy time for routine operations may be an actual measurement of the time or may be obtained from a time study. The occupancy times for nonroutine operations will always be from actual measurement of the time involved in the operation.

The intake of yellowcake by individual employees will be calculated using the following equation:

$$I = b\sum_{i=1}^{n} C_i \; t_i$$

Where

I = uranium intake µCi

b = breathing rate, 1.2 m^3/hr

C_i = average concentration of uranium in breathing zone air during time t_i, µCi/m^3

t_i = time of exposure to average concentration C_i, hrs

n = number of exposure periods

The exposure to radon daughters will be calculated using the following equation:

$$E = \sum_{i=1}^{n} \frac{W_i t_i}{176}$$

Where

E = annual radon exposure, working-level months

W_i = average number of working levels in the breathing zone air during time t_i, WL

t_i = time of exposure to average concentration W_i, hrs

176 = conversion from working-level hours to working-level months

n = number of exposure periods

Records of exposures will be maintained on all employees whose exposure is likely to exceed 25% of the applicable limits. The limit for intake of yellowcake will be 0.0048 μCi over a period of one calendar week or 0.063 μCi over a period of one calendar quarter. The limit for radon daughters is an annual limit which is 4 working-level months in the period of one calendar year. These limits are those specified in § 20.103 of Title 10, Code of Federal Regulations.

An over exposure will have occurred if the above limits have been exceeded. Also if the sum of the fraction of the quarterly yellowcake intake limit and the working level months for the past four quarters divided by four exceeds unity, an over exposure will have occurred. All over exposures will be reported to the appropriate NRC Regional Office.

The action level at the Crow Butte Project will be 25% of the 40 hour control measure specified in § 20.103(b)(2) of Title 10, Code of Federal Regulations. If any employee is exposed to radon daughters exceeding .02 working-level months, yellowcake greater than .0048 μCi, or a fractional combination of both that exceeds one, the action level will have been exceeded. Once the action level has been exceeded an investigation into the cause will be performed by the health physics technician. Once the cause has been determined corrective action will be taken to reduce the possibility of further exposures.

Action levels for airborne radioactivity have been described in Section 5.7.3. It is the intention of Wyoming Fuel Company to maintain exposures and airborne radionuclide concentrations as low as is reasonably achievable.

5.7.5 Bioassay Program

This section describes the bioassay program to be conducted at the Crow Butte R&D Project. All plant personnel will be included in the program. The objective of this program is to determine actual employee exposure and to assess the adequacy of the air sampling and contamination control programs. The action levels and the procedures to be followed in the event the action levels are exceeded are presented

Wyoming Fuel Company will initiate a bioassay program for its employees at the Crow Butte Project. Maintenance of the program will be the responsibility of the health physics technician. The program will be designed to closely follow the requirements of USNRC Regulatory Guide 8.22 Bioassays at Uranium Mills(1978).

The type of bioassay to be performed on a routine basis at the Crow Butte Project will be the urinalysis. This bioassay is useful for measuring the more soluble components of yellowcake. The yellowcake is assumed to be soluble, because the pilot plant will not incorporate a product drier and drying the yellowcake at elevated temperatures is known to decrease its solubility.

Since no yellowcake will be dried onsite, the possibility of yellowcake inhalation will be small. Therefore, all employees whose routine work assignments require them to enter areas where the possibility of yellowcake inhalation exists will be sampled on a quarterly basis. All other employees will be sampled on an annual basis. A baseline urinalysis will be performed on all employees prior to their initial assignment at the plant. In the event of a suspected over exposure to yellowcake dust, a sample will be collected after a 48 hour interval and analyzed as soon as possible. Records will be maintained to document the sample collection and analysis dates as well as the individual's record to allow the most recent results to be compared to the employees previous history. Examples of these forms are included in Appendix 5.7(A).

The action levels to be employed are those given in Table I of Regulatory Guide 8.22. If the urinary uranium concentration exceeds 15 μg/l, a second sample will be collected and a confirming analysis will be performed. If the second sample agrees with the first, the radiation safety office will conduct an investigation to determine the cause of the exposure and whether other employees may have been exposed. If the urinary uranium concentration exceeds the 30 μg/l, the actions stated above will be taken. In addition to these steps consideration will be given to changing the employee's work assignment so that the exposure to airborne yellowcake will be remote. If the urinary uranium concentration exceeds 30 μg/l for four consecutive samples or exceeds 130 μg/l for a single sample the above actions will be taken and the urine sample will be tested for albuminuria. If an exposure of this magnitude occurred and was confirmed, the appropriate regional office of the U.S Nuclear Regulatory Commission would be notified in writing. Any confirmed analysis above 15 µg/l will be treated as an over exposure even if sample contamination is suspected.

The air monitoring program described in section 5.7.3 is designed to alert the radiation safety office to any increases in airborne yellowcake. If urinary uranium concentrations increase above 15 µg/l and the air samples do not show a corresponding increase, then the air sampling program's adequacy of estimating the employees exposure should be suspect. After investigation and confirmation of the adequacy of the air monitoring program other causes may be investigated such as transient exposures or improper personal hygiene procedures.

5.7.6 Contamination Control Program

This section describes the contamination control program and surface contamination monitoring techniques to be employed at the Crow Butte R&D Project. Procedures to contain any uranium dust in restricted areas and prevent its migration into unrestricted areas are detailed. Action levels and corrective action requirements are discussed.

Surface contamination at the Crow Butte Project pilot plant will be minimized since yellowcake will not be dried at the site. The drying of yellowcake at conventional mills contributes significantly to the surface contamination problems usually encountered in these mills. The areas of potential contamination at the Crow Butte pilot plant will be associated with the precipitation circuit, slurry storage areas and to a lesser extent the recovery circuit. These areas will be designated restricted. Eating, drinking and smoking by employees in these areas will be prohibited. Other plant areas will be considered unrestricted.

Employees who enter an unrestricted area from a restricted one will be required to survey themselves for surface contamination and ensure that they meet the guidelines needed to leave a restricted area. This monitoring will consist of a visual examination to detect any yellowcake and a survey meter to ensure that any suspected contamination is below the acceptable limits. In the event that a nonroutine operation is required and the potential for contact with the product is present, then a waterproof suit will be worn by the operators. If this clothing becomes contaminated in the course of the operation the clothing may be rinsed off in a controlled area.

Equipment that must be removed from restricted areas for maintenance or repair must be thoroughly decontaminated Surface contamination of equipment, both internal and external, will be reduced to acceptable levels to prevent the possibility of contamination in the maintenance shops.

The primary method for control of surface contamination will be instruction in, and enforcement of, good housekeeping practices. In restricted areas all visible yellowcake will be cleaned up immediately to prevent its drying and possible suspension into the air which would pose an inhalation hazard. The plant operators will be instructed in the proper use of plant equipment and how to prevent product loss at various stages of the process. In unrestricted areas employees will continually be on watch for any visible yellowcake. If yellowcake is detected in an unrestricted area the health physics technician will be notified and an investigation into the source of the contamination will commence.

Surface contamination monitoring will be the responsibility of the health physics technician. Contamination surveys will be conducted in both restricted and unrestricted areas, with a greater frequency in the latter. Total surface activity will be measured with an alpha scintillator. A Ludlum Measurements, Inc. Model 43-5 Alpha Scintillation Probe or equivalent and countrate meter will be used for this survey. Specifications for this instrument are given in Appendix 5.7(A).

The removable surface contamination will be measured by using a smear test. A smear test will be performed by wiping a 100 cm^2area of the surface to be tested with a dry filter paper. The filter paper will then taken to the laboratory where the alpha activity on the surface of the filter is measured. The results will be expressed in units of dpm/100 cm^2. The instrument used for measuring the alpha activity on the filter is the same instrument used to measure alpha activity on air particulate filters and is described in Appendix 5.7(A). The instrument specifications and calibration procedures are given in that appendix.

The limits for surface contamination at the Crow Butte R&D Project are those shown in Table 5.7-2 and are adopted from the U.S. Nuclear Regulatory Commission publication entitled Health Physics Surveys in Uranium Mills(1980a).

TABLE 5.7-2

SURFACE CONTAMINATION LIMITS

FOR NATURAL URANIUM

Total[a]	5000 dpm/100 cm^2 average 15000 dpm/100 cm^2 maximum
Removable	1000 dpm/100 cm^2

[a]The average value may be averaged over an area not to exceed 1 m^2. The maximum is over an area not to exceed 100 cm^2.

These limits are expressed in terms of total and removable contamination. The limits are for surfaces in unrestricted areas and for equipment that is to be released for unrestricted use.

The surface contamination monitoring program at the Crow Butte Project will consist of two parts. The first part will be weekly surveys throughout the plant in both restricted and unrestricted areas. These surveys will include visual inspection for obvious signs of contamination and instrument surveys to determine total contamination. If the instrument survey indicates total contamination above 1000 dpm/100 cm^2,a smear test will be conducted to measure the removable contamination. If contamination above the limits listed in Table 5.7-2 is found in unrestricted areas then decontamination procedures will begin as soon as feasible. The cause of the contamination will be investigated and procedures to prevent future occurrences will be considered. The second part of the monitoring will be monthly smear tests in all unrestricted areas. Both the weekly surveys and the routine monthly smear tests will be documented and the records kept on file at the plant site.

In areas such as lunch rooms, action levels of 10 percent of the values given in Table 5.7-2 will be used. If these action levels are exceeded the area will be closed until it can be properly cleaned. The health physics technician will also try to determine the cause of the contamination. The lunch rooms will be visually inspected on a daily basis and surveyed weekly with an alpha detector and countrate meter. If during the alpha survey any areas are suspect, a smear test will be performed to ensure that the removable contamination is below the action level of 100 dpm/100 cm^2. All surveys and smear tests will be documented and the records retained at the plant site.

All shipments of yellowcake from the plant site will have the exterior surfaces of the transport vehicle surveyed to insure that the surface contamination is below the acceptable limits. Smear samples will be taken from areas that have the highest levels of contamination as indicated by the survey. The limits for removable surface contamination for yellowcake packages prepared for shipment will be 22,000 dpm per 100 cm^2 averaged over 300 cm^2. If these limits are not met then the vehicle will be decontaminated until smear tests of the areas of highest contamination result in levels below this limit.

5.7.7 Airborne Effluent and Environmental Monitoring Programs

This section outlines the operational program Wyoming Fuel Company proposes to use to monitor the environmental effects of any airborne effluents from the Crow Butte R&D plant. Particulates and radon gas will be measured at four locations. At the conclusion of operations the soil and vegetation at the air monitoring stations will be sampled and compared to the results of the preoperational sampling program. Sediments in Squaw Creek will be sampled semiannually. The ground and surface waters in the region will also be monitored for the concentration of natural uranium and radium-226.

The design of the operational radiological monitoring program is based on the preoperational radiological program (see Section 2.10) and on USNRC Regulatory Guide 4.14, Radiological Effluent and Environmental Monitoring at Uranium Mills (1980b). The operational radiological monitoring program is presented in Table 5.7-3.

Air particulates and radon gas will be monitored at four locations during the operation of the pilot plant. Figure 5.7-1 is a topographic map of the area surrounding the restricted area boundary. The air monitoring stations AM-1, AM-2 and AM-6 will be used to assess the radiological impact, if any, on the air quality in the region. These stations are located at the nearest residences in two prevalent downwind directions and near the town of Crawford. Site 7 is used as a background location. These stations will be operated for one year in order to determine background conditions. The preoperational air monitoring program began in April 1982.

The airborne particulates will be collected on the inlet filter of a regulated vacuum pump. The filter will be changed weekly or more frequently if dust loading is a problem. The pump will be in operation one week per month with the filters

TABLE 5.7-3
RADIOLOGICAL OPERATIONAL
MONITORING PROGRAM
CROW BUTTE R&D PROJECT

	Sample Collection				Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	Type of Analysis
AIR						
Particulates						
	Three	Nearest residences same as preoperational and near the town of Crawford	Continuous low volume air sampler with glass fiber filter	One week per month	Quarterly composite of filters according to location	Natural Uranium Th-230, Ra-226, Pb-210
	One	Control location same as preoperational	same	same	same	same
Radon	Four	Same as air particulates	Grab[1]	Monthly	Each sample	Rn-222
WATER						
Ground Water						
	One from each water supply well	Within 1 km of R&D restricted area boundary	Grab	Quarterly	Each sample	Total:Natural Uranium, Ra-226

[1] A grab sample shall consist of at least three(3) separate forty-eight(48) hour composite samples during a period of one(1) month.

Radiological Operational Monitoring Program (Cont'd)

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
Surface Water						
	Two from Squaw Creek	One up-stream, one down-steam of restricted area	Grab	Quarterly	Each sample	Total:Natural Uranium, Ra-226
SOIL						
	One each	Air sampling stations	Grab (top 5 cm)	At completion of R&D operations	Each sample	Natural Uranium, Ra-226
SEDIMENT						
	Two from Squaw Creek	One up-stream, one down-stream of restricted area	Grab	Semiannually	Each sample	Natural Uranium, Ra-226
VEGETATION						
	Four	Air sampling stations	Composite of dominate vegetation present	At completion of R&D operations	Each sample	Natural Uranium, Th-230, Ra-226, Pb-210, Po-210
DIRECT RADIATION						
	One each	Plant site, well field, evaporation ponds, air sampling stations	Dosimeter	Quarterly	Quarterly	Gamma exposure rate μR/hr using a continuous integrating device

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being composited according to location on a quarterly basis. The composite samples will be analyzed for the concentrations of natural uranium, thorium-230, radium-226, and lead-210.

The air filters will be analyzed by a consulting laboratory specializing in this type of analysis. The lower limits of detection will be those specified in NRC Regulatory Guide 4.14. The action level will be 25% of the limits given in 10 CFR Part 20 Appendix B Table II column 1. These action levels will be based on the results of the analysis after subtracting the corresponding background concentrations. If these action levels are exceeded an investigation by the radiation safety office will be conducted to determine the cause of the increase and to prevent its reoccurrence. It should be noted that the Crow Butte R&D plant will not have a product drier and therefore have no direct source of particulate emissions. Exceeding the action level would be a highly improbable occurrence.

Radon will also be measured at the air monitoring stations. Air samples will be collected in an Environmental Measurement, Inc., Radon Sampler I. This system is a single-pump, single-bag sampler designed to collect a composite ambient air sample over a 48-hour period. Particulates are removed by an inline 37mm diameter, 5 micron filter. The sample bag is made by Tedlar and has a 30 liter volume. The composite air sample in the bag is analyzed for radon-220 by drawing a dried, filtered sample of the air into a calibrated Lucas cell. After a delay of three hours the activity in the cell is determined and the results expressed as microcuries of radon per milliter of air. Three 48-hour composite samples will be collected per month at each air monitoring station.

The ambient air samples will be analyzed for the concentration of radon by Wyoming Fuel Company personnel. The same instruments and procedures will be used as those discussed in Section 2.10, Background Radiological Characteristics and Section 5.7.3, Airborne Radiation Monitoring Program. The lower limits of detection for this procedure and these instruments is below that required by the NRC Regulatory Guide 4.14. The action level will be 25% of the value listed for radon-222 in 10 CFR Part, Appendix B, Table II, column 1. Radon concentrations above the action level, after taking in to consideration background levels, will result in an investigation by the radiation safety office. This investigation's goal will be to identify the source of radon and recommend practicable methods of reducing its concentration or controlling its release. The relatively low production flow rates at the Crow Butte R&D plant will aid in keeping the off-site radon concentrations low. It appears unlikely that the action levels will be exceeded.

Gamma radiation will be measured at the air monitoring stations. Thermoluminescence detectors supplied by Eberline Instrument Corporation will be used to record the gamma radiation. These dosimeters were used during the preoperational monitoring program and a description and complete specifications for them are given in Section 2.10, Background Radiological Characteristics. The area around the plant site, wellfield and evaporation ponds will also be monitored using these dosimeters. All dosimeters will be exchanged on a quarterly basis.

Upon completion of the restoration phase of the project soil samples will be collected at the four air monitoring stations. These samples will be analyzed for the concentrations of uranium and radium-226. Preoperational samples were also collected at these locations and a comparison will be made to assess the effect the pilot plant may have had on the concentrations of these radionuclides in the soil.

During the preoperational monitoring program vegetation samples were collected at the four air monitoring stations. These samples were analyzed for natural uranium, and radium-226. After restoration of the pilot plant the vegetation near the air monitoring stations will be sampled again and analyzed for the same radionuclides. The samples are composites of the dominant vegetation types present.

Sediment in Squaw Creek was sampled at two locations on a semiannual basis for one year, prior to any construction in the area. The sample locations represent one sample up-stream and one down-stream of restricted area and are shown in Figure 5.7-1. During the operation of the pilot plant sediments at these sample locations will be collected semiannually and analyzed for the concentrations of natural uranium, thorium-230, radium-226 and lead-210.

Also detailed in Table 5.7-3 is the radiological monitoring of the surface and ground water in the area surrounding the restricted area boundary. Water supply wells within 1 km of this boundary will be sampled on a quarterly basis and analyzed for the concentration of natural uranium and radium-226. Two surface water samples will be taken from Squaw Creek, one up-stream and one down-stream of the restricted area boundary. These samples will be collected quarterly and analyzed for the concentration of natural uranium and radium-226.

5.7.8 Ground Water and Surface Water Monitoring Programs

Three types of unplanned liquid effluents can potentially be released from an in-situ uranium R&D project: 1) mining solutions which migrate to areas outside the wellfield 2) waste solutions in the subsoil resulting from loss of evaporation pond liner integrity and 3) mining solutions released at the surface from leaks or breaks in pipelines and at wellheads.

The ground water monitoring program described in this section will be followed during the operational and restoration phases of the R&D test. Analysis of eight production zone and two upper aquifer monitor wells for excursion indicators will insure that leach solutions are maintained within the wellfield area. A third upper aquifer well, PM-7, will be used for water level measurements. Provisions are given for analysis of excursion indicators, agency notification, and cleanup of affected areas. Pond leak detection system monitoring is described, along with appropriate actions should presence of a leak be determined. Monitoring procedures for pipelines and wellheads are also addressed.

No surface water monitoring will be needed as there will be no surface discharge from this R&D facility. This program has been designed in consideration of Regulatory Guide 3.46 (FP818-4) and Staff Technical Position Paper #WM-8102, "Ground Water Monitoring at Uranium In-Situ Solution Mines,"(1981).

Monitor and Baseline Wells. Waters of the production zone and overlaying aquifer will be monitored for the presence of migrating leach solutions. Monitoring will be initiated when mining begins, and continue until restoration is satisfactorily completed as determined by the NRC and Nebraska DEC.

Table 5.7-4 lists the operational monitoring program to be followed.

A ring of eight monitoring wells are to be completed in the production zone encircling the wellfield for lateral excursion control (see Figure 5.7-2). Two of these wells were installed in September, 1982 and included as observation wells in the hydrologic test (Section 2.6). Results of the test indicate the aquifer is essentially isotropic and heterogenous. For this reason the monitor wells can be placed at approximately uniform distances 61 m (200 ft) around the mining area. The radius of influence in detecting excursions should be the same for all wells. No thickness changes, faults or other conditions which might affect the monitoring capabilities of these wells were noted in the hydrologic data analysis.

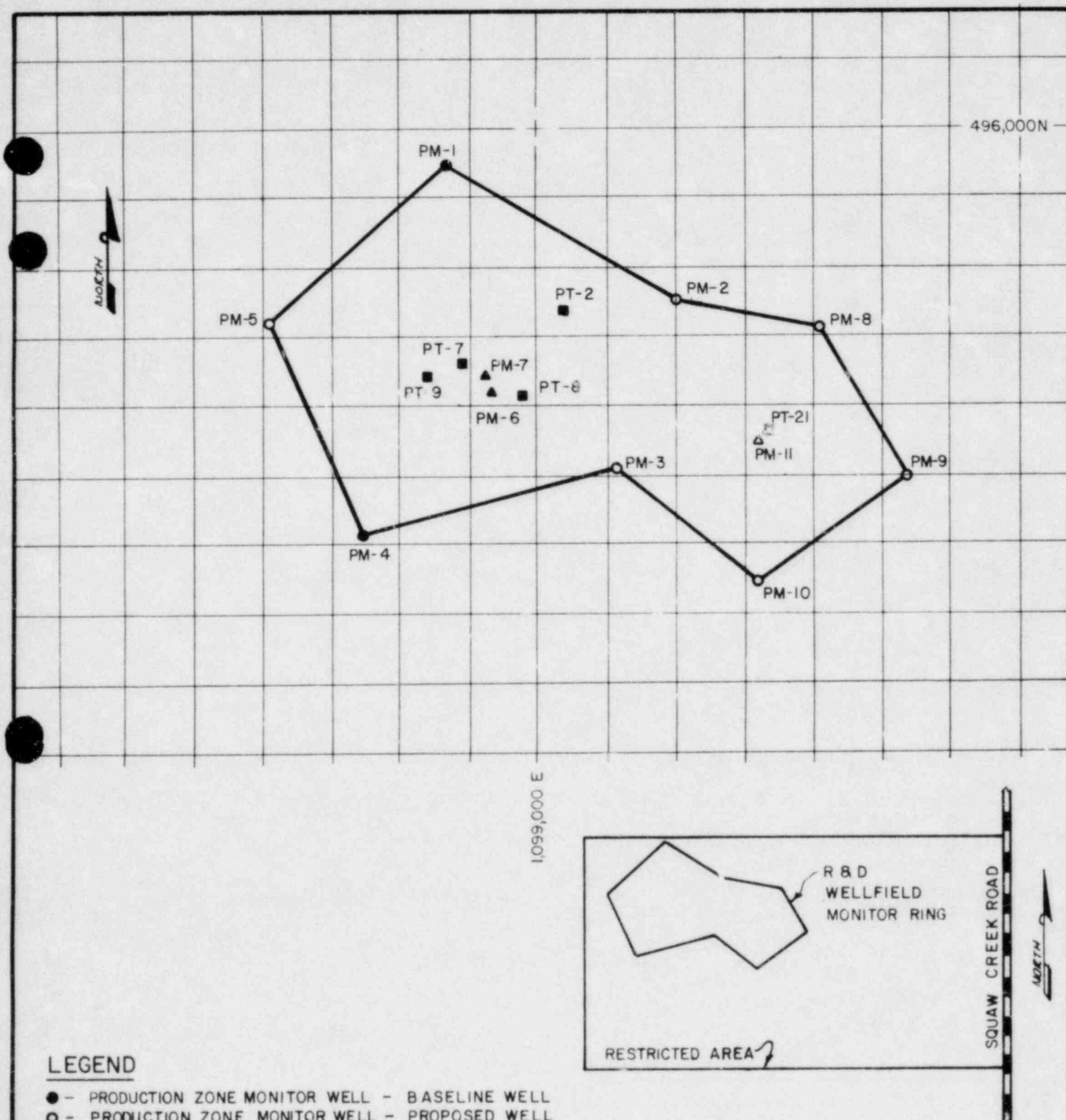
Two wells in the overlaying aquifer will be utilized for monitoring. One of these, PM-6, is installed and was included in the test described above. No leakage or fractures in the confining clay were noted, thus it is proposed that only the first overlaying saturated sand in the Brule Formation be monitored.

Four wells in the western R&D wellfield were chosen for baseline water quality sampling. These were installed in September 1982. A fifth well will be installed, in the eastern wellfield, for baseline sampling. The results from these wells will be used in determining the postoperational restoration values.

As of December 1982 these monitor and baseline wells have been sampled once. The results are presented in Section 2.11

TABLE 5.7-4
NONRADIOLOGICAL OPERATIONAL MONITORING PROGRAM
CROW BUTTE R&D PROJECT

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
Ground Water						
	One each	Production zone monitor wells	Grab	Two-week intervals	Within 24 hours	Excursion indicators: conductivity chloride, uranium
	One each	Upper aquifer monitor well	Grab	Two-week intervals	Within 24 hours	Excursion indicators: conductivity chloride, uranium
Water Levels	One each	Proudciton zone monitor well	Electric line	Immediately prior to sampling	Within 24 hours	Table, graph
	One each	Upper aquifer monitor well	Electric line	Immediately prior to sampling	Within 24 hours	Table, graph
Pond Level	One each	Evaporation ponds	Observation	Weekly	Weekly	Tabular
Pond Leak Detection System	One each	Evaporation ponds	Check for presence of liquid	Daily	Daily	Tabular
			Grab sample if liquid is present	Weekly	Within 24 hours	Leak indicators: conductivity, chloride, vanadium



LEGEND

- ● – PRODUCTION ZONE MONITOR WELL – BASELINE WELL
- ○ – PRODUCTION ZONE MONITOR WELL – PROPOSED WELL
- ▲ – UPPER AQUIFIER MONITOR WELL – BASELINE WELL
- ■ – PRODUCTION ZONE PUMP TEST WELL – BASELINE WELL
- △ – UPPER AQUIFIER MONITOR WELL – PROPOSED WELL
- □ – PRODUCTION ZONE WELL – PROPOSED BASELINE WELL

50 25 0 50 METERS
200 100 0 200 FEET

SCALE: 1"=200"

REV	BY	DATE

WYOMING FUEL COMPANY
CROW BUTTE PROJECT
Dawes County, Nebraska

BASELINE AND MONITOR WELL LOCATIONS

PREPARED BY:

DWN BY: R.E. LARSON | DATE: 12-10-82 | FIGURE 5.7-2

(Tables 2.11-5, 2.11-6 and 2.11-7). As specified in the preoperational monitoring program three additional sample sets will be obtained on a quarterly basis. This will afford an opportunity to judge if seasonal water quality fluctuations occur in either aquifer, although they are considered unlikely.

Prior to R&D start-up the additional six production zone monitor wells, one upper aquifer monitor well and one production zone baseline well will be drilled (Figure 5.7-2). Each well is to be sampled twice with sampling dates separated by at least two weeks. Analysis will be for the major ions, minor and trace elements which appeared in the original baseline wells, uranium and radium-226. These results will be used for establishing upper control limits and restoration values, as applicable.

Results of the initial sampling indicate the production zone is typical of waters found in the Chadron aquifer. The R&D test wells are characteristically high in uranium (0.119 to 0.933 mg/l) and radium-226 (136 to 602 pCi/l). The same is true of the production zone monitor wells which are located in ore due to the small R&D wellfield size.

Clean-up of the upper aquifer monitor wells was difficult due to low well yield. This appears the be a function of aquifer characteristics rather than well completion techniques. Sample results show high pH values (8.78 and 8.88), whereas typical Brule Formation water averages pH 7.6. The low calcium plus high sodium and potassium values in both wells indicate that some drilling mud is still present in the formation. However the major anions, minor elements and trace elements all appear to be unaffected by the presence of drilling mud. Further effort will be made to clean these wells prior to the next sampling. If not possible, this may indicate the first two overlaying sands do not produce usable quantities of water in this vicinity and need not be monitored by sampling.

Water Levels. Measurements of water levels are being taken monthly in the R&D baseline and monitor wells. This will continue until start-up of the test, at which time the operational monitoring program will take over with water levels measured once every two weeks (Table 5.7-5). The objective is to determine if any premining influences on the piezometric surface exist which should be taken into consideration when interpreting water level fluctuations during the mining phase. These may include effects of barometric pressure change or change in pumping rates of nearby wells.

Water level measurements in monitor wells during mining may be utilized to supplement water quality monitoring, but will not be used as an excursion indicator. In some cases early indication of an excursion may be observed as overpressuring of the aquifer resulting in a rise in water level in the nearest monitor well(s). This phenomenon will not always be observed, however.

A similar case can exist in upper aquifer monitor wells. Intrusion of water from the production zone can create a cone of impression, raising water levels locally. However, low flow rate excursions would not be detected in this manner.

Excursion Indicators. The lixiviant used will be an alkaline sodium carbonate/bicarbonate solution. The principal constituents are described in Section 3.0, Table 3.0-1. To make the lixiviant caustic soda (NaOH) is combined with carbon dioxide and ground water until the desired pH and chemical concentrations are reached. Chloride ions are contributed during resin elution and product precipitation. During leaching vanadium may be dissolved in addition to uranium. Total dissolved solids (TDS) of this solution will range from 1650 to 12000 mg/l.

An excursion indicator is generally chosen for two qualities. First, that parameter is in significant quantities in the lixiviant, and its presence over a certain limit would not be naturally occurring. Second, its geochemistry should be such that precipitation or immobilization does not occur immediately when native ground water is encountered.

For this leach chemistry the excursion indicators Wyoming Fuel Company intends to use are: conductivity (directly proportional to TDS), chloride and uranium.

Conductivity is a measure of the ability of a water sample to carry an electric current. This is directly related to the total quantity of dissolved ions in the water. Conductivity is useful in that it measures all ions which might increase due to leachate presence. The range of natural variation in conductivity will be determined by the quarterly baseline sampling. Conductivity will be measured using a specific conductance meter, and reported in μmhos. Two KCI standard solutions bracketing the anticipated range will be used for calibration (APHA,1976).

Chloride is a highly dissociated species and thus very mobile in ground water. Its presence in the lixiviant will be in quantities greater than in the native ground water. This concentration will increase with time as input from resin elution is received. Chloride has been used effectively to indicate excursions at other in-situ uranium mines.

The "Argentometric Method," or equivalent, will be used for chloride determination as described in <u>Standard Methods for the Examination of Water and Waste-water</u>(1976). This method utilizes a potassium chromate indicator for a silver nitrate titration of chloride.

<u>Uranium</u> will be present in significant quantities in the leach solution. This is due to oxidation by hydrogen-peroxide or oxygen followed by complexing as uranyl bicarbonate or uranyl tricarbonate. Although uranium precipitates in low Eh, hydrogen sulfide waters this is not expected to occur quantitatively in an excursion within the short distance to a monitor well. However, in some cases the appearance of uranium at the monitor well may trail that of conductivity and chloride by a few days.

The uranium concentration in water will be determined using a method commonly called the Bromo-PADAP method (Johnson and Florence, 1971), or equivalent. Uranium values are quantified spectrophotometrically using the indicator Br-PADAP. This method is widely used by the in-situ uranium solution mining industry for both monitor well analyses and process control.

<u>Upper control limits</u> are defined as "a concentration calculated for each excursion indicator, based on preoperational data, approximating a probable upper limit of natural baseline fluctuation" (NRC Staff Technical Position Paper #WM-8102, 1981). In agreement with that document, Wyoming Fuel Company proposes to set the upper control limit at 20 percent above the maximum baseline concentration for the

excursion indicators conductivity and chloride on a well by well basis. This appears consistent with existing baseline data. However, if subsequent baseline samples indicate this percentage is inappropriate, a new calculation or value will be proposed.

The upper control limit for uranium is proposed as 2.0 mg/l as U in the production zone. This is somewhat higher than the 20 percent increase described above. However, the dissolved uranium concentration varies by an order of magnitude or more within and around the ore area. As a result of the production bleed, water flowing inward from more highly mineralized areas, even just a few feet away, may significantly increase the uranium concentration at any particular monitor well. In upper aquifer monitor wells an upper control limit of 20 percent above maximum baseline will be used.

Monitoring and Excursion Action Procedures. Excursion monitoring and subsequent actions will utilize the following sequence. Samples will be obtained by air-lifting or pumping, as described in Section 2.11, until stale water is evacuated and fresh formation water is obtained. No preservation will be necessary since samples will be immediately taken to the laboratory for analysis.

1. Production zone and upper aquifer monitor wells are to be sampled at a frequency of two weeks (Table 5.7-4). Within 24 hours the conductivity, chloride concentration and uranium concentration will be determined.

2. If any one of these three parameters exceeds the upper control limit for a particular well a second sample will be obtained from that well within 24 hours. This sample, the verifying analysis, will be analyzed within 24 hours for chloride, uranium and conductivity.

3. If the second analysis finds the exceeding parameter back within acceptable limits, then it will be assumed the previous values resulted from laboratory error or contamination. No further action will be needed.

4. If the verifying analysis confirms that one parameter exceeds the upper control limit, then an excursion will be assumed until proven otherwise. Unbalanced production will be immediately instituted in the wellfield to begin drawing leach solutions back to the mining area. This may take the form of over-recovering or underinjecting. At Wyoming Fuel Company's option mining may be halted and restoration begun.

5. The remainder of the second sample will be analyzed for the major ions: calcium, magnesium, sodium, potassium, carbonate, bicarbonate and sulfate. Results will be compared with baseline values and a stiff diagram prepared. If results indicate the objectionable waters are naturally occurring, then the NRC and Nebraska DEC will be informed of this in writing. Unbalanced production will continue until agreement has been reached by both agencies regarding the origin of the waters.

6. During the period of excursion, the affected monitor well(s) will be sampled on a weekly basis and analyzed for the major ions, uranium and radium-226 to determine clean-up progress.

7. Agency notification will be as follows. If the verifying analysis indicates an excursion both NRC and Nebraska DEC will be notified by phone within 24 hours or the next working day. Written notification will follow within 7 days, and will state the proposed clean-up action. Monthly reports will be submitted to both agencies stating A) clean-up activities the preceding month, B) assays of the affected monitor well(s) and C) planned activities for the following month. Final clean-up will be

demonstrated by three month-spaced samples having major ion concentrations within the accepted baseline range for that well.

Evaporation Pond Monitoring. Leaks of waste solutions through the pond liners will be monitored by use of an underdrain leak detection system and pond level indicators. The latter will consist of marks at half-foot intervals with which the level of fluid in the ponds can be determined.

Leak detection systems will be installed beneath the liners of each evaporation pond. Section 4.2 gives a detailed description of these systems. The french drain situated at the lower end of each pond will culminate in a sump with a vertical stand pipe.

The ponds will contain waste fluids from four sources: filter backwash, eluant bleed, reverse osmosis brine and restoration fluids. Constituents will be essentially the same as those of the lixiviant, although more concentrated. The chloride concentration may vary from 200 to 40,000 mg/l with a final average of 12,650 mg/l. Vanadium will be removed as a contaminant from the process solutions and deposited in the ponds. Concentrations are expected from .02 to 1500 mg/l as V_2O_5 and average 271 mg/l. Total dissolved solids will also be high due to the concentrated nature of the waste streams.

Leak Indicators. The proposed leak indicators are vanadium, chloride and conductivity. These are estimated to be the most likely parameters to be present if a leak occurs. An upper control limit of 0.2 mg/l as V_2O_5 will be used. Chloride and high conductivity are typical in natural soil water although at this location the values are unknown. For this reason the upper control limits will be set at 5000 μmhos conductivity and 1000 mg/l chloride which will be representative of the more dilute end of the waste solutions. However, as a condition, vanadium must be present in the sample before a leak is determined to have occurred. If natural soil water is encountered, upper control limits may be adjusted if needed.

Pond Monitoring and Action Procedures. Monitoring of the ponds will be performed daily as a routine operator responsibility. The waste fluid level in each pond will be recorded weekly. These values will be evaluated to determine if level fluctuations are due to waste input, precipitation, evaporation or other factors. Comparison will be made with maximum working volume and freeboard limitations.

The underdrain leak detection system will be monitored daily, by checking within the stand pipe to ascertain if liquid is present. If liquid is found the following procedure will be instituted:

1. A sample of the liquid will be obtained and analyzed for the control parameters conductivity, chloride and vanadium within 24 hours.

2. If the upper control limits are not exceeded, the liquid will be assumed to be naturally occurring and future samples will be obtained weekly.

3. If the upper control limits of either conductivity or chloride, plus vanadium are exceeded then a second sample will be obtained within 24 hours and analyzed for the control parameters.

4. Positive results of the verifying analysis will indicate that a leak is present in the pond liner. Pond fluids will immediately be transferred to the adjacent pond. Subsurface water will be removed from the underdrain system by pumping to the adjacent pond. Extent of subsurface contamination will be determined and the leak repaired.

5. The NRC and Nebraska DEC will be informed by phone after confirmation by the verifying analysis within 24 hours or the next working day. Written notification will follow within 7 days. A written report of corrective actions and progress will be submitted monthly until normal pond operation is resumed.

Wellfield Surface Monitoring. Wellheads and exposed pipelines in the wellfield will be monitored for leaks and breaks. Operators will visually inspect this equipment as a routine part of daily operations. In addition, gauges indicating trunk line pressures will be read and compared with previous measurements each shift. If any of the above indicate that a leak or rupture is occurring, immediate action will be taken to 1) stop the liquid flow 2) contain the fluid and 3) repair the damaged equipment in a manner to preclude future occurrences. Records, notification and remedial action procedures described in Section 7.5 will be followed. Preventative maintenance will be the major factor in controlling incidents of this nature.

5.7.9 Quality Assurance

The quality assurance program that will be initiated at the Crow Butte R&D Project is described in this section. The objective of this program is to provide confidence in the results obtained from the monitoring programs that will be employed during the R&D plant operation. This program will allow Wyoming Fuel Company personnel to identify deficiencies in sampling and measurement techniques and to instigate corrective action when necessary.

The quality assurance program to be conducted at the Crow Butte Project is designed to provide confidence in the results of the monitoring programs described in previous sections. The USNRC Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Normal Operations) Effluent Streams and the Environment(1979), was used as a basis for the program. There are eight main sections of the program and each will be discussed in detail.

Organization Structure and Responsibility. In Section 5.1 the corporate organization and administrative procedures are presented. The authority and responsibility of each level of management in regard to the quality assurance programs are discussed. The site manager and environmental coordinator will have responsibility for review and evaluation of monitoring data and reports. The data dealing with radiological safety will also be reviewed by the corporate radiation safety officer. The environmental coordinator and corporate radiation safety officer will have responsibility for review and approval of any written procedures associated with the radiological and nonradiological monitoring programs.

Qualifications of Personnel. The qualifications of the radiation safety officer and the health physics technician are similar to those presented in the NRC Draft Regulatory Guide, Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable (1980c).

The minimum qualifications of the radiation safety officer are as follows:

Education: A bachelors degree in the physical science or engineering from an accredited college or university.

General Experience: One year supervisory experience and one year in a uranium mill or related experience.

Health Physics Experience: One year work experience in applied health physics, radiation protection, industrial hygiene, or similar work.

Specialized Training: At least four weeks of formalized courses in health physics and radiation protection.

Specialized Knowledge: A thorough knowledge of the proper application and use of all the health physics equipment used at the mine, the procedures for radiological sampling and monitoring, and methods of exposure calculation.

The minimum qualifications for the health physics technician are as follows:

Education: An associates degree in the physical sciences, engineering or a health-related field. Alternately, a high school diploma plus 2 years of relevant work experience in applied radiation protection.

General Experience: One year of work experience in a uranium mill or related industry involving radiation protection.

Health Physics Experience: One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety.

Specialized Training: At least four weeks of specialized training in radiation health protection.

Specialized Knowledge: Knowledge of the proper operation of health physics instruments used for monitoring and surveying at the mine, and personnel dosimetry requirements.

The qualifications of the individuals chosen to assume the responsibilities of the radiation safety officer and health physics technician will be submitted at a later date.

It will be the responsibility of the radiation safety officer to ensure that all personnel performing quality related activities are trained and qualified in the activities they must perform. These personnel will be made aware of the nature and goals of the quality assurance program and their proficiency in performing activities affecting quality assurance will be maintained by retraining, reexamination, and performance reviews.

Operating Procedures and Instructions. Written procedures will be prepared and approved for all activities involving sample collection, preparation and analysis of samples, calibration of radiation and radioactivity measurement systems, and reduction, evaluation and reporting of data. These procedures and any changes will be reviewed and approved by individuals knowledgeable in the procedures.

Records. Records will be maintained to adequately document sample collection, analysis, and reporting. Records for sample collection will include a sample description, sample collection location, date, analysis required, the individual collecting the sample, and laboratory performing the analysis, if not performed by Wyoming Fuel Company. Analysis records will include such items as the instrument readings, instrument backgrounds, reagent blanks, and data reduction and verification. The result of calibration checks and date of calibration will also be recorded. Finally, the distribution of the results will be documented.

Quality Control in Sampling. Instruments used for continuous measurement or sample collection will be calibrated on a regularly scheduled basis. At the Crow Butte Project this requirement will generally pertain to the environmental monitoring of radon and airborne radionuclides. The collection efficiency of the air particulate samplers will be documented and their flow rate calibrated at six month intervals.

When grab sampling is used procedures will be developed to ensure that the sample is representative of the material being sampled. Replicate samples will be collected periodically to ensure reproducibility. This will facilitate the comparison of grab samples collected at different intervals.

When samples are to be sent to an outside laboratory for analysis, written procedures will be followed to ensure proper preservation technique, labelling, packaging, shipping, and storage of the samples. The laboratory will be notified that the samples are being released and will notify Wyoming Fuel Company upon receipt. A complete listing of the samples and the required analysis will accompany each shipment.

Quality Control in the Laboratory. Instruments used in the laboratory at the Crow Butte Project will be calibrated against standards that are traceable to the National Bureau of Standards (NBS). If the instrument is calibrated on site, the activity of the source used for the calibration will be certified. If the instrument is not calibrated on site, it will be sent to a laboratory whose procedures and standards are certified.

The individual instruments will be subjected to daily performance checks, when in use. The background will be determined by an appropriate method and a check source will be used to monitor the count rate or counting efficiency. Investigative and corrective action will be initiated should the instrument fail to produce results within the predetermined control value range.

In order to assess the quality of the analyses in the laboratory, replicate samples will be run routinely. This will allow an estimate of the precision that can be expected for the analysis. Spiked samples will be analyzed and evaluated to determine the accuracy of the procedure. Reagent blank samples will be run periodically to ensure reagent contamination is not a problem. When using commercial laboratories random duplicate samples will be sent to different laboratories to aid in evaluation of the quality of the results.

Finally a percentage of the calculations will be verified by someone other than the analyst. If a computer program is used the input data and program will be verified.

Review and Analysis of Data. The data will be reviewed as it is received, by the health physics technician. The data will be examined to determine any extraordinary results, as well as, possible trends resulting from sources such as instrumental drift or gradually changing backgrounds. Finally all duplicate, spiked, and reagent blank samples will be evaluated. The data will be reviewed on a periodic basis by the radiation safety officer. If abnormalities are found corrective action will be taken and documented.

Audits. Audits of the quality assurance program will be conducted during the planned, periodic audit of the radiation safety program. This audit will be conducted by representatives of the corporate management, operations management, and representatives of the radiation safety office.

The results of the audit will be documented. If indicated, corrective action and reaudit will be required.

REFERENCES

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APPENDIX 5.7(A)
INSTRUMENT SPECIFICATIONS, SAMPLING TECHNIQUES, AND ANALYTICAL PROCEDURES

5.7(A) Appendix

This appendix contains information concerning instrument specification, sampling techniques, analytical procedures and calibration information. Table 5.7(A)-1 lists the type of monitoring required at the Crow Butte R&D Project and cross references it to the type of instrument that will be used to accomplish the measurement. All instrumentation will be duplicated to provide back up in the event of a failure and also during the time required for manufacturers recalibration. It should be noted that the instruments listed represent the minimum criteria and instrumentation by another manufacturer may be substituted provided the specification are equal to or greater than those of the instruments listed in Table 5.7(A)-1.

The instrument specification are listed after Table 5.7(A)-1. This is followed by the sampling and analytical procedures. Finally some of the forms used for record keeping are included.

TABLE 5.7A-1

INSTRUMENTS AND MONITORING OBJECTIVES
AT THE CROW BUTTE R&D PROJECT

Instruments	GAMMA External	RADON Daugnters	RADON Gas	URANIUM In Air	URANIUM On Surfaces Survey	URANIUM On Surfaces Smear
Model 19 μR meter (2)	*					
MS-3 Scaler		*	*	*		*
Model 2000 Scaler		*	*	*	*	*
Model 43-10 Alpha Sample Counter (2)		*		*		*
Model 43-5 Alpha Scintillation Probe (2)					*	
Model 3 Countrate Meter					*	
SAC-R5 and Cells			*			
Bendix BDX55HD		*				
RAS-1 Air Pump (2)		*		*		
Radon 2 Bag Sampler (2)			*			

SPECIFICATIONS FOR THE LUDLUM MEASUREMENTS, INC.
MODEL 12S MICRO R METER

Linearity	± 5% of full scale
Discrimination Range	2-60 millvolts
Imput Impendance	0.1 megohm
High Voltage	400-1500 VDC regulated to within 1%
Calibration	Less than 15% variance to battery end point
Meter Response	
Fast	3 sec
Slow	11 sec
Counting Ranges	0-3 micro R/hr with multiples of 1, 10, 100, and 1,000
Meter	50 microamp 2 1/2" dia taut-band suspension
Detector	RCA 6199 coupled to a 1" x 1" NaI (Tl) scintillator
Calibration Frequency	6 months
Manufacturer	Ludlum Measurements, Inc. 501 Oak Street Sweetwater, TX 79556

SPECIFICATIONS FOR THE LUDLUM MEASUREMENTS, INC.

MODEL 2000 PORTABLE SCALER

Input Sensitivity	Charge sensitive adjustable from 0.5×10^{-3} micro-coulombs
Resolution	Two pulse per 10 micro-seconds
High Voltage	Adjustable from 100 to 2500 volts. Can support 100 megohm scintillation loads to 1500 volts
Scaler	Six decade Light Emitting Diode readout
Meter	2½" panel meter. Scales for battery check and high voltage readout
Timer	Time base in minutes from 0 to 99 with multiples of x0.1, x1, and x10 or an EXT position for manual timing
Power	115 volts 50-60 Hz single phase
Battery	4 each "D" cell typical life -20 hours
Calibration Frequency	6 months
Manufacturer	Ludlum Instruments, Inc. 501 Oak Street Sweetwater, TX 79556

SPECIFICATIONS FOR THE LUDLUM MEASUREMENTS, INC. MODEL 43-5 ALPHA SCINTILLATION PROBE

Scintillator	ZnS(Ag)
Window	1 mg/cm^2 aluminized mylar
Counting Area	50 cm^2 active area
Manufacturer	Ludlum Measurements, Inc. 501 Oak Street Sweetwater, TX 79556

SPECIFICATIONS FOR THE LUDLUM MEASUREMENT, INC. MODEL 43-10 ALPHA SAMPLE COUNTER

Scintillator	ZnS(Ag)
Window	0.8 mg/cm^2 mylar
Counting Area	26.5 cm^2 active area
Photomultiplier Tube	RCA 6199
Manufacturer	Ludlum Measurements, Inc. 501 Oak Street Sweetwater, TX 79556

SPECIFICATIONS FOR THE LUDLUM MEASUREMENTS, INC.
MODEL 3 SURVEY METER

Range	Four linear ranges, meter scale presentation 0-5K cpm with multiples of x.1, x1, x10 and x100
Response	Toggle switch selection for 3 or 11 seconds
Sensitivity	40 millivolts
Reset	Push button switch for meter reset
High Voltage	Externally adjustable from 400 to 1500 volts
Audio	Built-in Unimorph speaker with on-off switch
Connector	"C" series
Linearity	± 5% of full scale
Calibration Stability	Less than 5% variance to battery end point
Meter	50 micro-amp, 2½" diameter
Calibration Frequency	6 months
Manufacturer	Ludlum Measurements, Inc. 501 Oak Street Sweetwater, TX 79556

SPECIFICATIONS FOR THE EBERLINE INSTRUMENT CORPORATION
MODEL SAC-R5 DETECTOR AND SC-6 SCINTILLATION CELL

Photomultiplier Tube	Nominal 5 inch, 10 stage end window tube
Background	One cpm maximum when set properly
Connection	Single coaxial MHV type connector
Input Resistance	120 meg-ohms
High Voltage	To 2500 volts
SC6 Cell Volume	1.4 liters
Response Factors	
CPM per pCi	4.3
CPM per pCi/l	6.0
Calibration Frequency	6 months
Manufacturer	Eberline Instrument Corp. P.O. Box 2108 Santa Fe, NM 87501

SPECIFICATIONS FOR THE EBERLINE INSTRUMENT CORPORATION
MODEL MS-3 SCALER

High Voltage	Regulated, Adjustable from 200 to 2500 volts
Scaler	Six Decade LED readout
Timer	Time base in minutes with settings of 1, 2 and 5 and multiples of x.1, x1 and x10
Timer Accuracy	Better than 0.05%
Connector	MHV series coaxial
Temperature	32°F to 140°F
Power	115 VAC, 50/60 Hz, ¼ amp
Calibration Frequency	6 months
Manufacturer	Eberline Instrument Corp. P.O. Box 2108 Santa Fe, NM 87501

SPECIFICATIONS FOR THE BENDIX CORPORATION
MODEL BDX 55HD PERSONNEL MONITORING PUMP

Flow Range	1-3 lpm
Flow Capacity	2 lpm at 20" H_2O
Flow Accuracy	$\pm$ 5% between 3" and 10" H_2O back pressure
Flow rate consistency	$\pm$ 5% of initial setting with two(2) adjustments during sampling period
Sampling Duration	12 hours with a 37 mm diameter, 0.8 micron filter
Calibration Frequency	6 months
Manufacturer	The Bendix Corporation Environmental and Process Instrument Division 12345 Starkey Rd Largo, FL 33543

SPECIFICATIONS FOR THE EBERLINE INSTRUMENT CORPORATION
MODEL RAS-1 REGULATED AIR SAMPLER

Pump Type	Oil-less, carbon vane
Maximum Capacity	40 cfm at 0 pressure drop
Ultimate Vacuum	26 inches Hg at sea level
Typical Operating Capacity	0.5-2.0 cfm
Sample Size	47 mm
Flow Meter	0-100 liters per minute
Filter	Outlet and by-pass filter/muffler
Power	115 volts, 60 Hz at 5A
Thermal Protector	In motor
Calibration Frequency	6 months
Manufacturer	Eberline Instrument Corp. P.O. Box 2108 Santa Fe, NM 87501

SPECIFICATIONS FOR ENVIRONMENTAL MEASUREMENTS, INC. RADON I RADON SAMPLER

Type	Semi-automatic single bag sampler
Housing Volume	225 liters
Pump	Single action piston, DC motor driven
Controls	Power switch, flow control adjustment
Prefilter	Membrane filter, 5.0 micron, 37 mm diameter
Flow Rate	0.2 to 4.0 liters per hour, 1.5 ml per pulse, adjustable
Power	110 volts, 60 Hz
Temperature Range	-10°C to +50°C
Calibration Frequency	None
Manufacturer	Environmental Measurements, Inc. 215 Leidesdorff Street San Francisco, CA 94111

RADON DAUGHTER MEASUREMENTS

The modified Kusnetz method for measuring radon daughter working levels will be used at the Crow Butte R&D Project. In this method a volume of air will be sampled using the Bendix BDX 55HD sampler and a high efficiency membrane filter. Normally a five minute sample will be taken at a flow rate of 2 lpm resulting in a sample volume of 10 liters. After a delay of 40 to 90 minutes the alpha activity on the filter will be measured using the Ludlum model 43-10 alpha sample counter and model 2000 scaler. The count time and sample volume will be adjusted to insure a practical lower limit of 0.03 working levels. The information concerning sampling time and rate will be recorded as well as the analysis information. The Eberline MS-3 scaler will serve as backup for the model 2000 scaler while there will be two model 43-10 alpha sample counters.

RADON SAMPLING

Radon gas is monitored at the Crow Butte R&D Project by collecting air samples using the Environmental Measurements, Inc. radon sampler. This sampler is primarily a small pump and a gas collection bag, all housed in a plastic drum. The pump is operated by 110 VAC current and operates only periodically. Approximately every twelve seconds the pump is switched on and delivers 1.5 ml of air to the bag. At the end of each sampling period the gas collection bag is exchanged for an empty one and the full bag is taken to the lab for analysis. Two consecutive 48 hour samples followed by one 72 hour sample will be collected at each air monitoring station per month at the Crow Butte R&D Project.

In the plant, air samples may be taken over a shorter time period. This can be accomplished by increasing the pulse rate of the pump. An alternate method would be to use an evacuated scintillation cell with a filtered inlet. Open the filtered inlet in the atmosphere to be tested and fill the cell.

ROUTINE PROCEDURE

1. Secure the drum assembly to the air monitoring station.
2. Open sampler by releasing the locking ring which holds the lid assembly in place and remove the lid (if there is a full gas collection bag already in place close the hose clamp and remove).
3. Attach an evacuated gas collection bag to the exposed tubing on the underside of the lid and open hose clamp.
4. Carefully place the gas collection bag into the drum so that it will fill easily and without any resistance.
5. Replace the lid being careful not to crimp the bag between the lid and drum assembly.
6. To replace the particulate filter the white dome must be removed from the lid assembly. Do this by pulling the six nylon fasteners to their up position and then pulling the dome up.

7. The filter holder is now exposed and can be pried apart. A 37 mm diameter, 5 micron filter is placed in the holder and the filter halves snapped together.

8. The white dome is then replaced on the lid assembly.

9. Plug the unit into a 110 VAC outlet and record the time and required information on the data sheet.

10. At the end of each sampling period disconnect the sampler from the outlet and record the time on the data sheet.

11. Repeat the procedure, starting with step 2, until 2 consecutive 48 hour samples and one 72 hour sample have been collected at this air monitoring station. After this required seven day sampling period the sampler may be moved to next air monitoring station.

RADON ANALYSIS

1. Determine the cell background by counting the evacuated cell for at least ten minutes. The background should be less than 1 cpm.

2. Attach the gas collection bag, in which the radon is to be determined, to the inlet of the drying tube (Figure 5.7A-1).

3. Change filter in system.

4. Attach the cell to the drying tube outlet and to the vacuum pump inlet (Figure 5.7A-1).

5. Turn on the pump and open valve no. 2 on the cell. This insures a vacuum on the cell.

6. Open all hose clamps. Open valve no. 1 on the cell. Sample should now flow freely from the bag through the tube and the cell and out through the pump.

7. Allow approximately 10 times the cell volume to flow through the system to purge it.

8. Close cell valve no.1 and allow the pump to develop a vacuum in the cell.

9. Close cell valve no. 2 and open cell valve no. 1. This fills the cell with sample.

10. Open cell valve no. 2 and repeat steps 8 and 9 once again. With the sample in the cell, close both cell valves.

11. Stop the pump, close all hose clamps and remove the cell.

12. Wait at least three hours before counting the cell.

13. Follow the Eberline instructions on using the SAC R5 to count the cell. Use a count time of ten minutes. Note: Do not remove the light shield from the SAC R5 if power is applied to the system. Permanent damage may result.

14. After counting the cell twice and recording the data required by the data sheet, perform the indicated calculations.

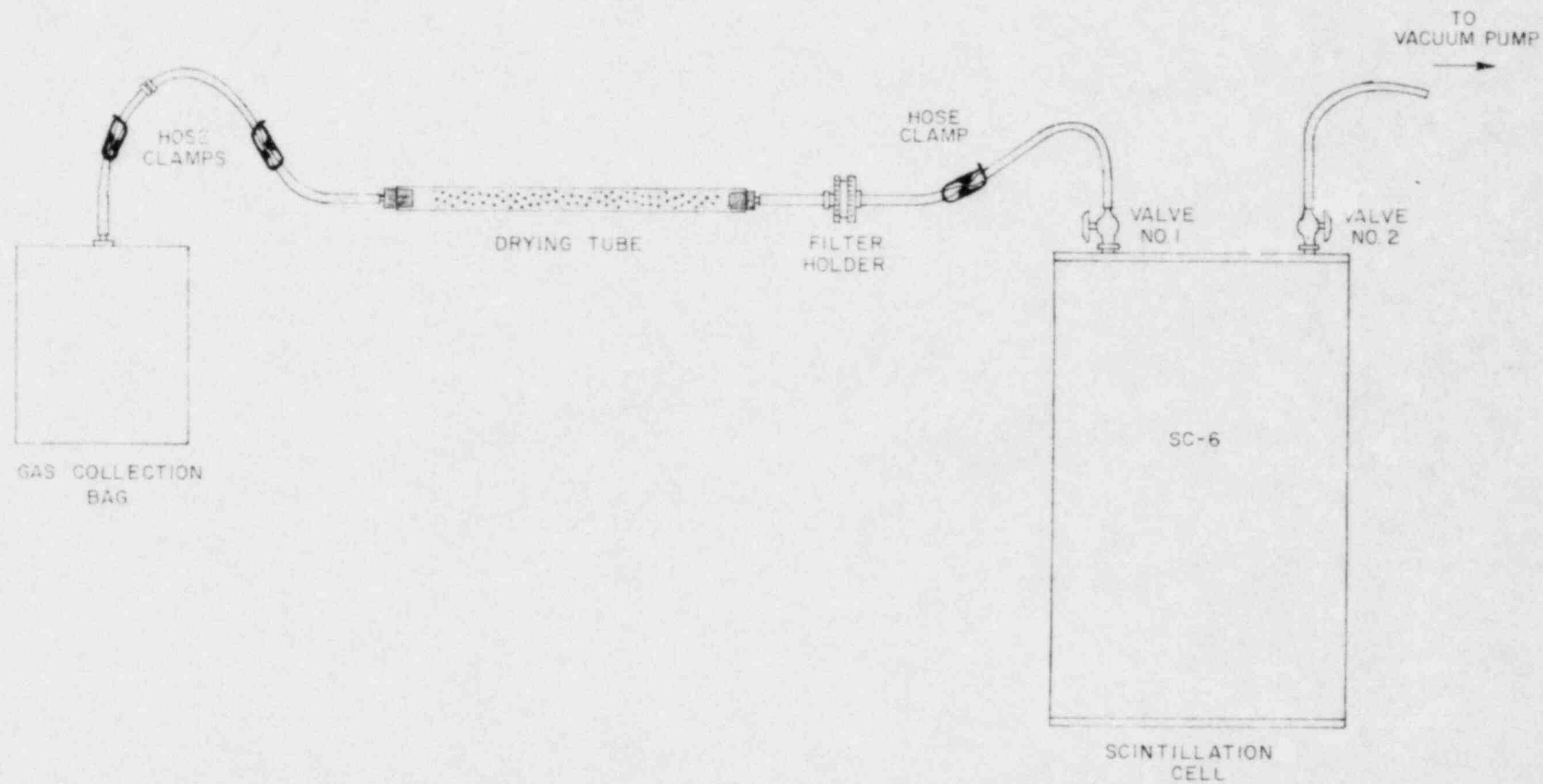
15. If the results appear reasonable, the cell may be evacuated. Do this by attaching the vacuum pump to cell valve no. 2. Turn on the pump and open cell no. 1 and no. 2. Allow at least 10 cell volumes to pass through the cell. Close cell valve no. 1 and allow the pump to evacuate the cell. Close cell valve no. 2. Turn pump off and disconnect cell.

16. Do not use this cell again for at least four days because the radon daughters will cause a high background.

17. Use the vacuum pump to completely evacuate the gas collection bag. This bag may be used again, immediately if needed.

FIGURE 5.7A-1

Equipment Set-Up for Transfer of Sample from Gas Collection Bag to Scintillation Cell



2-25-82 DL

SURVEY FOR AIRBORNE URANIUM

The Eberline RAS-1 pump will be used at the Crow Butte R&D Project to conduct surveys for airborne uranium. A volume of air will be drawn through a high efficiency filter. The alpha activity on this filter will then be counted using the Ludlum Measurements, Inc. model 43-10 alpha sample counter and model 2000 scaler. The filter will be counted again at least 24 hours later to allow for correction due to radon daughters. The count time and sample volume will be adjusted to ensure a lower limit of detection of 20 μg uranium. All sampling information and analytical data will be recorded on the appropriate forms. The Eberline MS-3 scaler will serve as backup for the model 2000 scaler. There will be two alpha sample counters.

SURVEY FOR SURFACE CONTAMINATION

Surveys for surface contaminations will be made with Ludlum model 43-5 alpha scintillation probe and model 3 count rate meter. The surface will be scanned with this instrument and if contamination above 1000 dpm/100 cm^2 (100 dpm/100 cm^2 in lunch room) is present in an unrestricted area then a smear sample will be required.

The smear sample will be taken with a dry filter paper. An area of 100 cm^2 representing the area of highest contamination as determined by the alpha scintillation probe will be wiped. The alpha activity on this sample will be determined using the Ludlum model 43-10 alpha sampler counter and model 2000 scaler. The results of the survey and smear test will be documented on the appropriate forms and maintained at the plant site. There will be duplicate model 43-5 alpha scintillation probes and model 43-10 alpha sample counters. The model 2000 scaler will serve as a backup for the model 3 countrate meter and the Eberline MS-3 scaler will be a backup for the model 2000.

AIR PARTICULATE SAMPLING

Low volume air sampling systems have been permanently installed in meteorological instrument shelters at four locations in and around the Crow Butte R&D restricted area. The low volume air samplers employed are the Eberline RAS-1 system consisting of a Gast Manufacturing Corporation vacuum pump, air flow regulator, rotameter type air flow indicator, and filter paper holder. The sampling systems must be run continuously for one year. The samples which are collected on 0.3 micron glass fiber filter papers, should be composited on a quarterly basis and sent to a laboratory for the analysis of natural uranium, thorium-230, radium-226, and lead-210.

The flow rate will be 000ibrated immediately before use and at six month intervals in order to insure the accuracy of the volume of air sampled. This calibration will be accomplished through the use of a Teledyne Hastings-Raydist mass flow meter.

CALIBRATION

1. Assemble the Teledyne Hasting-Raydist Laminar Flow Mass Transducer in-line downstream of the filter element (see Figure 5.7A-2). Connect the vacuum guage and install clean glass fiber filter.

2. Connect transducer to flow meter with patch cord supplied. Check wiring, plug meter into 110 volt outlet and turn unit on. Allow 20-30 minutes to warm up to operating temperature.

3. Zero flow meter readout.

4. Turn pump on allow 10 minutes to warm up.

5. Adjust flow as indicated by the rotameter, to the values given on the calibration data sheet. At each flow setting record the flow indicated by the digital meter. Also record the reading on the vacuum guage at each flow setting.

6. Complete the information and calculations on the calibration data sheet.

7. Remove the Laminar Flow Mass Transducer and connect the filter. Do not remove the vacuum guage.

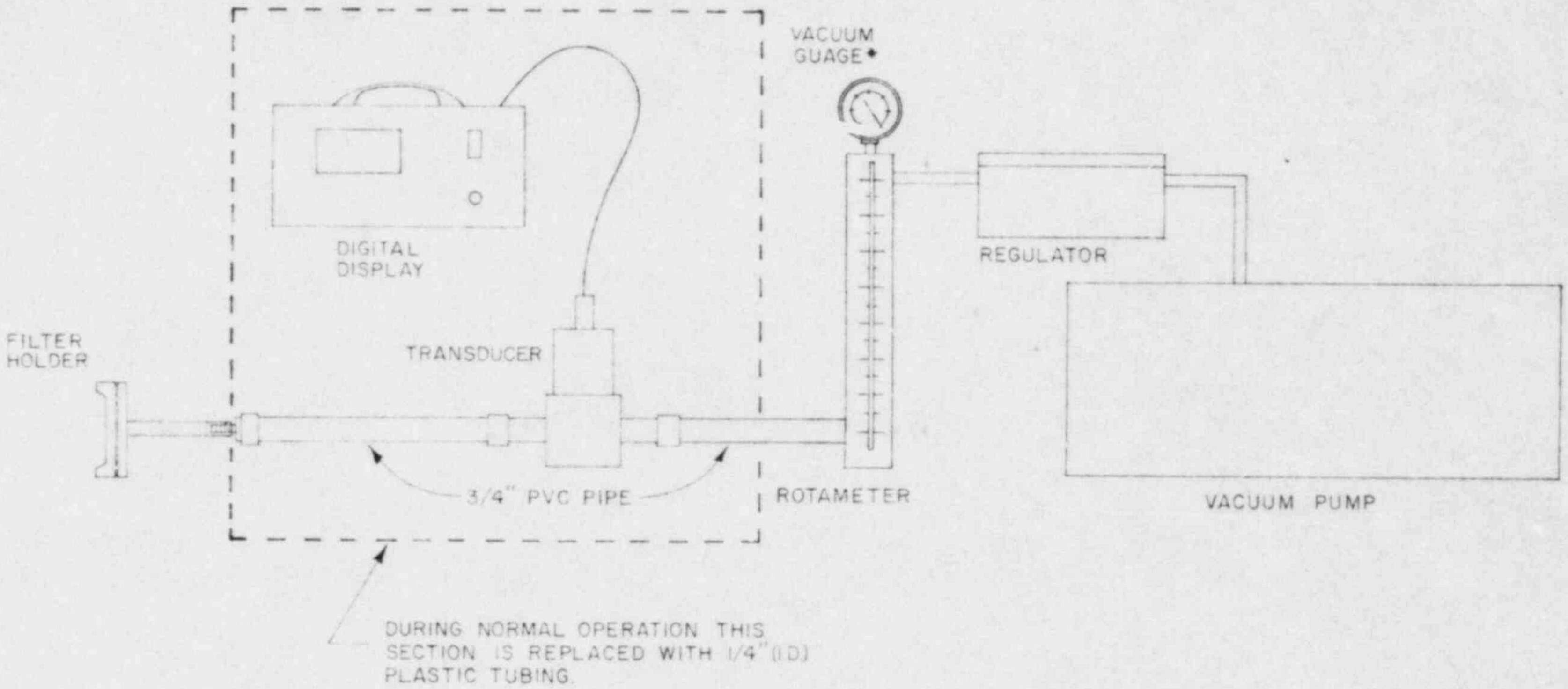
Calibration (Cont'd)

8. Set rotameter to 20 lpm and record the vacuum reading and calculate the required data on the calibration sheet under " Normal Configuration". The corrected rotameter reading is the value of the actual flowrate in slpm with the rotameter set at 20. Enter this value in the blank at the bottom of the page.

9. Remove vacuum guage.

FIGURE 5.7A-2

AIR SAMPLING PUMP CONFIGURATION DURING CALIBRATION



*GUAGE PLACED IN TOP OF ROTAMETER AFTER REMOVAL OF SLIDE COVER AND THREADED PLUG-BALL STOP.

2-25-82 DL

WYOMING FUEL COMPANY
CROW BUTTE PROJECT

SUMMARY OF RADON GAS SURVEYS

SURVEY PERIOD ______________

LOCATION I.D.	LOCATION DESCRIPTION	DATE	PRESENT µCi /ml	PREVIOUS µCi/ml	RECOMMENDED ACTION

REMARKS:

WYOMING FUEL COMPANY
CROW BUTTE PROJECT

SUMMARY OF RADON DAUGHTER SURVEYS

SURVEY PERIOD ______________

LOCATION I. D.	LOCATION DESCRIPTION	DATE	PRESENT WORKING LEVEL	PREVIOUS WORKING LEVEL	RECOMMENDED ACTION

REMARKS:

WYOMING FUEL COMPANY
CROW BUTTE PROJECT

SUMMARY OF AIRBORNE URANIUM SURVEYS

SURVEY PERIOD ______________

LOCATION I.D.	LOCATION DESCRIPTION	DATE	PRESENT URANIUM CONCENTRATION µCi /ml	PREVIOUS URANIUM CONCENTRATION µCi /ml	RECOMMENDED ACTION

REMARKS:

882 DL

WYOMING FUEL COMPANY
CROW BUTTE PROJECT

RECORD OF GAMMA RADIATION SURVEYS

SURVEY PERIOD ________________ NAME ________________

INSTRUMENT IDENTIFICATION

Manufacturer ____________________ Serial No. ____________________

Model No. ____________________ Calibration Date ____________________

LOCATION I.D.	LOCATION DESCRIPTION	DATE	PRESENT GAMMA LEVEL mr / hr	PREVIOUS GAMMA LEVEL mr / hr	RECOMMENDED ACTION

REMARKS:

882 DL

WYOMING FUEL COMPANY
CROW BUTTE PROJECT

SUMMARY OF BIOASSAY RESULTS

NAME ______________________ I D NUMBER ______________________

TIME PERIOD	WORK CATEGORY	DATE SAMPLED	RESULTS ($\mu g U/l$)	ACTION TAKEN	REVIEWED BY	DATE
Initial	*Prior to starting employment*			*Background Sample*		

REMARKS:

882 DL

WYOMING FUEL COMPANY
CROW BUTTE PROJECT

RECORD OF BIOASSAY SAMPLE COLLECTION AND HANDLING

NAME	EMPLOYEE ID NUMBER	WORK CATEGORY	DATE BOTTLE DISTRIBUTED	DATE BOTTLE RETURNED	DATE SENT TO LABORATORY	NAME OF LABORATORY	DATE RESULTS RETURNED	RESULTS ($\mu gU/l$)

WORK CATEGORIES:

D - Dryer operation or maintenance

Op - Operator

M - Maintenance

L - Laboratory

W - Wellfield

O - Other (Explain)

WYOMING FUEL COMPANY
CROW BUTTE PROJECT

RADIATION EXPOSURE RECORD

NAME ______________________ SOCIAL SECURITY NO. ______________

JOB TITLE ______________________ DATE OF BIRTH ______________

PERIOD: FROM ________ TO ________
MO. DAY YR. MO. DAY YR.

WEEK ENDING	WORK AREA NO.	LOCATION DESCRIPTION	OCCUPANCY hrs.	GAMMA EXPOSURE RATE mr / hr	EXPOSURE mr	WORKING LEVELS W L	EXPOSURE WLM	URANIUM CONCENTRATION µCi /ml	URANIUM INTAKE µCi
METHOD OF DETERMINING OCCUPANCY:				TOTAL EXPOSURE THIS PERIOD					
☐ FROM EMPLOYEE				PREVIOUS QUARTER TO DATE EXPOSURE					
☐ FROM SUPERVISOR				EXPOSURE FOR THIS QUARTER					
☐ TIME STUDY				PREVIOUS YEAR TO DATE EXPOSURE					
				YEAR TO DATE EXPOSURE					

WYOMING FUEL COMPANY
CROW BUTTE PROJECT
AIR SAMPLING PUMP CALIBRATION

Ambient Temperature ^{o}C ____________ (a)   Date ____________

Ambient Barometric Pressure in Hg ____________ (b)   Filter Type ____________

Pump Serial No. ____________   Filter Diameter ____________

(c) Rotameter Setting	(d) Mass Flow Meter Reading slpm	(e) Vacuum Guage Reading in Hg	(f) System Pressure (b-e) 25.4 mm Hg	(g) Corrected Rotameter Reading $\left(c \times \sqrt{\frac{f}{760}} \times \sqrt{\frac{298}{a+273}}\right)$	% Error $\left(\frac{g-d}{d} \times 100\right)$
10					
20					
30					
40					
40					
30					
20					
10					
Normal Configuration					
20	---				---

Flow rate with rotameter set at 20 = ____________ slpm

Signature ____________________

WYOMING FUELS COMPANY

CROW BUTTE PROJECT

AIR PARTICULATE SAMPLING RECORD

Air Monitoring Station No. ____________ Rotameter Setting ____________

Pump Serial No. ____________ Flow Rate ____________ slpm

START				END				Elapse Time(min.)	Average Flow Rate slpm	Volume of Air Sampled
Date	Time	Rotameter Setting	Initials	Date	Time	Rotameter Setting	Initials			

Total volume of air sampled during the quarter ____________

WYOMING FUEL COMPANY
RADON SAMPLING AND ANALYSIS FORM

RADON SAMPLING DATA

Air Monitor Station No. ________

Gas Collection Bag No. ________

Sample Composite No. ________

Comments:

Initials ________

Start Collection: Date ________

Time ________ am/pm

End Collection: Date ________

Time ________ am/pm

Elapse Time: (hrs) ________

Midpoint of Collection (a): Date ________

Time ________ am/pm

RADON ANALYSIS DATA

Date ________

Cell No. ________

Cell eff. ________ cpm/pCi/l (b)

Cell Background Total Counts ________

Count Time ________

Counts Per Minute ________ (c)

(d) Time	________ am/pm	________ am/pm
(e) Sample Counts	________	________
(f) Count Time	________	________
(g) Counts Per Minute (e/f)	________	________
(h) Net Counts (g-c)	________	________
(i) Cell Concentration pCi/l (h/b)	________	________
(j) Elapse Time (hrs) (d-a)	________	________
(k) Decay Correction $(e^{7.55 \times 10^{-3} j})$	________	________
(ℓ) Corrected Radon Concentration (ixk)	________	________
(m) Average Concentration pCi/l	________	
(n) Standard Deviation $\left(\pm\sqrt{\Sigma(\ell - m)^2}\right)$	________	
(o) Range at 95% Confidence (8.98n)	________	
(p) Radon Concentration (m±o)	________	

SECTION 6.0

GROUNDWATER QUALITY RESTORATION, SURFACE RECLAMATION, AND PLANT DECOMMISSIONING

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6. GROUND-WATER-QUALITY RESTORATION, SURFACE RECLAMATION, AND PLANT DECOMMISSIONING

One of the primary objectives of the R&D Project is to demonstrate restoration capabilities at the site for this particular ore body. In most cases methods to be used are those commonly accepted in the industry. Aquifer restoration is, however, a developing field and testing of promising new methods may be desirable.

Information is presented in this section according to the outlines of USNRC Regulatory Guide 3.46 (Task FP818-4) and Staff Technical Position Paper WM8102 "Ground Water Monitoring at Uranium In-Situ Solution Mines," (1981).

6.1 Ground Water Quality Restoration

Mining and ground water restoration will take place in two phases at this site. The eastern five-spot well pattern is designated primarily as a restoration demonstration. That unit will be mined-out quickly, within a period of approximately six months. Ground water restoration should be accomplished within an additional 6 to 8 months. Mining of the two units will be initiated at the same time, however due to its larger size, uranium recovery may take up to 12 months in the western well pattern. This pattern will be utilized to test various lixiviant or oxidant concentrations and well spacings. Nine to 12 months are allowed for restoration of this area.

The combined well patterns occupy 0.34 ha (0.83 ac) as outlined by the perimeter injection wells. It is estimated that leach solution extending beyond the injection wells will occupy additional areas of 30% in the 0.01 ha (0.03 ac) pattern and 20% in the 0.32 ha (0.79 ac) pattern for a total contacted area of 0.40 ha (0.99 ac). Using a mineralized zone thickness of 4.6 m (15 ft) and porosity of 29%, one pore volume equals 5,319,023 l (1,402,648 gal).

Current estimates are that treatment of between 10 and 15 pore volumes will be required to complete restoration. This hypothesis will be tested by the R&D Project. Of this amount, less than two pore volumes will be waste (R.O. brine) sent to the ponds for disposal by evaporation. The remainder (R.O. permeate) will be recirculated back to the wellfields for clean-water sweep.

The contaminants to be removed during restoration will be those contained in the leach solution (see Section 3, Table 3.0-1). The major constituents are sodium, chloride and sulfate. No difficulties are expected in removing these ions as they exist in a dissociated state and have little tendency for retardation in the aquifer. Initial TDS may exceed normal ground water by up to 1000 percent. The TDS concentration will decrease rapidly during removal of the first few pore volumes and more slowly in following pore volumes, typical of an exponential decay curve. Other ions will be elevated above background concentrations to a lesser degree. These include uranium, vanadium and radium-226.

The primary restoration method will be reverse osmosis surface treatment and clean-water sweep. Other methods or combinations of methods may be used if appropriate. Alternatives may include ground water sweep, ion exchange, activated carbon absorption, surface chemical precipitation and in-situ chemical addition. One objective of the R&D

facility is to determine workable, cost effective restoration methods which can be applied to a commercial situation.

Initially ground water sweep will be used only to bring contaminants inside the pattern perimeter. In this method the concentrated lixiviant is pumped out of the wellfield using the recovery well. Native ground water begins sweeping into the wellfield perimeter displacing lixiviant. Conductivity of the recovered liquid is monitored to determine when a majority of the lixiviant has been removed. This liquid is treated by reverse osmosis to yield a clean-water product and concentrated brine discharge to the ponds.

Reverse osmosis filtration coupled with clean-water sweep will be implemented after a short period of ground water sweep. At this time it appears that a reverse osmosis unit will be used for water treatment, however, another similar unit such as electrodialysis may be substituted without affecting restoration capabilities. Removal of water from the wellfield continues, pumping from either recovery or injection wells. Changing the pumping well location allows new flow streams to be established and more effective flushing of contaminated waters. The clean water product from the R.O. is then injected into the wellfield minus the 10 to 20 percent R.O. reject stream. In essence the same pore volume of water is used to flush the mined aquifer 10 to 15 times.

The small percentage loss of water to waste (10 to 20 percent) allows a cone of depression to be established and draws native ground water into the area. The natural reducing capacity of this water will aid in reprecipitation of any minor and trace elements remaining in solution. This may also be enhanced by addition of a chemical reductant as the final stage of restoration.

At this date one set of samples has been analyzed from the monitor and wellfield baseline wells. Restoration limits can be set once all of the baseline data is compiled.

This data will be submitted when available, together with a listing of proposed restoration levels. It is the intent of Wyoming Fuel Company to restore the ground water to its highest potential premining use category. Individual ground water parameters will at least be returned to levels commensurate with the ground waters highest potential premining use. This will be based on Nebraska ground water classification standards.

All monitor, injection and production wells will be plugged and abandoned prior to final closure of the site and after NRC and Nebraska DEC have accepted ground water restoration. The exception to this will be if the land owner requests that one or more wells be left open.

The plugging method to be used is as follows. Cement will be poured into the well to fill the screened area plus 5 feet above the screen. Bentonite mud is then placed in the casing to within 13 feet of ground surface. This is topped with an additional 10 feet of cement. A hole is then dug around the well, and the top 3 feet of casing removed. The hole is backfilled and the surface revegetated.

6.2 Reclamation of Disturbed Lands

At the end of restoration, disturbed lands within the restricted area will be returned to their premining use. A total of approximately 2.7 ha (6.7 ac) will have been affected by mining activities. The plant area, ponds site, access roads and culvert area will experience the greatest amount of disturbance. During construction of these areas approximately 66,520 m^3 (87,000 yd^3) of soil will be moved. In the construction process approximately 72 percent of this soil will be compacted from a density of $2.1x10^3$ to $2.8x10^3$ g/cm^3 (75.5 to 100 lbs/ft^3).

Reclamation will consist of several operations. Within the wellfield, disturbance will be minimal. Soil may be compacted in areas from the drilling and maintenance traffic. Closure of the wells will also require some surface disturbance immediately surrounding each well. The nonvegetated or disturbed areas will be plowed to aerate the soil. A mixed grass seed mixture and fertilizer will then be spread. Assistance will be obtained from the U.S. Soil Conservation Service to determine the proper seed mix and rate of application.

A culverted crossing is to be constructed across the western branch of the unnamed tributary for the access road. Fill dirt will originate from the pond excavation. During reclamation this earth will be replaced back into the ponds and the tributary slopes reseeded. Roads will be removed and the land surface disked and reseeded. The culvert and road may be left in place at the land owners request.

Preparation of the plant and pond areas will follow standard land reclamation practices. Excess soil from the built-up plant base and pond embankments will be returned to the ponds as fill. Land surface contours will be similar to original contours, although the pond area may be slightly recessed. This is due primarily to the loosely compacted state of the original soil. Final fill will occupy less volume. Finally, topsoil will be replaced on all plant and pond disturbed areas. Reseeding and fertilizing will follow U.S. Soil Conservation Service recommendations.

A period of one to two years will be required to firmly establish grass populations. During this time fences will be maintained to keep livestock out of the area and away from tender vegetation. After that time the land may be returned to its premining use, grazing.

6.3 Plant Decommissioning

Prior to release from the site for unrestricted use all equipment, buildings and other items will be checked for radioactive surface contamination. Records will be kept of equipment and corresponding surface contamination levels for all items released. If contamination exceeds the limits given in Table 6.0-1 (USNRC,1976,1980) further attempts should be made to reduce levels. All items not in compliance with these levels will be disposed of at a site approved for by-product materials, such as an active mill tailings disposal site.

If the R&D test proves successful Wyoming Fuel Company may wish to pursue a commercial scale operation. In that case the company may desire to keep the R&D plant and ponds intact. If so an application and environmental report will be submitted to NRC prior to final decomissioning. An alternative may be to sell the equipment and building to a source material license holder. If so, then equipment and building parts will be cleaned of easily removable contamination prior to shipping. Those final levels may be higher than for unrestricted

TABLE 6.0-1

SURFACE CONTAMINATION LEVELS
FOR URANIUM AND ASSOCIATED DECAY PRODUCTS
(Table from USNRC, 1976,1980)

Average (total)	5,000 dpm alpha per 100 cm^2	Averaged over no more than 1 m^2
Maximum (total)	15,000 dpm alpha per 100 cm^2	Applies to an area of not more than 100 cm^2
Removable	1,000 dpm alpha per 100 cm^2	Determined by smearing with dry filter or soft absorbant paper, applying moderate pressure, and assessing the amount of radioactive material on the smear

release (Table 6.0-1), but will comply with D.O.T. shipping restrictions.

Dismantling of the facility and pond closure will take place after ground water restoration has been confirmed by NRC and Nebraska DEC. Reusable equipment will be segregated from worn-out or scrap items, both types cleaned, and distributed appropriately as determined by residual surface contamination levels. Cleaned refuse may be disposed of in sanitary landfills.

Wellhead and monitoring equipment will be removed and the trunk lines dug up. Well closure is described in sub Section 6.1. Most of this material, except gauges and meters, will not be reusable.

Pond closure will be as follows. First, any remaining liquids will be transferred to tank trucks of suitable construction and shipped to an approved disposal site. Bottom sludge can then be loaded into a tank truck or placed in lined drums for disposal. The pond liners are then cleaned to the degree possible. If after cleaning they meet the limitations for surface contamination, the liners will be cut into smaller pieces, placed in the pond bottoms and covered with soil to final contours. If contamination limits are exceeded the liners will be placed on trucks and hauled to an approved disposal site. Cement from storage pads and the building floor will be decontaminated if necessary, broken up and placed in the pond bottom. Road bed materials and the parking surface area will also go into the pond. Underdrain piping will remain in place or be shipped as appropriate.

Other radioactive solid waste produced by the mining activities will be shipped to an approved by-product disposal site. This may include spent resin, sand from filters, clothing, respirators, soil from spill areas, etc.

6.4 Postreclamation and Decommissioning Radiological Surveys

After the equipment, building and piping have been removed from the wellfield area, a gamma survey will be conducted over the same wellfield grid as was surveyed preoperationally. Results will be compared with those detected initially. Soil samples will then be obtained from locations indicated as "hot spots" and areas of significant recorded lixiviant spills. These surface samples will be analyzed for natural uranium and radium-226 content. Based upon the results, contaminated soil will be removed and shipped to a disposal site if necessary. In certain areas, slightly contaminated soil may be disked with surrounding soil to lower levels to those limits currently acceptable.

The plant area will be comprised of compacted earth, some surface covering material, a cement foundation and the building. Once the building and cement pads have been removed, a walk around gamma survey will be made of the compacted area. Any contaminated areas will be sampled and removed for proper disposal. The compacted area will then be dozed for recontouring, excess soil placed in the pond pits and the topsoil replaced. A final gamma survey will be performed and the results compared with the preoperational survey.

If leaks were detected in a pond liner during operation, then final clean-up may be accomplished once the liner has been cut up. With the subsurface exposed, radiation surveys may be performed and the sand or a subsurface sampled. These areas will be cleaned to currently appropriate standards prior to backfilling of the ponds. Backfill and topsoil will then be replaced and the final gamma survey performed.

Ground water restoration will be accomplished prior to release of the site for unrestricted use. Methods and restoration parameters are described earlier in this section. Once Wyoming Fuel Company decides that restoration is complete, the NRC and Nebraska DEC will be so notified. Stability of restoration will be confirmed by taking three set of samples spaced at monthly intervals from selected wellfield baseline wells. It is anticipated that two wells in each wellfield pattern will be chosen for restoration confirmation sampling. These will be analyzed for the full baseline suite of parameters. A final sample set will be obtained after an additional six month interval. Restoration will be complete if relative geochemical stability is maintained within the wells.

6.5 Financial Assessment

Following is an estimate of costs to be incurred by Wyoming Fuel Company or an independent contractor during restoration, decommissioning and reclamation of the Crow Butte R&D site.

Ground Water Restoration

R.O. Processing ($1.33 per 1,000 gal)(From Riding and Rosswog, 1979)	$18,700 to 28,000
Labor (12 mo., 17 people) (Includes lab and supervision)	500,000 +
Total	$ 528,000

Facility Decommissioning

Building and Equipment-Labor (10 people, 1 month)	50,000
Plug and Abandon Wells (max. 29 at \$500 ea)	14,500
Recontour Pond and Plant Site (80,000 yd^3 at \$.75/yd^3) (Includes equipment & labor)	60,000
Supervision (2 mo., 1 person)	6,000
Total	\$ 130,000

Land Reclamation

Replace Topsoil, Plowing (7,200 yd^3 at \$.75/yd^3)	5,400
Revegetation-Planting, Seed, Fertilizer, Mulch (\$1,500 per acre, 6.7 acres)	10,050
Continued Maintenance-2 years (1 man-year)	25,000
Total	\$ 40,450

By-product Waste Disposal

Quantity

Soil around 18 production/injection wells 3 ft radius, 2½ in. deep = 107 ft^3, 8,000 lbs

Spent resin, 100 ft^3, 4,000 lbs

Filter material, up to 100 ft^3, 10,000 lbs

Pond Sludge, max. 140,000 lbs

Miscellaneous material, 10,000 lbs

Maximum Anticipated By-product Material 172,000 lbs

Disposal

Approximately 5 truckloads, 160 mi one way

Cost - (Estimate only)		20,000
Ground Water Monitoring		
Samples Analysis		15,000
Labor (part-time, 9 mo)		3,000
	Total	$ 18,000

REFERENCES

Riding, J.R. and Rosswog, F.F., Restoration of Ground Water Quality After In-Situ Uranium Leaching, prepared for U.S. Department of the Interior, Bureau of Mines, by Ford, Bacon and Davis Utah, Inc., Contract No. J0275028, August 1979.

U.S. Nuclear Regulatory Commission, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-product, Source, or Special Nuclear Material," Division of Fuel Cycle and Material Safety, November 1976.

U.S. Nuclear Regulatory Commission, "Health Physics Surveys in Uranium Mills," Draft Regulatory Guide and Value/Impact Statement, Task OH710-4, August 1980.

U.S. Nuclear Regulatory Commission, Staff Technical Position Paper, "Ground Water Monitoring at Uranium In-Situ Solution Mines" #WM-8102, December 1981.

SECTION 7.1

ENVIRONMENTAL EFFECTS OF SITE PREPARATION AND CONSTRUCTION

7.1 ENVIRONMENTAL EFFECTS OF SITE PREPARATION AND CONSTRUCTION

This section addresses the environmental effects of site preparation and construction of the proposed R&D facility. The potential effects of construction activities are presented on the local population and the environment.

The site layout for the R&D facility involves a plant building, two solar evaporation ponds, two wellfields and access roads. These and other features will be contained within an area of approximately 20 ac (8 ha). The actual disturbance will be approximately 6.7 ac (2.7 ha). Both of these areas are contained within the Restricted Area (RA) of approximately 80 ac (32.3 ha). The RA location is defined as the N/2 SE/4 Section 19, Township 31 North, Range 51 West, Dawes County, Nebraska.

Site preparation and construction activities will involve topsoil salvaging, pond excavation, building erection, road construction and completion of injection, production and monitor wells. Proposed heavy equipment for construction include dozers, scrapers, motor-graders, a water truck, compaction equipment (sheeps-foot-roller), drilling rigs and heavy trucks (e.g., concrete).

The proposed impact of these operations on the environment and mitigative procedures are as follows.

The principal land use to be impacted by site preparation and construction will be grazing. In the worst case, cattle would be excluded from the entire 80 ac (32.3 ha) RA. Assuming cattle would be excluded from the construction phase through ground water restoration there would be a loss of 2.6 AUM/year to 7.8 AUM/year. The 2.6 AUM/year is based on proper use as determined by field observation of present range condition while 7.8 AUM/year is based on the present stocking rates used in the area. Fencing of this area would have a direct benefit as the present range would be rested and as a result, carrying capacity would increase.

The vegetation will be removed in the construction area. This is an unavoidable impact. There were, however, no threatened or endangered plant species documented within the RA. The vegetation in the RA is dominated by disclimax flora with a low productivity. Considerable opportunity for floristic enhancement exists during revegetation. This vegetation removal is considered a short-term impact with potential long term benefits through reclamation.

There will be minimal short term impacts on wildlife species as a result of construction activities and no long term impacts. There were no documented threatened or endangered mammals, birds, reptiles, amphibians or fish in the RA. The RA provides marginal habitat for big game (mule deer, white-tailed deer) while carnivores (red foxes, coyotes, raccoons, long tailed weasels, stripped skunks) are expected to occur regularly in low numbers.

The nesting territory of raptors, including a pair of golden eagles and a pair of redtailed hawks, lies within the RA. Rough-legged hawks, northern hariers, prairie falcons and kestrals also utilize the RA. Impacts on these species will be in direct proportion to a reduction in suitable prey. This should be minimal as a result of a small disturbance.

In general, wildlife will flee from the area as a result of normal construction activity. Through proper reclamation, it is felt the wildlife habitat for both terrestrial and aquatic species can be enhanced.

Field investigations identified ten new archeological resource locations. These sites are represented by three Native American components, six Euroamerican locations and a buried deposit of undetermined cultural association. Two of these sites identified as 25DW114 and 25DW112 warrant further investigation if they are to be directly impacted. These two resources will not be impacted during construction activities. Therefore, the area has been recommended to be cleared for construction of the R&D facility (see Section 2.4, Regional Historic, Archeological, Architectural, Scenic and Natural Landmarks).

The effects of construction on the hydrologic system should be minimal. During construction there may be increased sediment from adjacent unnamed tributaries to Squaw Creek. This sediment would result from earth moving activities exposing soil to potential wind and water erosion. This condition will be temporary as the site will be stabilized.

Well completion will not adversely affect ground water during the construction phase. Completion methods previously discussed in this application are designed to prevent comingling of aquifers and provide adequate mechanical integrity for use during the operational phase. Well clean-up will result in removing a small volume of water relative to the overall recharge capacity of the zone of well completion. No water users will be impacted as a result of completion of wells.

The effects of construction on the immediate population, which are unavoidable, will result from increased traffic to and from the construction site, noise from heavy equipment, minimal fugitive dust and a slight increase in the work force.

The nearest residence is approximately one-half mile from the proposed R&D facility. Trees and topographic differences between the site and this residence will cut down the visual impact during construction. Further, traffic will normally enter the road to the RA from a topographic low prior to passing this residence's drive. Since there is a one-half mile separation between the proposed construction and the residence, noise should be no problem.

Fugitive dust during construction will be controlled within the RA by watering roads as necessary.

The social and economic effects of construction on the town of Crawford and surrounding area will be slight because of the small scale of activities. The total work force during construction will not stress existing public facilities. Income from salaries are expected to result in increased business and governmental incomes thus having a positive economic impact on the community.

SECTION 7.2

ENVIRONMENTAL EFFECTS OF OPERATIONS

7.2 ENVIRONMENTAL EFFECTS OF OPERATIONS

The major environmental concerns during the operation of the Crow Butte R&D facility are those potential impacts of mining on the groundwater, the radiological impacts, the impacts of evaporation pond leakage (if it were to occur) and disposal of wastes.

Excursions represent a potential effect on the adjacent groundwater as a result of operating the Crow Butte facility. During operations, injection of the lixivant into the wellfield will result in a degradation of water quality compared to pre-mining conditions. Movement of this water out of the wellfield results in an excursion. Excursions of contaminated groundwater in a wellfield can result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units which allow movement of the lixivant out of the ore zone, poor well integrity, and hydrofracturing of the ore zone or surrounding units. Based on information already presented in this application, none of the above are expected to be a problem. This is not to say that an excursion will never occur. Past experience from other R&D leaching projects and Commercial Scale in situ leach projects have shown that when proper steps are taken in monitoring and operating the wellfield, excursions, if they do occur, can be controlled and serious impacts on the groundwater system prevented. Control of excursions at the Crow Butte R&D facility, if they occur, will be accomplished by increasing the negative potentiometric pressure in the wellfield and effectively drawing contaminated water back into the wellfield. The monitoring and sampling program as designed will provide early detection of any lateral or vertical excursions.

The long term impacts on the groundwater quality should be minimal since restoration of the wellfield will be accomplished during operations. The drawdown effects on the aquifer as a result of operations will also be minimal. A discussion of drawdown effects is presented in Section 2.6, Hydrology.

Another potential impact during operations would be evaporation pond leakage or failure. If ponds were to leak uncontrolled, this could potentially contaminate the shallow aquifer (Brule) and contaminate the soil in the area. To mitigate this impact, ponds will be installed having an impermeable synthetic liner and underliner of compacted soil. This dual liner system should prevent uncontrolled seepage. Furthermore, the ponds contain a leak detection system which will be checked daily allowing for the early detection of a leak, thereby minimizing the quantity of leakage. Pond or dam failure could also result in unacceptable contamination of surface and groundwater. Such a failure is highly unlikely since the ponds have been designed and will be constructed to prevent failure of the dikes.

The radiological impacts resulting from the Crow Butte R&D facility should be minimal. Section 7.3, Radiological Effects, of this application discusses in detail the radiological pathways as well as the potential impacts on the population and the environment.

A small volume of solid waste will be generated at the Crow Butte R&D facility. Present plans are to dispose of these solid wastes at an NRC licensed disposal site.

Other potential environmental impacts associated with operations will be those effects on flora and fauna, grazing patterns and socioeconomic effects.

As noted in Section 7.1, Site Preparation and Construction, there should be no threatened or endangered plant or wildlife species impacted. Surface disturbance will result in loss in habitat over the life of operations. Since the disturbance will be small, no significant impacts are expected on these species.

To mitigate the potential for wildlife entering the pond area an 8 ft wildlife proof fence will be constructed around the ponds. In consideration of water fowl landing on ponds, Wyoming Fuel

Company is proposing the use of carbide explosives during peak water fowl migration. Water fowl should not be a serious problem since the proposed R&D facility is not located in a significant water fowl migratory route.

Present grazing patterns in the RA will temporarily be disrupted during operations. The loss of animal units has been discussed in Section 7.1. This impact will be temporary and will be mitigated over the long term through reclamation.

The addition into the Crawford area of approximately 6 to 8 personnel at the R&D facility will not stress public facilities in the area. Incomes derived from the payroll of 17 anticipated employees are expected to benefit the Crawford area through purchased goods and services.

During operations traffic will increase to and from the R&D facility. This traffic, resulting from employees and routine deliveries, will increase fugitive dust slightly. Fugitive dust as well as additional noise should not significantly impact the nearest residences, as they are approximately one-half mile from the proposed site.

SECTION 7.3

RADIOLOGICAL EFFECTS

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7.3 RADIOLOGICAL EFFECTS

An assessment of the radiological effects of the Crow Butte R&D Project must consider the types of emissions, the potential pathways present, and an evaluation of the potential radiological hazard associated with the emissions and pathways. Since the proposed R&D Project is an in-situ operation the particulate emissions normally associated with a conventional mill will not be present. Another source of particulate emissions, a product dryer will not be present since the yellowcake will be stored and shipped as a slurry. The only routine radioactive emission will be radon-222 gas.

Radon-222 is present in the ore body and is formed from the decay of radium-226. The radon dissolves in the lixiviant as it travels through the ore body to a production well, when the solution is brought to the surface the radon is released.

In order to assess the radiological effect of radon-222 on the environment an estimate of the quantity released during the R&D operation must be made. Meteorological data and dispersion models are used to predict the ground level air concentration at various points in the environment. The ingrowth of radon daughters is important and their concentration in the soil, vegetation and animals must be calculated. Finally, the impact on man from these concentrations of radionuclides in the environment must be determined.

In the following sections the assumptions and methods used to arrive at a conservative estimate of the radiological effects of the Crow Butte R&D Project will be discussed briefly. A detailed presentation is included as Appendix 7.3(A). The anticipated effects will be compared to naturally occurring background levels. This background radiation, arising from cosmic and terrestrial sources as well as naturally occurring radon-222, comprises the primary radiological impact to the environment in the region surrounding the proposed project.

7.3.1 Exposure Pathways

Emissions from the Crow Butte R&D Project will be minimal. The proposed project is a small scale in-situ facility. Particulate emissions sources normally associated with conventional mills such as crushing and grinding operations, ore storage pads, and mill tailings ponds will not be present. The product at the facility will be stored and shipped as a slurry, therefore emissions from a product dryer are also eliminated. The only source of radioactive emissions from the facility will be the evolution of radon gas.

This gas will be dissolved in the leaching solution and will be released as the solution is brought to the surface. The evolution of this gas at the production wells will be controlled through the use of covered wellheads. The pump discharge lines will be under pressure and will maintain the gas in solution until it reaches the production surge tank. This tank will be vented through the roof of the plant and will be equipped with a turbine ventilator to draw air out of the tank. The residence time of the solution in the tank will be sufficient to allow the release of a majority of the gas through the vent at a safe level above the plant.

The solution will then be passed through filters and ion exchange columns which will be pressurized and therefore the release of radon gas would be improbable. From these columns the solution will be pumped to an injection surge tank, where it will be refortified with chemicals before being pumped to the wellfield. This tank will be vented in a manner similar to the production surge tank and if any additional radon-222 leaves the solution it would be vented at this location.

The injection wells will be closed and pressurized. This should eliminate them as a source of radon emissions. The evaporation ponds will not contain sufficient radium-226 concentrations to produce significant radon-222 emissions, therefore the ponds are not considered as a source of radon. The primary source of radon will be the production surge tank vent and to a lesser extent the injection surge tank vent. For the purposes of these calculations it will be assumed that the entire quantity of radon present in the leach solution will be released from the production surge tank vent. The height of the vent was assumed to be 7 m (23 ft) above the foundation of the facility.

The atmospheric emission of radon will lead to its presence in all quadrants of the region surrounding the Crow Butte R&D Project. Due to the relatively short half-life of radon-222, the ingrowth of radon daughters during wind blown transportation must be considered. There exists an inhalation pathway as a result of the emission of radon gas. As the radon daughters ingrow, deposition on the ground surface increases. A pathway exists due to external radiation exposure arising from two sources. One source is radon and its daughter in the air, which is considered the cloud contribution. The other source is from radon daughters deposited on the ground, this source being termed the ground contribution.

A third pathway exists, which is the ingestion pathway. This results from direct foliar deposition and radionuclides in the soil being assimilated by the vegetation. The vegetation may represent a direct ingestion pathway to man if consumed and a secondary pathway if fed to animals which are in turn consumed by man.

7.3.2 Exposures From Water Pathways

There will be no planned discharges of liquid effluents containing radionuclides from the Crow Butte R&D Project. The solutions in the zone to be mined will be controlled and adequately monitored to insure that migration does not occur. The overlying aquifers are also monitored. The action to be taken in the event of an excursion, as well as the anticipated environmental effects of such an event have been discussed in Section 7.5.

The evaporation ponds will be lined with an impermeable synthetic liner and therefore the ponds are not considered a source of liquid radioactive effluents. There will be a leak detection system installed to provide a warning if the liner develops a leak. The remedial action and environmental consequences of a liner failure are discussed in Section 5.7.

The Crow Butte R&D plant will be located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment will drain to a sump and be pumped to the ponds. The pad is of sufficient size to contain the contents of the largest tank in the event of its rupture.

Since there will be no routine liquid discharges from the Crow Butte R&D plant there are no definable water related pathways.

7.3.3 Exposures From Air Pathways

The primary source of radioactive emissions is radon-222 released into the atmosphere through a vent in the production surge tank. This release results in radiation exposure via three pathways inhalation, ingestion, and external exposure. The atmospheric concentrations of radon gas at various locations in the region around the Crow Butte R&D Project are estimated using an atmospheric dispersion model similar to the one incorporated into the computer simulation MILDOS (USNRC,1981). The joint frequency data compiled from a five year observation period at the National Weather Service Station located at Scottsbluff, Nebraska were used to define the atmospheric conditions in the project area.

Based on the site specific data and method of estimation presented in Appendix 7.3(A), the emission rate of radon-222 from the Crow Butte R&D Project is conservatively assumed to be 128 Ci/yr. Based on this release rate and average meteorological conditions the concentrations of radon at nine locations were calculated. Table 7.3-1 lists the locations or receptors. The direction and distance from the source of emissions is given in the table as well as the receptor's elevation relative to the R&D facilities foundation. The first six receptors are located on the restricted area boundary. The wind pattern in the region results in a bimodal distribution with prevailing wind directions from both the east-southeast and west-northwest. The closest boundary to the source is at receptor 6 located 256 m (840 ft) to the south of the facility. The location with the highest predicted offsite concentrations is receptor 3 located 265 m (869 ft) to the west on the restricted area boundary. Receptor 7 is at the air monitoring station, AM-1, located at the residence closest to the R&D facility. Receptor 8 is located at another residence in a predominant downwind direction. The air monitoring station AM-2 is located at this residence. Finally since the dose from the ingestion pathway is due to Pb-210 and this radon daughter requires sufficient time to ingrow it is assumed that the ingestion doses result from vegetables grown or cattle grazed 10 km (6 mi) to the west of the facility at receptor 9.

Table 7.3-1 contains the estimated radon-222 concentrations at each of the receptors. Also included in this table is the limit for radon-222 concentrations in unrestricted areas which is listed in 10 CFR Part 20 Appendix B Table II. The location with the highest predicted concentration, receptor 3 is approximately six percent of the limit. The radon-222 concentrations have been adjusted to correct for radioactive decay during transit.

The unit of exposure to radon and its daughters is called a working level. One working level is defined as any combination of radon daughters in one liter of air that will result in the ultimate emission of $1.3 \times 10^{+5}$ MEV. Table 7.3-2 lists the predicted concentrations of radon and its daughters expressed as working levels at each of the receptors. The maximum permissible concentration (MPC) is listed as well as the percentage of the MPC for each location. Also listed in the table are the concentrations of Pb-210, Bi-210 and Po-210.

The dose received from radon daughters is through inhalation and the primary organ dose is to the bronchial epithelium

TABLE 7.3-1

INDIVIDUAL RECEPTOR LOCATION DATA
CROW BUTTE R&D PROJECT

Receptor No.	Location Name	Distance (m)	Direction	Z (m)	Rn-222 Concentration (Ci/m^3)
1	Boundary N	250	N	-10	7.72E-12
2	Boundary ESE	600	ESE	8	3.58E-11
3	Boundary W	265	W	8	1.99E-10
4	Boundary WNW	283	WNW	5	1.47E-10
5	Boundary NNW	274	NNW	-7	7.84E-12
6	Boundary S	256	S	12	8.48E-11
7	AM-1	671	E	8	1.73E-11
8	AM-2	1310	NNW	-14	1.31E-12
9	Garden & Pasture	10000	W	0	5.01E-13
	Maximum Permissable Concentration				3.00E-9

TABLE 7.3-2

RESULTS OF MPC CHECK
CROW BUTTE R&D PROJECT

Receptor Description		Rn-222(WL)	Pb-210	Bi-210	Po-210
Boundary N	Conc., pCi/m^3	4.03E-06	1.44E-09	3.04E-10	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	1.21E-04	3.61E-10	1.52E-12	0
Boundary ESE	Conc., pCi/m^3	3.75E-05	1.20E-07	8.59E-10	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	1.13E-03	3.00E-08	4.30E-12	0
Boundary W	Conc., pCi/m^3	1.26E-04	5.43E-08	1.60E-08	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	3.78E-03	1.36E-08	7.99E-11	0
Boundary WNW	Conc., pCi/m^3	7.62E-05	3.03E-08	0	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	2.29E-03	7.57E-09	0	0
Boundary NNW	Conc., pCi/m^3	3.70E-06	1.56E-09	0	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	1.11E-04	3.90E-10	0	0
Boundary S	Conc., pCi/m^3	5.34E-05	2.01E-08	7.32E-09	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	1.60E-03	5.22E-09	3.66E-11	0

TABLE 7.3-2

RESULTS OF MPC CHECK
CROW BUTTE R&D PROJECT

(Cont.)

Receptor Description		Rn-222(WL)	Pb-210	Bi-210	Po-210
AM-1	Conc., pCi/m^3	2.29E-05	1.14E-07	1.42E-09	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	6.88E-04	2.84E-08	7.11E-12	0
AM-2	Conc., pCi/m^3	2.65E-06	5.31E-08	2.25E-10	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	7.95E-05	1.33E-08	1.12E-12	0
Garden & Pasture	Conc., pCi/m^3	3.86E-06	2.23E-06	1.86E-08	0
	MPC pCi/m^3	3.33E-02	4.00E+00	2.00E+02	7.00E+00
	Fraction of MPC	1.14E-04	5.58E-07	9.30E-11	0

of the tracheobronchial region. Table 7.3-3 lists the doses to the bronchial epithelium at each of the receptors as a result of a one year exposure to the concentrations predicted at each of the receptors. These estimated doses were calculated based on the assumption that 14 hours per day were spent indoors. The dose resulting from exposure to naturally occurring radon levels in the Western Great Plains has been estimated at 560 mrem/year (USNRC,1979a). The increase above this background level predicted for the nearest residence at AM-1 is slightly more than one percent.

An inhalation dose is also received as a result of Pb-210, Bi-210 and Po-210 in the air. The inhalation of these radionuclides results in a dose to the lungs and also a dose to the whole body, bone, liver and kidneys. These doses have been included in the tabulation of the total dose which is presented in Table 7.3-6 of Section 7.3.5.

The airborne radon daughters decay to Pb-210 which can result in an ingestion dose as deposition on the ground occurs. The uptake of the radionuclides from the soil by vegetation can be estimated. Another source contributing to radionuclides in the vegetation is foliar deposition. The radionuclide of primary concern when dealing with the ingestion pathway is lead-210. In order to be sure of a conservative estimate of the radiological effects of the Crow Butte R&D Project, it was assumed that all ingestion doses resulted from vegetation grown 10 km (6 mi) to the west of the facility. This assumption over predicts the significance of the ingestion pathway but should reflect the maximum impact at any of the receptors.

TABLE 7.3-3

INHALATION DOSE FROM
FROM RADON DAUGHTERS

CROW BUTTE R&D PROJECT

Receptor Location	Dose to Bronchial Epithelium (Mrem/yr)
Boundary N	3.01E+00
Boundary ESE	1.50E+01
Boundary W	7.88E+01
Boundary WNW	5.73E+01
Boundary NNW	3.04E+00
Boundary S	3.35E+01
AM-1	7.46E+00
AM-2	6.15E-01
Garden & Pasture	3.84E-01
Natural Background (USNRC, 1979a)	5.60E+01

The concentration of lead-210 in five types of vegetation was calculated. These vegetation types were 1) above ground vegetables, 2) potatoes, 3) other below ground vegetables, 4) pasture grass and 5) hay. The concentration of lead-210 was calculated in meat and milk as a result of raising cattle on 50 percent pasture grasses and 50 percent hay grown 10 km (6 mi) west of the facility.

The fifty year dose commitment to the whole body, bone, liver and kidney resulting from a one year intake of food grown 10 km (6 mi) west of the facility is listed in Table 7.3-4. The fifty year dose commitment is used to express the total dose to the reference organ that will be accrued during the remaining life time of the individual. This is necessary since the biological half-life of some radionuclides is such that they will remain in the body for long periods of time. The exposed individual is assumed to be an adult 20 years of age and live until 70 years of age, hence the term 50 year dose commitment.

7.3.4 Exposure From External Radiation

Exposure to external radiation will arise from two sources at the Crow Butte R&D Project. The primary source is from radionuclides that have been deposited on the ground. A secondary source is from radionuclides that are present in the air. Radon and its daughters are considered the only sources of external radiation at the restricted area boundary.

Table 7.3-5 lists the total dose from external radiation that is predicted at each of the nine receptors. These doses represent exposure from both radionuclides on the ground (ground dose) and radionuclides in the air (cloud dose). The

TABLE 7.3-4
INGESTION DOSE CALCULATED
AT RECEPTOR 9
CROW BUTTE R&D PROJECT

Organ	50 year Dose Commitment (mrem/yr)
Whole Body	5.85E-05
Bone	1.65E-03
Liver	4.70E-04
Kidney	1.32E-03

TABLE 7.3-5

EXTERNAL RADIATION DOSE
CROW BUTTE R&D PROJECT

Receptor No.	Receptor Location	External Radiation Dose (mrem/yr)
1	Boundary N	6.50E-04
2	Boundary ESE	1.33E-02
3	Boundary W	2.23E-02
4	Boundary WNW	1.24E-02
5	Boundary NNW	6.09E-04
6	Boundary S	9.42E-03
7	AM-1	1.01E-02
8	AM-2	1.80E-03
9	Garden & Pasture	5.72E-03
	Normal Background (USNRC, 1979a)	1.27E+02

dose is calculated to the whole body and is assumed equal to the dose to all other organs. The closest boundary is at receptor 6, where the dose is 9.42E-03 mrem/year. The highest predicted dose is at receptor 3 where a dose of 2.23E-02 mrem/yr was calculated. Included in the table is the average dose resulting from expose to natural occurring external radiation in the Western Great Plains (USNRC,1979a). The highest predicted dose, occurring at receptor 3, is only an increase of 0.02 percent above this background figure.

7.3.5 Total Human Exposures

Atmospheric releases of radon-222 result in doses received via three pathways inhalation, ingestion, and external exposure. Table 7.3-6 details the estimated doses from these three pathways at three receptors. Receptor number 3 is included because it represents the site boundary with the highest predicted concentrations. The receptors 7 and 8 are presented since they are located at the two closest residences to the Crow Butte R&D Project.

The highest dose at each location is to the bronchial epithelium and results from inhalation of radon daughters. The inhalation dose from Pb-210 and Po-210 is included in the table. The ingestion dose is assumed to result from consuming vegetables, beef and milk produced at a location 10 km west of the facility. The external radiation dose from the ground and the cloud is presented. The total dose is given and represents the sum of all the pathways. It should be noted that a shielding factor of 0.825 is applied to both external radiation doses before the total dose was calculated. This shielding factor was determined by assuming 14 hours per day are spent indoors during which a shielding factor of 0.7 is used.

TABLE 7.3-6

TOTAL DOSE COMMITMENT
VIA ALL PATHWAYS
CROW BUTTE R&D PROJECT

Receptor Description	Exposure Pathway	Whole Body	Bone	Liver	Kidney	Ave. Lung	Bronchial Epithelium
Boundary W	Inhalation	4.05E-07	1.26E-05	3.21E-06	1.05E-05	3.41E-06	7.88E+01
	Ingestion	5.85E-05	1.65E-03	4.70E-04	1.32E-03	---	---
	External(grd)	5.99E-03	5.99E-03	5.99E-03	5.99E-03	5.99E-03	5.99E-03
	External(cld)	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02
	Total	1.84E-02	2.01E-02	1.89E-02	1.97E-02	1.84E-02	7.88E+01
AM-1	Inhalation	8.48E-07	2.64E-05	6.72E-06	2.19E-05	7.13E-06	7.46E+00
	Ingestion	5.85E-05	1.65E-03	4.70E-04	1.32E-03	---	---
	External(grd)	2.56E-03	2.56E-03	2.56E-03	2.56E-03	2.56E-03	2.56E-03
	External(cld)	7.51E-03	7.51E-03	7.51E-03	7.51E-03	7.51E-03	7.51E-03
	Total	8.37E-03	9.98E-03	8.78E-03	9.65E-03	8.31E-03	7.47E+00
AM-2	Inhalation	3.96E-07	1.23E-05	3.14E-06	1.02E-05	3.33E-06	6.15E-01
	Ingestion	5.85E-05	1.65E-03	4.70E-04	1.32E-03	---	---
	External(grd)	4.39E-04	4.39E-04	4.39E-04	4.39E-04	4.39E-04	4.39E-04
	External(cld)	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03
	Total	1.54E-03	3.15E-03	1.96E-03	2.81E-03	1.49E-03	6.16E-01
Natural Background (USNRC, 1979)		1.53E+02	1.88E+02	1.54E+02	---	---	5.60E+02

The external dose to the whole body is calculated and assumed to be equal to the dose to other organs. For comparison the dose from natural background radiation to the organs of interest for an average individual living in the Western Great Plains is presented in Table 7.3-6 (USNRC,1979a).

The annual population dose commitment to the population in the region within 80 km of the Crow Butte R&D Project is also predicted. The method of calculation is presented in Appendix 7.3(A). The results are contained in Table 7.3-7 where the dose to the whole body, lungs, bone and bronchial epithelium is expressed in terms of person-rems. For comparison the dose to the population within 80 km of the facility due to natural background radiation has been calculated and included in the table. These figures are based on the 1980 population and average radiation doses reported for the Western Great Plains (USNRC,1979a).

The atmospheric release of radon also results in a dose to the population on the North American continent. This continental dose is calculated by comparison with a previous calculation based on a 1 kilocurie release near Casper Wyoming, during the year 1978. The results of these calculations are included in Table 7.3-7 and also combined with dose to the region within 80 km (50 mi) of the facility to arrive at the total radiological effects of one year of operation at the Crow Butte R&D Project.

For comparison of the values listed in Table 7.3-7, the dose to the continental population as a result of natural background radiation has been estimated. This estimate is based on a North American population of 346 million and a dose to each person of 100 mrem/yr to the whole body, bone and lung

TABLE 7.3-7

DOSE TO THE POPULATION
FROM ONE YEARS OPERATION
CROW BUTTE R&D PROJECT

	Dose (person rem/yr)			
	Whole Body	Lungs	Bone	Bronchial Epithelium
Dose received by population within 80 km of the facility	0.050	0.024	0.777	1.50
Natural Background for population within 80 km of the facility	6564.	8066.	6607.	24025.
Dose received by population beyond 80 km of the facility	1.18	0.27	16.1	7.50
Total continental dose	1.23	0.29	16.8	9.00
Natural background for the continental population	3.46E+07	3.46E+07	3.46E+07	1.73E+08
Fraction increase in continental dose	3.55E-08	8.38E-09	4.86E-07	5.20E-08

and a dose of 500 mrem/yr to the bronchial epithelium. The maximum radiological effect of the Crow Butte R&D Project would be to increase the dose to the bone of the continental population by 4.86E-05 percent.

7.3.6 Exposure to Flora and Fauna

In arriving at the ingestion doses, the concentration of Pb-210 in five types of vegetation grown 10 km (6 mi) west of the facility was estimated. The amount of Pb-210 in cattle grazed on pasture grasses and hay grown at this location was then calculated. The results are presented in Table 7.3-8. These values are low compared to a maximum Pb-210 concentration of 7.31E-08 µCi/kg found in vegetation samples collected during the preoperational radiological monitoring program. As can be seen the effect of the facilities operations on flora and fauna in the area will be minimal.

As has been shown in the previous sections, the radiological impact on man of the Crow Butte R&D Project will be slight. The emissions from a small-scale R&D operation such the proposed facility will be so low as to be indistinguishable from natural background levels. The results of calculations such as those previously presented are conservative by nature and must be viewed in the proper perspective. When the results of the calculations are compared to naturally occurring background levels the magnitude of the calculated effects can be seen.

There are no applicable limits for radiation exposure of species other than man, although it is excepted that most species are less radiosensitive than man. Therefore the radiation protection limits applicable to man will be conservative

TABLE 7.3-8

PREDICTED CONCENTRATIONS OF Pb-210
IN VEGETATION AND CATTLE*
CROW BUTTE R&D PROJECT

	Pb-210 µCi/kg
Vegetation (edible portion)	
Above ground vegetables	3.7E-09
Potatoes	3.8E-10
Other below ground vegetables	3.8E-10
Pasture grass	8.1E-09
Hay	3.8E-09
Cattle (muscle concentration)	2.11E-10
Maximum found in vegetation from preoperational monitoring	7.31E-08

* Vegetation grown 10 km (6 mi) west of facility and cattle grazed at same location.

for most other species. Since the results presented in the previous discussions have shown that the radiological effect on man of the Crow Butte R&D facility will be minimal, it can be extrapolated that the radiological effect on biota other than man will not be significant.

APPENDIX 7.3(A)

METHODS USED IN ESTIMATING
THE RADIOLOGICAL EFFECTS

APPENDIX 7.3(A)

Calculation of Airborne Effluent Concentrations. The method used to estimate the ground level concentration of airborne effluent at a particular receptor location is similar to that used in the computer Model MILDOS(NRC 1981). Since the Crow Butte R&D Project will not dry the yellowcake product and it is an in-situ process rather than a conventional mill, there will be no particulate emission from the plant. The only airborne radioactive effluent associ'ted with the process will be radon-222 gas and its daughter products. This fact simplifies the calculation considerably. Resuspension is not consider as a source contributing to the airborne concentrations and radon and its daughters are not assumed to be depleted because of deposition.

The following equation is used to calculate the ground level concentrations

$$X(x,y,i,j) = \frac{Q(y,i,j)}{(\pi/2)^{\frac{1}{2}} \delta_z \bar{u}(\pi x/8)} \exp\left(\frac{-h^2}{2\delta_z}\right)$$

....eq. 1

Where

$X(x,y,i,j)$ = ground level air concentration, Ci/m^{-3}

x = downwind distance, m

y = crosswind distance, m

i = radionuclide i

j = source j

$Q(i,j,y)$ = emission rate, Ci/sec

δ_z = vertical standard deviation of the plume concentration, m

$\bar{u}$ = average wind speed, m/sec

h = effective height of plume centerline, m

$\pi x/8$ = sector width at distance x, m

The mixing layer height is estimated from figures presented by Holworth (1972) and the average mixing layer height calculated as follows:

$$\frac{1}{L} = \frac{1}{2}\left(\frac{1}{L_{am}} + \frac{1}{L_{pm}}\right) \quad \text{.... eq. 2}$$

Where

L = Average mixing layer height, m

L_{am} = mean annual morning mixing layer height, m

L_{pm} = mean annual afternoon mixing layer height, m

The mixing layer height effects the dispersion of effluents only in unstable and neutral conditions since stable conditions limit the dispersion in the vertical direction. The vertical dispersion, δ_z, is calculated using the following equation:

$$\delta_z = (ax)(1+bx)^c \quad \text{.... eq. 3}$$

Where

δ_z = vertical dispersion, m

x = downwind distance, m

a,b,c = contants that are functions of stability (see Table 2.2-2 NRC,1981)

At a distance, x_L the plume reaches the average mixing layer height. At this distance the vertical standard deviation of the plume, δ_z is equal to 0.47 L.

To calculate the ground level concentration at distances greater than $2x_L$ the following equation can be used:

$$X(x,i,j) = \frac{Q(i,j)}{(\pi/8)xL\bar{u}} \qquad \text{.... eq. 4}$$

For distances between x_L and $2x_L$ linear interpolation between equation 1 and equation 4 is used to arrive at a ground level concentration. It should be noted that in stable conditions equations 1 is used to calculate ground level concentrations at any downwind distance.

In equation 1 the effective plume rise, h, is calculated from the following equation:

$$h = h_s + h_m - h_r \qquad \text{.... eq. 5}$$

Where

h	= effective plume height, m
h_s	= stack height, m
h_m	= plume rise due to momentum, m
h_r	= receptor elevation relative to mill center, m

If the receptor is below the elevation chosen as mill center then h_r is negative. The rise due to momentum is calculated as follows:

$$h_m = 1.5\left(\frac{VD}{\bar{u}}\right) \qquad \text{.... eq.6}$$

Where

h_m = plume rise due to momentum

V = exit velocity m/sec

D = stack diameter m

$\bar{u}$ = average wind speed, m/sec

Equations 1 and 4 are used to calculate the ground level concentrations at a particular receptor location without consideration of the actual joint frequency data. The value obtained by equations 1 or 4 must be adjusted by multiplying by the fractional joint frequency of occurrance for the particular wind speed, direction and stability that was used in the calculation. The total ground level concentration is then the sum of the concentrations obtained for all six wind speed classes and all six stability classes in the given downwind direction.

Additionally the source term can be adjusted for receptors that are not located on the midline of a sector. The source term is weighted by the following equation:

$$Q(i,j,y) = \frac{(\pi x/8)-y}{(\pi x/8)} Q(i,j,o) \quad \text{.... eq. 7}$$

where

$Q(i,j,y)$ = emission rate for pollutant, i from source, j, for a crosswind distance y, Ci/sec

$Q(i,j,o)$ = emission rate for radionuclide, i from source j at the midline of a sector

x = downwind distance, m

y = crosswind distance, m

The above calculations are valid for point sources and gaseous emissions, that is deposition and plume depletion are not considered. Since radon is the only radiological emission from the Crow Butte R&D project the calculations above are suitable for estimating its ground level concentration at various distances from the source. Due to the relatively short half-life of radon-222, the ingrowth of radon daughters during transport is important. The radon concentrations are corrected for decay by the following equation:

$$Q(Rn,x) = Q(Rn,o) \exp(-\lambda_{Rn}\tau) \quad \text{....eq 8}$$

Where

$Q(Rn,x)$ = source strength of radon at distance x, Ci

$Q(Rn,o)$ = source strength of radon at time of emission Ci

λ_{Rn} = decay constant, sec^{-1}

τ = transit time, sec

The concentration of radon daughters is calculated with the following equation:

$$X_n = X_1 \left(\prod_{i=2}^{n} \lambda_i\right) \left\{ \sum_{i=1}^{n} \left[\frac{\exp(-\lambda_i \tau)}{\prod_{j=1, j\neq i}^{n} (\lambda_j - \lambda_i)} \right] \right\} \quad \text{.... eq.9}$$

Where

X_n = concentration of daughter n, Ci/m^3

X_1 = concentration of radon, Ci/m^3

λ_i = decay constant, sec^{-1}

τ = transit time, sec

Calculation of the Environmental Concentrations. In order to calculate the dose to individuals from the airborne effluents associated with the Crow Butte R&D Project the concentrations of these radionuclides in various parts of the environment must be predicted. Predicting the ground level air concentrations using the equations in the previous section is the first step. From these airborne concentrations and a deposition rate the ground concentration can be calculated. The following equation is used for this estimate:

$$X_g(i,t) = \frac{1 - \exp -(\lambda_i + \lambda_e)t}{\lambda_i + \lambda_e} \quad X_i \; Vd_i \qquad \text{....eq. 10}$$

Where

$X_g(i,t)$ = ground surface concentration of radionuclide i, a time t, pCi/m^2

t = time interval over which deposition has occurred, sec

λ_e = environmental loss rate constant, sec^{-1}

λ_i = decay constant for radionuclide i, sec^{-1}

X_i = annual average ground level air concentration for radionuclide i, pCi/m^3

Vd_i = deposition velocity for radionuclide i

In all calculations an environmental lost rate contant corresponding to a fifty year half-life is assumed. A depositional velocity of 0.01 m/sec is used for all calculations involving radon daughters.

From ground surface concentrations and the air concentrations the concentration in five categories of plants can be calculated. These five categories are 1) edible above ground vegetables, 2) potatoes, 3) other edible below ground vegetables, 4) pasture grass and 5) hay. The equation used to estimate the radionuclide concentration in vegetation is as follows:

$$C_v(i) = W_i \; F_r \; E_v \left[\frac{1 - \exp\left(-\lambda_w t_v\right)}{Y_v \; \lambda_w} \right] + X_g(i) \; \frac{B_v(i)}{\rho} \qquad \text{....eq. 11}$$

Where

$C_v(i)$	= concentration of radionuclide i in vegetation v (pCi/kg)
W_i	= depositional velocity of radionuclide i $pCi/m^2/sec$
F_r	= fraction of deposition retained on plants (assumed = 0.2)
E_v	= fraction of foliar deposition reaching edible portions of the plant
λ_w	= decay constand due to weathering (assume a 14 day half-life) sec^{-1}
t_v	= duration of exposure for vegetation v (sec)
Y_v	= yield density of vegetation v, kg/m^2
$B_v(i)$	= soil to plant transfer coefficient for radionuclide i and vegetation v
ρ	= soil areal density for plowing (assume 240 kg/m^2)

The value for E_v is assumed to be unity for all above ground edible plants and 0.1 for all below ground plants. Pasture grass is assumed to have a 30 day growth period while all the other categories have a 60 day growth. The yield density for pasture grasses is assumed to be 0.75 kg/m^2 while all other vegetation is 2.0 kg/m^2. The soil to plant transfer coefficients are those listed in Table 3.3-3 of MILDOS (NRC,1981).

The concentrations of radionuclides in beef and milk are calculated from the estimated concentrations in hay and pasture grasses. The following equation is used to calculate the concentrations in beef;

$$C_b = Q\ F_b(i) \left[F_p\ C_p(i) + F_h\ C_h(i) \right] \qquad \text{.... eq. 12}$$

Where

$C_b(i)$	=	concentration of radionuclide i in meat, pCi/kg
Q	=	feed ingestion rate (assumed 50 kg/day)
Fb(i)	=	feed to meat transfer coefficient for radionuclide i (pCi/kg per pCi/day ingested)
$C_h(i)$	=	concentration of radionuclide i in hay, pCi/kg
$C_p(i)$	=	concentration of radionuclide i in pasture grass, pCi/kg
F_p	=	fraction of total feed requirement satisfied by pasture grass
F_h	=	fraction of total feed requirement satisfied by hay

The feed to meat transfer coefficients that were used in all the calculations are those listed in Table 3.3-3 of MILDOS (NRC,1981). The fraction of hay used for the total feed requirement was assumed to be 0.5, the other half of the feed requirement was assumed to be fulfilled by pasture grasses.

Finally the concentration of radionuclides in milk can be estimated using equation 12. In this equation the feed to meat transfer coefficient is replaced with the feed to milk transfer coefficient from Table 3.3-3 in MILDOS (NRC,1981).

Dose Calculations. Now that the environmental concentrations of the radionuclides have been estimated the resulting dose from them can be calculated. The dose conversion factors used are those listed in MILDOS (NRC,1981) and represent the 50 year dose commitment resulting from a one year uptake. The calculation of working levels was based on the method presented in UDAD (NRC,1979).

Inhalation doses were calculated using the foll^wing equation;

$$d_o(inh) = \sum_i X_i \; DCF_{i,o}(inh) \qquad \text{.... eq. 13}$$

Where

$d_o(inh)$ = inhalation dose to organ o (mrem/yr)

(i) = ground level air concentration of radionuclide i

$DCF_{io}(inh)$ = inhalation dose conversion factor for radionuclide i and organ o

Inhalation doses are assumed to arise from exposure to Pb-210 and Po-210.

The ingestion dose is normally calculated for four different age groups. When the ingestion dose is calculated at individual receptor locations the adult age group is assumed. When the regional ingestion doses are calculated all four age groups are assumed to be present. One-half of the radionuclide concentration in vegetation is assumed to be lost during food preparation. The total ingestion rate is calculated as follows:

$$I_{ia} = U_{ma}\ C_m(i) + U_{ba}\ C_b(i) + 0.5 \sum_v U_{va}\ C_v(i) \quad .... \text{ eq.14}$$

Where

I_{ia} = activity ingestion rate for radionuclide i and age group a, (pCi/yr)

U_{ma}, U_{ba}, U_{va} = milk, beef and vegetable ingestion rate for age group a (l/yr or kg/yr)

$C_m(i)$, $C_m(i)$, $C_v(i)$ = concentration of radionuclide i in milk, beef or vegetables

The calculation of the ingestion dose resulting from the ingestion rate calculated above is as follows:

$$d_{oa}(ing) = \sum_i I_{ia} DCF_{ioa}(ing) \quad .... \text{ eq.15}$$

Where

d_{oa} = ingestion dose for organ, o and age group a (mrem/yr)

I_{ia} = ingestion rate of radionuclide i and age group a (pCi/yr)

$DCF_{ioa}(ing)$ = dose conversion factor for radionuclide i, organ o, and age group a, (mrem/pCi)

The external exposure dose arises from two sources; 1) airborne gamma emitters (cloud dose) and 2) ground contaminated with gamma emitters (ground dose). As in MILDOS (NRC,1981) a shielding factor of 0.825 is assumed, which corresponds to an indoor residence time of 14 hours per day at a shielding factor of 0.7. The total external radiation dose is calculated using the following equation:

$$d_o(ext) = 0.825\sum_i X_g(i)\ DCF_{io}(grd) + X_i\ DCF_{io}(cld) \quad .... \text{ eq.16}$$

Where

$d_o(ext)$ = external dose to organ o

$X_g(i)$ = ground concentration of radionuclide i (pCi/m^2)

$DCF_{io}(gnd)$ = dose conversion factor for exposure of organ o to ground concentrations of radionuclide i ($mrem/yr$ per pCi/m^2)

$DCF_{io}(cld)$ = dose conversion factor for exposure of organ o to a cloud of radionuclide i ($mrem/yr$ per pCi/m^3)

X_i = ground level air concentration of radionuclide i, (pCi/m^3)

A working level is defined as any combination of radon daughters resulting in the ultimate emission of $1.3x10^{-5}$ MEV. The method of calculating working levels for this estimation is similar to the method described in "Tne Uranium Dispersion and Dosimetry (UDAD) Code" (USNRC,1979b). The working level conversion factors listed in UDAD are used in these computations.

The exposure resulting from to a given working level is calculated in the same manner as that in UDAD. The dose is calculated for the bronchial epithelium of the tracheo-bronchial region. Indoor exposure assumes 50% equilibrium between radon and its daughters, and the following equation is used to calculate the dose from exposure to radon and its daughters;

$$d(BE,Rn) = 0.625\ f_i\ X_{Rn} + 1.25x10^5(1-f_i)(WL) \quad .... \text{ eq.17}$$

Where

d(BE,Rn)	=	dose to the bronchial epithelium from radon and its daughters (mrem/yr)
0.625	=	conversion factor in mrem per pCi/m^3
f_i	=	fraction of indoor exposure
X_{Rn}	=	ground level air concentration of radon (pCi/m^3)
$1.25x10^5$	=	conversion factor mrem/WL
WL	=	outdoor working level

In the estimated doses arising from operation of the Crow Butte R&D Project, the inhalation dose from Rn-222 and its daughters through Po-214 is calculated by the method stated above. This dose is to the bronchial epithelium. The inhalation doses from Pb-210 and Po-210 are calculated to the whole body, bone, kidney, liver and the mass average lung. A particle size of 0.3 microns is assumed. The ingestion dose is assumed to result from Pb-210 and is calculated for the whole body, bone, kidney and the liver. The dose from external radiation is calculated to the whole body and these values are assumed to be equivalent to the doses received by the other organs. The contribution from the ground and cloud components are summed to arrive at the total exposure from Rn-222, Po-218, Pb-214, Bi-214 and Pb-210.

Regional Dose Calculations. The annual population dose commitment is calculated and is the dose received by the population for a one year exposure and consumption period with a fifty year dose commitment. Population doses are calculated for the region within an 80 km (50 mi) radius of the Crow Butte R&D Project. The area within the 80 km radius is subdivided with sixteen angular intervals and twelve concentric rings resulting in 192 sectors. The air and ground concentrations are calculated at each sector midpoint. Individual inhalation and external exposure doses resulting from these doses are multiplied by the population in each sector, converted to rems and summed overall the sectors. The result is an exposure expressed as person-rems/yr.

The ingestion doses are calculated based on regional agricultural production and not population. The agricultural production factors listed in Table 4.2-6 of MILDOS for South Dakota were used in these estimates (USNRC,1981). The air and ground concentrations for each sector are used with the area of the sector and agricultural productivity rate to calculate the total activity in each food group for the sector. The total activity in the region is determined by summing over all spacial intervals. The doses are calculated by assuming the age distribution in the region is the same as that for the United States and using the appropriate dose conversion factors and intake rates.

The following equation was used to calculate the inhalation and external radiation dose to the population in the region surrounding the Crow Butte R&D Project.

$$PD_o(inh\&ext) = 10^{-3} \sum_{s=1}^{192} P_s[d_{os}(inh) + d_{os}(ext)] \qquad \text{..... eq.19}$$

Where

$PD_o(inh\&ext)$= the population dose to organ o from inhalation and external radiation (person-rem/yr)

P_s = population in sector s

$d_{os}(ext)$, $d_{os}(inh)$ = dose to organ o in sector s from external or inhalation pathways (mrem/yr)

To calculate the total activity in the food in area around the Crow Butte project the following equation is used:

$$Q_{fi} = \sum_{s=1}^{192} G_f \, A_s \, C_{fs}(i) \qquad \ldots\ldots \quad \text{eq.19}$$

Where

Q_{fi} = the total activity from radionuclide i in food f (pCi)

G_f = production rate of food f ($kg/yr/km^2$ or $l/yr/km^2$)

A_s = area of sector s (km^2)

$C_{fs}(i)$ = concentration of radionuclide i in food f in sector s

The total ingestion dose is calculated by the following equation:

$$PD_o(ing) = 10^{-3} \sum_f \sum_i \sum_s E_f \, Q_{fi} \, F_{fa} \, DCF_{ioa} \qquad \ldots\ldots \ \text{eq. 20}$$

Where

$PD_o(ing)$ = population ingestion dose to organ o (person-rem/yr)

E_f = fraction of activity left in food f after preparation

Q_{fi} = total activity of radionuclide i in food f (pCi)

F_{fa} = fraction of the production of food type f ingested by individuals in age group a

$DCF_{ioa}(ing)$ = dose conversion factor for radionuclide i, organ o and age group a (mrem/yr per pCi ingested)

The dose to the continental population from radon is estimated by comparison with the results obtained previously for an assumed 1 k Ci release from a site near Casper Wyoming. The doses resulting from this 1 k Ci release are listed in Table 3.3-10 of MILDOS (USNRC,1981).

The total population dose is the sum of the inhalation, external radiation, and ingestion doses and the continental population dose from radon.

The equations that have been described were used to arrive at the estimated doses listed in Section 7.3. They were taken from MILDOS and only changed to reflect the fact that radon was the sole source of radioactive effluents (USNRC,1981).

The joint frequency data required for the atmospheric dispersion model were obtained in Scottsbluff, Nebraska and are tabulated in Appendix 2.5(A). The population and land use information are detailed in Sections 2.2 and 2.3. Table 7.3(A)-1 lists the required input parameters that are specific to the Crow Butte R&D Project. A detailed site plot plan is contained in Section 3.0 and numerous topographic maps of various scales are presented throughout the report.

Table 7.3(A)-2 contains the coordinates of the source and the various receptors used in the calculations. In all cases the ingestion doses were calculated assuming the vegetables and cattle came from a farm located 10 km west of the Crow Butte R&D Project area. This was done to allow a conservative estimate of the ingestion dose, since Pb-210 would have sufficient ingrowth time during transit. Finally Table 7.3(A)-3 lists the calculational method used to estimate the radon release from the Crow Butte R&D Project. The calculations are similar to those used by the USNRC for evaluation of the Teton Project, an in-situ project in Wyoming (USNRC,1982). The residence time for the production and restoration solutions was estimated at 7 days. This is a conservative estimate and serves to over estimate the radon emissions. Also it is assumed that the leaching solutions contact only mineralized sands. It should be noted that the flow rates used in the calculation are the maximum design specifications for the facility. As a result of these assumptions the calculated annual emission rate of 128 Ci per year is felt to be a conservative prediction.

TABLE 7.3(A)-1

SITE SPECIFIC INFORMATION

CROW BUTTE R&D PROJECT

Parameter	Value
Average ore quality, U_3O_8, in ore body (R&D wellfield area only)	0.36%
Ore Radon-222 activity, assuming equilibrium with U-238	1012 pCi/g
Operating days per year (plant factor)	365 days
Dimensions of ore body	
Area per year to be mined	0.00405 km^2
Average thickness of body	1.5 meters
Average screened interval	4.6 meters
Average production flow rate	378 lpm
Formation porosity	28%
Process recovery	95%
Leaching efficiency	50%
Rock density	1.92 g/cm^3
Restoration flow rate	378 lpm
Production cell parameters	
Residence time	assume 7 days
Type of cell pattern	variable
Radius	20, 28, 40, m
Average cell flow rate	189 lpm
Annual Rn-222 emission from production	128 Ci/yr
Annual Rn-222 emission from restoration	128 Ci/yr
Source stack description	surge tank vent
Stack height	7 m
Stack diameter	0.18 m
Stack exit velocity	2.0 m/sec

TABLE 7.3(A)-2

SOURCE AND RECEPTOR COORDINATES

CROW BUTTE R&D PROJECT

	East (km)	North (km)	Elevation (m)
Sources			
1. Surge Tank Vents	0	0	7
Receptors			
1. North Boundary	0	0.25	-10
2. East Southeast Boundary	+0.554	-0.23	8
3. West Boundary	-0.265	0	8
4. West Northwest Boundary	-0.261	0.108	5
5. North Northwest Boundary	-0.105	0.253	-7
6. South Boundary	0	-0.256	12
7. AM-1	0.671	0	8
8. AM-2	-0.501	1.210	-14
9. Pasture & Vegetation Garden	-10.0	0	0

TABLE 7.3(A)-3

CALCULATION OF ANNUAL RADON EMISSIONS

CROW BUTTE R&D PROJECT

1. To calculate the concentration of radon per cubic foot of ore assume secular equilibrium with U-238

$$(28300\ cm^3/ft^3)(1.92\ g/cm^3)(1-0.28)(1012\ pCi/gm)(10^{-12}\ Ci/pCi) = 3.96x10^{-5}\ Ci/ft^3$$

2. Assuming an emanation coefficient of 0.20 and pore space of 28%, the concentration of radon in a cubic foot of water is

$$(3.96x10^{-5}\ Ci/ft^3)(1/.30)(.20)=2.64x10^{-5}\ Ci/ft^3 \text{ of } H_2O$$

3. The radon released from a production flow rate of 100 gpm

$$(100\ gal/min)(0.1337\ ft^3/gal)(1440\ min/day)(365\ day/yr)(2.64x10^{-5}\ Ci/ft^3) = 185\ Ci/yr$$

4. Assuming a seven day residence time and an equilibrium value for radon of 0.69

$$(0.69)(185\ Ci/yr) = 128\ Ci/yr$$

REFERENCES

United States Nuclear Regulatory Commission, Draft Environmental Statement Related to the Operation of the Teton Project, NUREG-0925, Washington, D.C., June, 1982.

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SECTION 7.4

NONRADIOLOGICAL EFFECTS

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7.4 NONRADIOLOGICAL EFFECTS

In this section the anticipated environmental effects of routine discharges of nonradioactive wastes are presented. The relatively small scale of the proposed R&D facility and the short duration of its operation will serve to decrease the already minimal effects associated with the in-situ uranium process. The effects of plant construction and operation as well as radioactive emissions have been discussed in previous sections.

Two gaseous nonradiological effluents are anticipated at the Crow Butte R&D Project. Hydrochloric acid will be stored on site. The storage tank will be equipped with a limestone scrubber to remove hydrogen chloride gas from the air passing from the vent. The other gaseous effluent will be carbon dioxide that is liberated during the precipitation process.

To predict the concentration of hydrogen chloride in the region around the mill, its rate of release must be estimated. The following assumptions were used in the estimate.

1. Hydrogen chloride gas is emitted from the scrubber only during the process of filling the tank.
2. The acid concentration is 32% with a temperature of 10°C (50°F) and a partial pressure of 11.8 mm Hg.
3. One tank truck delivery is 1,497 kg (3,300 lb) of acid and it requires one hour to fill the tank.
4. The scrubber efficiency is 99%.
5. Emissions occur from a scrubber vent 3. m (9.8 ft) above the facilities foundation. The vent has a diameter of 0.20 m (8. in) and a flow velocity of 0.2 m/s (.66 ft/s).

The estimate of hydrogen chloride gas released during the tank filling process is 3.2 g. Using this source term, the atmospheric dispersion calculations presented in Appendix 7.3A and the average meteorological condition, the highest concentration of hydrogen chloride is anticipated at the restricted area boundary 265 m (869 ft) to the west of the facility. At this location a concentration of 2.5×10^{-2} $\mu g/m^3$ is predicted. The threshold limit value for hydrogen chloride is 7000 $\mu g/m^3$. This predicted concentration is very low and only occur during the one hour required to fill the tank. This tank will only be filled three to four times during the life of the project. The effects of this emission on the region surround in the Crow Butte R&D Project will be insignificant.

To predict the increased levels of carbon dioxide in the atmosphere around the facility its emission rate must be determined. This gas is evolved during the neutralization step of the precipitation circuit. From the chemical consumption data presented in Section 3, there will be 1.6×10^{-4} gms of CO_2 evolved daily. Using the atmospheric dispersion calculations from Appendix 7.3A, the predicted concentration of CO_2 at the western restricted area boundary is 6.6 $\mu g/m^3$. This concentration is small compared to a normal atmospheric concentration of CO_2 of 650,000 $\mu g/m^3$. As can be seen in the discussion above the release of CO_2 from the facility should produce no measurable effects on the environment.

There will be a small diesel generator on site to serve as emergency back-up power in the event of electrical power loss. This generator will produce both particulate and gaseous emissions typical of similar sized generators but its operation will be rare and only for short intervals.

There will be an increase in the total suspended particulates (TSP) in the region as a result of the Crow Butte R&D Project. This increase in TSP will be greatest during the short time required for site preparation. Revegetation will be performed quickly to mitigate the problems associated with the resuspension of dust and dirt from disturbed areas. All areas disturbed during construction will be revegetated during the operation of the facility with the exception of the plant area pad, the roads, and areas covered by the pond liner. Of these the most significant source will be dust emissions from unpaved roads. The amount of dust can be estimated from the following equation which is taken from <u>Supplement No.8 for Compilation of Air Pollutant Emission Factors</u> (USEPA,1978)

$$E = (0.81s)\left(\frac{S}{30}\right)\left(\frac{365 - w}{w}\right)$$

Where

E = emission factor, lb/vehicle-mile

s = silt content of road surface material, 40%

S = average vehicle speed, 30 mph

w = mean number of days with 0.01 inches or more of rainfall, 85

Using the values stated above the emission factor is equal to 0.25 lb/vehicle-mile. The distance from the facility to Highway 71 is 3 miles one-way. Assuming 20 employees, a five workday week and a 25% increase to allow for additional traffic the total mileage on dirt roads is 750 mi/week. This corresponds to a dust emission of 4.9 ton/yr as a result the increased traffic on dirt roads. This additional traffic will represent a small increase in that already present and if the dust present a problem the emissions can be reduced by the appropriate control procedures such as the use of dust control chemicals on the road surface. The duration of increased suspended particulates will be short, on the order of two years. At the time of reclamation the TSP will increase but after the revegetated growth takes hold the TSP should return to premining levels.

All of the airborne emissions presented above will have minimal impact on the environment. At no time during the life of the project is it anticipated that the ambient air quality standard of the State of Nebraska will be exceeded. These standards are included in Table 7.4-1.

During construction, there is a possibility that sediment load may increase in Squaw Creek. A culvert will be installed in one branch of the unnamed tributary where it will be crossed by an access road. If rain, producing runoff occurs during construction some of the fill may be carried into the creek. Significant precipitation during construction of the ponds and plant might also produce the same effect. Plant cover for erosion control will be established as soon as possible on exposed areas. Little additional suspendable material should be produced during operation and ground water restoration. Site reclamation with backfilling of the ponds, grading the plant site, and replacing topsoil will also expose unsecured soil for suspension in runoff waters. The increased sediment load as a result of precipitation during construction or restoration should not significantly effect the quality Squaw Creek since the streams more sensitive areas are located upstream from the tributaries point of entry.

TABLE 7.4-1

AMBIENT AIR QUALITY STANDARDS

OF THE STATE OF NEBRASKA*

Particulate Matter

Primary standards

75 micrograms per cubic meter annual geometric mean

260 micrograms per cubic meter maximum 24-hour concentration not to be exceeded more than once a year

Secondary standards

60 micrograms per cubic meter annual geometric mean

150 micrograms per cubic meter as a maximum 24-hour concentration not to be exceeded more than once a year

Sulfur dioxide

Primary standards

80 micrograms per cubic meter (0.03 ppm) annual arithmetic mean

365 micrograms per cubic meter (0.14 ppm) as a maximum 24-hour concentration not to be exceeded more than once a year

Secondary standard

1300 micrograms per cubic meter (0.5 ppm) as a 3-hour concentration not to be exceeded more than once per year

Nitrogen dioxide

Primary and secondary standards

100 micrograms per cubic meter (0.05 ppm) annual arithmetic mean

Carbon monoxide

Primary and secondary standards

10 milligrams per cubic meter (9.0 ppm) as a maximum 8-hour concentration not to be exceeded more than once a year

40 milligrams per cubic meter (35 ppm) as a maximum 1-hour concentration not to be exceeded more than once a year.

Ozone

Primary and secondary standards

235 micrograms per cubic meter (.12 ppm) as a maximum 1-hour concentration not to be exceeded more than one day a year

Hydrocarbons

Primary and secondary standards

160 micrograms per cubic meter (0.24 ppm) as a maximum 3-hour concentration (6 a.m. to 9 a.m.) not to be exceeded more than once a year

* Source: NAPC, 1975

The effect of the production phase of the project on water levels in the Chadron aquifers was discussed in 2.6.1. During this phase of the project the water level in wells located in Crawford that are completed in the Chadron Formation are expected to decrease by 0.04 m (0.12 ft). This amount of draw down will be masked by normal fluctuations in the water level. It has been estimated that during the ground water withdrawal that occurs in the restoration process the water levels in Crawford may decrease by a maximum of 15 cm (6.in). This decrease should not have any significant effect on the water use in the area. The majority of the population in the area that use ground water as a source of water, complete their wells in the Brule Formation and this aquifer will not be impacted by the mining operation. The water supply in the town of Crawford is the White River and not the Chadron aquifer. As a result the proposed mining activities will alter the water use patterns in the area very little. The drawdown in the water level experienced in the Chadron aquifer at the town of Crawford will return to normal levels after restoration is completed at the Crow Butte R&D Project.

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system. The septic system will meet the requirements of the state of Nebraska. These systems are in common use throughout the United States and the effects of the system on the environment is known to be minimal.

From the above discussion can be seen that the effects of the planned discharges of nonradioactive effluents from the Crow Butte R&D Project will be insignificant. This is due to the small volumes of effluents, their generally benign environmental effects and the short life expectancy of the facility.

REFERENCES

Nebraska Air Pollution Control, Rules and Regulations, State of Nebraska, Department of Environmental Control, June 1975.

United States Environmental Protection Agency, Supplement No. 8 for Compilation of Air Pollutant Emission Factors 3rd, PB-288-905, Research Triangle Park, NC, May 1978.

SECTION 7.5

EFFECTS OF ACCIDENTS

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7.5 EFFECTS OF ACCIDENTS

Two major types of accidents may be associated with an in-situ uranium mining facility: 1) those involving radioactive materials and 2) nonradiological accidents of a chemical or physical nature. For each, varying degrees of impact may be experienced. The probability of occurrence and effects of accidents at the Crow Butte R&D site are discussed in this section. This information is provided in accordance with USNRC Regulatory Guide 3.46(Task FP818-4).

7.5.1 Accidents Involving Radioactivity

Three classes of potential radiological accidents may be associated with an R&D project. The severity of their effects is judged by the amount of radioactivity which could be released and the likelihood of retrieval.

Large Releases. Large releases to the environment are those accidents which could involve surface or subsurface contamination by leaching or waste solutions in sizable quantities. Such potential accidents are undetected leachate migration and loss of pond integrity.

Mining fluids are normally maintained in the production aquifer within the immediately vicinity of the wellfield. The function of the encircling monitor well ring is to detect any lixiviant which may migrate away from the production area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with in-situ mining. Although it is highly unlikely, it can be hypothesized that an excursion of leachate might pass the monitor well ring undetected.

A radioactive release due to an undetected excursion is unlikely at this project, however. The two small R&D wellfields will be surrounded by a ring of eight monitor wells. These wells are located no further than 61 m (200 ft) from the wellfields and are screened in the ore-bearing Chadron aquifer. Additionally, monitor wells will be placed in the first overlaying aquifer above each wellfield segment. Sampling of these wells will be on a biweekly basis as described in Section 5.7.8. Past experience at R&D and commercial operations has proven this monitoring system to be effective in detecting leachate migration. The total effect of close proximity of the monitor wells, low flow rate from the two well-patterns (maximum of 378 lpm), and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion remote.

If an undetected migration were to occur the effect can be projected. First, in a horizontal excursion the quantity would have to be small to escape notice by the monitor well ring. Dilution would occur as the fluid traveled. Second, the native ground water has reducing capacity as is evidenced by presence of the uranium ore body and the hydrogen sulfide odor. Toxic elements such as uranium, arsenic, selenium and vanadium would be reduced and precipitated as dilution by the native ground water takes place. Elements like radium-226 may be retarded by absorption on clays. In essence, natural restoration should occur within a relatively short distance.

Migration of fluids to overlaying aquifers is also considered. Several controls are used to prevent this. First, Wyoming Fuel Company has plugged all exploration holes to prevent comingling of Brule and Chadron aquifers and to isolate the mineralized zone. Successful plugging was tested by conducting a hydrologic test in the proposed R&D wellfield area. Results indicated that no leakage or communication exists between the mineralized zone and overlaying aquifers. In addition, prior to start of production a well integrity test will be performed on all injection/recovery wells. This requirement of the Nebraska Underground Injection Control Regulations will insure that all wells are constructed properly and capable of maintaining pressure without leakage. Lastly, monitor wells completed in the overlaying aquifer will be sampled routinely and analyzed for presence of leach solution. It is unlikely that an excursion would escape detection.

Seepage of contaminant containing solutions from the evaporation ponds into ground or surface water is a potential release of radioactivity. However, this should not be a problem at the Crow Butte R&D site. Construction and operational safeguards as described in Section 4.2 will be implemented to insure maximum competency of the synthetic liner and earthen embankments. The graded compacted underdrain leak detection system will allow daily observation for liner leakage. Should the unlikely event occur of pond fluids seeping into the compacted subsoil, the liquid would quickly be absorbed. According to the NRC conclusion stated in the Generic Environmental Impact Statement (USNRC,1979) "the most effective way to reduce potential ground water contamination and associated health effects is to reduce the amount of moisture available to carry toxic contaminants away from impoundments." The pond soil foundation will have a low ambient moisture due to its elevation, soil type and preparation.

Failure of the embankments from washout resulting in loss of disposed fluids is also very unlikely. The small size of the ponds and inclusion of a freeboard allowance will preclude over-washing of the walls during high winds. Choice of location for the two ponds was made in consideration of best protection from excessive runoff and flood conditions. The ponds are situated just below the hill crest and will receive only direct precipitation. Lastly, the life of the ponds will be of short duration. Thus, normal erosion should not be a problem.

During the production phase of the R&D project, one or both ponds may contain contaminated fluids. These will originate primarily from the production bleed, lab waste and equipment washdown. If a leak is detected in one pond liner at that time, pond contents may be transferred to the adjacent pond and the liner repaired. During restoration both ponds will contain significant volumes of liquids. However, an emergency capacity of 1.8 m (6 ft) will be maintained at all times. If a liner failure occurs, up to 6,288,800 l (1,661,500 gal) of transfer liquid could be accommodated in the other pond assuming it was filled to capacity.

Should the unlikely event of a pond failure occur, the potential radiological consequences would be insignificant and undetectable after a short period of time. This conclusion is drawn from the short and long-term effects measured after uranium mill tailings dam failures at various locations where large volumes of liquids (average 4.9×10^7 l) and solids (average 1.4×10^7 kg) were released (USNRC,1982).

Small Releases. Failure of the pumping circuit, otherwise described as loss of fluids from surface piping, is the most common form of release from R&D and commercial in-situ uranium mines. This results when breaks, leaks or separations occur in pipes which transfer mining fluids from the process plant to the wellfield and back.

All piping from the plant, to and within the wellfield will be buried for frost protection. It will be constructed of high density polyethylene pipe with butt-welded joints. To insure competency of the pipe and joints, the pipelines will be pressure tested above operating pressures prior to final burial. It is unlikely that a break will occur in a buried section of line because no additional stress is placed on the pipes. Trunkline flows and wellhead pressures will be monitored each shift for process control. Underground pipelines are protected from the major cause of failure, that of vehicles accidently driving over the lines causing breaks. The only exposed pipes will be at the plant, the wellheads and in the control house in the wellfield.

The main production and injection pipelines from plant to wellfield will be a maximum of 183 m (600 ft) in length. Pregnant or barren lixiviant will flow through these lines at a maximum of 378 l/min (100 gpm). If a major break in an exposed section of one of these lines were to occur for a one hour period, up to 22,680 l (6,000 gal) of leach solution could be released. A break at the production well nearest to Squaw Creek would have to flow 213 m (700 ft) before entering Squaw Creek. Except under the most saturated conditions, the soil would absorb the liquid before it reached the creek.

The probability of this magnitude release is low. Instead, small occasional leaks at pipe joints and fitting at the wellheads are to be expected. Until remedied, these leaks will drip fluid which will be absorbed by the underlying soil.

After pipe repair the soil can be surveyed for contamination and removed to a pond or storage area if necessary.

Preventative maintenance will be used to preclude this type of spill to the maximum extent possible. Operators will inspect exposed pipe lines each shift for small leaks and weakened areas.

Impact of such a spill would be to increase primarily Na, Cl and several trace metals in the soil. Radium would precipitate as radium carbonate or exchange onto clays. This soil would have to be removed, if contaminated, and disposed of.

The steps to be followed subsequent to a spill are given below:

1. Take immediate action to stop the spill. Prevent it from flowing away from the local area.
2. Mark the extent of the spill with stakes and remove standing liquid to a pond or appropriate tankage.
3. For spills of greater than 3,780 l (1,000 gal) obtain representative soil samples for analysis of uranium, radium and vanadium.
4. Where comparison of analytical results and baseline soils concentrations show contamination is present, remove soil to storage area for future shipment to an approved disposal site.

On-site records will be kept of all spills greater than 3,780 l (1,000 gal). The written report will include the following 1)date and time of the spill, 2) location, 3) type and composition of material spilled, 4) volume spilled, 5) cause of the spill and 6) any containment measure taken. Location and types of samples taken should be described together with results and clean up measures. Results of any gamma surveys should be recorded.

The NRC and Nebraska DEC will be notified within 24 hours of any spill greater than 3,780 l (1,000 gal). A written report will follow within 7 days detailing the conditions leading to the failure, corrective actions taken and clean-up results. If the spill leaves the restricted area or enters Squaw Creek, both agencies will be notified immediately.

Trivial Releases. Releases which result in no environmental radiological impact are considered trivial. An example is the leakage or rupture of a plant process vessel. All such vessels will be stored inside the plant building on a reinforced concrete floor which contains curbs and sumps for liquid control. Any such vessel will be immediately repaired and the area cleaned to prevent contamination of employees and other equipment.

7.5.2 Transportation Accidents

Three types of materials transportation will be associated with the Crow Butte R&D Project:

1. Delivery of process chemicals,
2. Transport of radioactive contaminated waste to an approved disposal site, and
3. Transfer of yellowcake slurry upon completion of the project.

All transport will be made with contracted vehicles and experienced, trained drivers. Major public highways will be traveled except for final access to the site.

Based on the production schedule and material balance, it is estimated that a maximum of 25 bulk chemical deliveries will be made to the site. Approximately 30% of these will be at the time of start-up. The remainder will be spaced throughout the production phase. Types of deliveries will be carbon dioxide, caustic soda, hydrochloric acid, sodium chloride and oxygen. Since no unusual or hazardous driving conditions are known to exist in this part of Nebraska, the accident rate for these vehicles should be that of the overall chemical trucking industry.

A finite amount of radioactive (by-product) waste materials will be generated during operation of the pilot plant, restoration and reclamation. Used equipment and pipes may have surface contamination of uranium and radium-226. Soils which have absorbed a spill may contain uranium, radium-226 and small amounts of trace metals. Sludge from the evaporation ponds will contain varying concentrations of salts, radionuclides and trace metals.

Transport of by-product waste materials will likely be to one of the existing uranium mill tailings ponds in Wyoming. Prior to any disposal, Wyoming Fuel Company will obtain NRC approval for the proposed location. The environmental effects of a by-product material accident, in the very unlikely event one were to occur, would be highly localized due to the low radioactive content of the waste material. For example, the specific activity of uranium ore is usually estimated to be $1x10^{-9}$ Ci/g while $6x10^{-7}$ Ci/g is used for yellowcake. This by-product material waste would generally have a lower specific activity than that of ore.

In the accident analysis of the Sand Rock Mill Project a transportation accident involving yellowcake was assumed for which was calculated an environmental release fraction of $9x10^{-3}$ of fractional probability of occurrence. This represents the initial airborne material released at an accident site carried by a 5 m/s (10 mph) wind for a 24 hour period. Assuming a population density of 62 people per square kilometer, a fifty year dose commitment to the lungs of the general population was estimated at between 0.9 and 13 man-rem, depending on the severity of the spill. This value was considered small when compared with the estimated 50 year integrated lung dose of 1427 man-rem from natural background (USNRC,1982). The lower activity of the wastes and low population density in northwest Nebraska and Wyoming would produce even lower dose commitments than the above estimates in the event of an accident.

If an accident should occur resulting in spillage of the waste materials, clean-up of the location would begin as soon as possible. Spilled material would be scraped up and placed in the same or similar truck. Any soil beneath the materials would also be removed until contamination levels were acceptable.

At the conclusion of the R&D test, all yellowcake which has been produced will be shipped to a processing or storage facility. The yellowcake slurry will be transported either in a trailer mounted tank vessel or in lined drums.

It is estimated that between one and three shipments will be required. All travel except at the site will be on major public highways. The probability that a collision, noncollision, or "other event accident" will occur is in the range of 1.0×10^{-6} to 1.6×10^{-6}/km (USNRC,1982).

Wyoming Fuel Company has developed a spill contingency plan and emergency response program for use with Crow Butte R&D site shipments. According to this plan, specified equipment will be kept on-site or in shipment vehicles for containment and clean-up use. All site and supervisory personnel will be trained in emergency response. The plan of action and notification procedures for appropriate local, state and federal officials is included as Appendix 7.5(A).

7.5.3 Other Accidents

Site accidents not involving radioactivity should not be a major factor at the Crow Butte R&D Project. The operation will be of small size with fewer than 20 operating personnel involved. The facility will consist of one small process/office building, two evaporation ponds and a combined wellfield area of no greater than 0.34 hectares (0.85 acres). Most of the wells will be installed prior to start of operations. Thereafter, periodic maintenance should be the only large vehicle activity in the wellfield.

Personnel will be trained in safety and emergency procedures in accordance with Mine Safety and Health Administration regulations. Initial and refresher training will include occupational safety, first aid, radiation safety and fire procedures. Since the facility will be operated 24 hours a day, as an additional precaution two persons will operate each of the evening and night shifts.

Another possible type of accident is leakage or rupture of process or chemical holding vessels. Precautionary measures have been taken to contain any such event. As shown in Figure 3.1-7 of Section 3.1 the hydrochloric acid and sodium hydroxide storage tanks will be located on curbed, sumped cement pads. These pads will be outside the process building and approximately 0.3 m (1 ft) lower in elevation than the building.

All process tanks will be located inside the plant building. The cement floor will be curbed with collection sumps central to the tankage. This area has sufficient capacity to contain the entire contents of one or more tanks should rupture occur. The material would be collected in the sump, then pumped to either a process tank or the evaporation ponds. Tanks of oxygen and carbon dioxide will be stored away from the processing building and yellowcake storage area. This location is approximately 13.8 m (45 ft) west of the plant building. No accidents are anticipated which would adversely affect the environment or surrounding population.

REFERENCES

U.S. Nuclear Regulatory Commission, "Draft Generic Environmental Impact Statement on Uranium Milling," NUREG-0511, April 1979.

U.S. Nuclear Regulatory Commission, "Draft Environmental Statement Related to the Operation of Sand Rock Mill Project," NUREG-0889, March 1982.

APPENDIX 7.5(A)

SPILL CONTROL PLAN

EMERGENCY PROCEDURES

The cargo of this truck is natural uranium concentrate (U_3O_8), commonly called yellowcake. This material:

IS NOT EXPLOSIVE

WILL NOT BURN

CAN BE APPROACHED WITHOUT DANGER. The danger of radiation harm is insignificant if exposure is only a few days.

IS POISONOUS. It should not be breathed, swallowed or put in mouth.

DO NOT TAKE YELLOWCAKE AS SOUVENIRS

In the event of an accident involving spillage of yellowcake, the following actions are reccmmended if appropriate:

1. LIFESAVING, RESCUE AND FIREFIGHTING. This may be done with little fear towards the hazards from the yellowcake. If possible, avoid breathing yellowcake dust and avoid swallowing it. Yellowcake on the skin or clothing is relatively harmless and simple washing methods will remove it. If you become contaminated with yellowcake, please wait for advice from health officials. To avoid ingestion of uranium, do not eat, drink or smoke while near the spill.

2. CONTACT THE LOCAL LAW ENFORCEMENT AGENCY. Tell the police of the accident with spillage of "LOW SPECIFIC ACTIVITY"(LSA) radioactive material called uranium ore concentrate "YELLOWCAKE". Ask them to notify the state health department. Give them the location of the accident site and tell them of any injuries to persons.

3. <u>USE THE FOLLOWING PROCEDURES FOR DRUMS OR A SLURRY TANK-NOT LEAKING</u>. Rope off area and keep persons from tampering with vehicle. Request police assistance to keep people at least 20-25 feet from the accident.

   Assure people there is no danger from the sealed truck or drums. Professional assistance is on the way.

4. <u>PROCEDURES FOR DRUMS OR SLURRY TANK-LEAKING</u>. The vehicle contains emergency equipment to cover and contain the leaking material. Rope off area and keep persons at least 20-25 feet away from vehicle and yellocake. Ask for police assistance in routing traffic around spill.

   Try to contain the leaking material. Use shovels to cons ruct temporary dikes and levies if there is potential for runoff. Tarpaulins or plastic sheets should be used to cover the material and prevent wind blown dust. Wear a respirator.

5. <u>FILL OUT THE QUESTIONNAIRE ATTACHED</u>. Please fill out the information as quickly as possible and the NOTIFY ONE OF THE FOLLOWING (call collect):

Plant Manager	Crawford, Nebr.	(308)665-2132	Off.
Wyoming Fuel Company	Crawford, Nebr.		Home
David Stout	Denver, Colo.	(303)989-5037	Off.
Wyoming Fuel Company	Denver, Colo.	(303)457-4357	Home
Steve Collings	Denver, Colo.	(303)989-5037	Off.
Wyoming Fuel Company	Denver, Colo.	(303)697-4548	Home

As soon as one of these is notified, then the company will continue the internal and regulatory agency notification procedures.

NOTE: Anyone involved in the accident, the initial containment, or exposed to contamination in any way should give their name and address to the civil authorities and follow their instructions before leaving the site.

<u>TO WHOM IT MAY CONCERN</u>
IN CASE OF ACCIDENT

Rescue and lifesaving may be done with little fear of the hazards from the cargo in this truck. If possible, avoid breathing dust from spilled cargo. **DO NOT DELAY RESCUE EFFORTS!**

After needed rescue, lifesaving, first aid or firefighting, please read the attached instructions in the event of cargo spillage.

Please note that a box of emergency equipment was the last item loaded onto this truck. It should be accessible through the rear cargo doors (trailer) or in the passenger area (tanks).

TO THE DRIVER:
Keep these emergency procedures with your shipping papers.

ACCIDENT QUESTIONNAIRE

1. Name of Caller ______________________________
2. Location of Caller ______________________________
3. Time of Accident ______________________________
4. Place of Accident ______________________________
5. Name of Police Dept. Notified ____________________
6. Phone No. of Police Notified ____________________
7. Is the Driver Injured? ______________________
8. Name of Driver ______________________________
9. Destination ______________________________
10. Bill of Lading Number ______________________
11. Can the Truck be Driven Safely? ________________
12. Estimate the Number of Square Feet ______________ of Spilled Material.
13. Has the Spill Been Covered? ____________________
14. Is the Spill on Ground? ______________________
15. Is the Spill in Water? _____ Lake? ____ Stream? ________
16. Is Spill Near a Building? ____________ Sewer? _______
17. Is the Accident Place Lighted or Night? ____________
18. Other Comments ______________________________

____

____

____

____

19. Where Can You Be Reached By Phone? ______________
    (a) Near the Accident Site ____________________
    (b) Home or Business Phone ____________________

COMPANY NOTIFICATION

In the case of an accident or spill, one of the following persons will be notified by the driver or another caller.

Steve Collings - Manager of Uranium
David M. Stout - Environmental Coordinator
(To be named) - Plant Manager

The company notification system should then begin. Notification will be duplicated to insure that all persons and agencies have been contacted. Use the following flow chart.

Manager of Uranium	**Environmental Coordinator**	**Plant Manager**
Notify all of the following:	**Notify all of the following:**	**Notify all of the following:**
ENVIRONMENTAL COORDINATOR	PLANT MANAGER	MANAGER OF URANIUM
PLANT MANAGER	MANAGER OF URANIUM	ENVIRONMENTAL COORDINATOR
STATE POLICE	STATE POLICE	CLEAN-UP TEAM
CLEAN-UP TEAM	CLEAN-UP TEAM	STATE POLICE
NRC	NRC	STATE DEPT. OF HEALTH
STATE DEPT. OF HEALTH	STATE DEPT. OF HEALTH	NRC

Important Phone Numbers

Nebraska	
Department of Health	402/471-2168
State Patrol	402/477-3951
Department of Environmental Control	402/471-2186
Wyoming	
Department of Health	307/777-7659
State Police	307/777-7301
Kansas	
Department of Health	913/862-9360
Highway Patrol	913/782-8100
Oklahoma	
State Health Department	405/271-5600
Department of Public Safety	405/424-4011
Occupational and Radiological Health	405/271-5221
U.S. Nuclear Regulatory Commission	
Region III	312/858-2660
Region IV	817/334-2841

SPILL CLEAN-UP EQUIPMENT

The following equipment should accompany each shipment for use in case of emergency. The spread of spills should be restricted as soon as possible. Exposed yellowcake should be covered to prevent drying and spreading.

1. Shovels (2, short handled)
2. Plastic sheeting (2,000 square feet)
3. Dust respirators (3, half-face)
4. Barricade rope
5. Radiation zone and reflective warning signs
6. Disposable coveralls (3 pair)
7. Work gloves (6 pair)
8. Rubber boots (3 pair)
9. Rolls of plastic tape (3)
10. Small first-aid kit
11. Clipboards with tablets and pencils (2)
12. Pocket knives (3)

Other equipment should be obtained near the accident site or brought with the clean-up team. The clean-up crew should also bring calibrated survey instruments and their TLD badges. The clean-up team leader should make periodic phone reports to a company official, and a final written report explaining all activities and findings.

After clean-up all equipment should be washed with detergent and water to reduce surface contamination levels. Equipment should then be surveyed for residual radiation. All persons involved should thoroughly wash hands and exposed areas with soaps and water. Place soiled clothing in plastic bags for washing or disposal at an approved site.

SECTION 8.0

ALTERNATIVES TO PROPOSED ACTION

8.0 ALTERNATIVES TO PROPOSED ACTION

The alternatives applicable to the proposed Crow Butte R&D facility are: to mine by in situ extraction using another lixivant chemistry, to dispose of liquid wastes by methods other than using solar evaporation ponds, to develop a commercial facility without going through the R&D project phase, to mine the ore body by conventional methods or no mining alternative.

Lixivant Chemistry

Wyoming Fuel Company is proposing to use a sodium bicarbonate lixivant. In general, the choice is between acidic or alkaline lixivants. At a site where the groundwater contains carbonate, as at the Crow Butte R&D site, an alkaline lixivant will mobilize fewer hazardous elements from the ore body and will require less chemical addition than an acidic lixivant.

Ammonium carbonate could have been proposed rather than sodium carbonate; however, ammonium tends to absorb on clays (making restoration difficult) and may decompose into other nitrogen compounds. Therefore, because of the potential detrimental environmental impacts, ammonium carbonate is not as desirable as sodium carbonate. Calcium, magnesium or potassium bicarbonates could also be used and may be tested in the event sodium carbonate proves unacceptable.

Waste Handling

Wyoming Fuel Company is proposing to utilize solar evaporation ponds to handle liquid waste generated from the R&D facility. An alternative to solar evaporation ponds would be deep well injection. The amount of liquid waste generated by the proposed R&D facility does not justify the costs of deep well injection, but deep well injection will be considered for a commercial facility.

Alternatives have been considered to the location and design of the ponds. In general, the proposed location will not have any significant long term impacts on the environment. This has been discussed in Sections 7.1, 7.2 and 7.3.

The pond design is such that seepage of toxic materials into subsurface soil and hydrologic system should be prevented or reduced to the maximum extent reasonably achievable.

No R&D Project

If the action taken were to attempt development of a commercial facility without first going through a research and development phase, several serious factors would remain unresolved until well into the commercial operation. Identification and demonstrating restoration of the aquifer would not be accomplished prior to mining. Technical aspects of leach rates, leach chemistries, etc., to be used in the operation would likewise be undefined until mining commenced. Economics of the operation would not be clearly evaluated. These above mentioned technical and economic factors justify the construction and operation of a R&D facility prior to commercialization of the Crow Butte Project.

Conventional Mining

Use of conventional mining methods for a commercial operation (open pit, underground) are presently considered not economically feasible. Generally, open pit mining is used for ore deposits relatively close to the surface. The overburden to ore ratio under present economic conditions would preclude recovery of the Crow Butte deposit using open pit mining methods. Underground mining is generally used for deeper deposits. Present economic and technical factors make underground mining of the Crow Butte deposit undesirable.

No Mining

If the action were taken not to mine the ore body, this would result in leaving a potentially valuable mineral resource untouched. This would result in a loss of potential economic gain for the company as well as the surrounding community and region. Furthermore, it has been the policy of our federal government to encourage uranium resource development, to the extent projects are environmentally feasible, to provide fuel for nuclear reactors. If the Crow Butte Project is not allowed, nuclear fuel from the site would not be available.

SECTION 9.0

ENVIRONMENTAL APPROVALS AND CONSULTATIONS

9.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

By this application and environmental report Wyoming Fuel Company is applying for a source material license as required by the U.S. Nuclear Regulatory Commission (USNRC). Wyoming Fuel Company is also required to obtain a permit from the State of Nebraska to operate Class III injection wells under the Nebraska Underground Injection Control Program. This UIC permit will also require approval from the Environmental Protection Agency (EPA).

Wyoming Fuel Company will notify the USNRC during the review process in the event Wyoming Fuel Company applied for additional permits.