ALASKA NATURAL GAS TRANSPORTATION SYSTEM

Final Environmental Impact Statement

NORTH BORDER

MARCH 1976

U.S. DEPARTMENT OF THE INTERIOR

WASHINGTON, D.C. 20240

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TRANSPORTATION SYSTEM

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This final Environmental Impact Statement has been prepared under the provisions of Section 102(2)(C) of the National Environmental Policy Act of 1969 (P.L. 91-190). Contact regarding the document should be addressed to:

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SUMMARY

( ) Draft (x) Final Environmental Statement
United States Department of the Interior, Alaska Natural Gas Transportation System EIS Task Force

1. Type of action: (x) Administrative ( ) Legislative

2. Brief description of action: Action pending is granting rights-of-way permits for crossing Federal lands. A 5,580-mile buried pipeline has been proposed to transport natural gas from Prudhoe Bay (Alaska) to markets in the lower United States. The pipeline, as proposed, would cross all, or portions of, Alaska; Yukon Territory, Northwest Territories, British Columbia, Alberta, and Saskatchewan (Canada); and Idaho, Washington, Oregon, California, Montana, North Dakota, South Dakota, Minnesota, Iowa, Illinois, Indiana, Ohio, West Virginia, and Pennsylvania. As proposed, all activities necessary for pipeline construction and operation will be phased over a seven-year period. Of all lands traversed by the proposal, 406 miles will involve lands under the jurisdiction of five Federal agencies, all of whom have permitting authority. Other permits or licenses also must be issued before construction may begin or the project becomes operational.

3. Environmental impact and adverse environmental effects: Because of the linear nature of the proposal, a wide spectrum of environmental impacts will occur if the pipeline is built. Impacts, which are detailed in the Overview and geographically-oriented volumes, will occur on climate, topography, geology, soils, water resources, vegetation, fish and wildlife, social and economic environments, land use and productivity, cultural resources, recreation and esthetics, and air quality (including noise). All impacts will not be adverse.

4. Alternatives considered: Alternatives covered include the courses of action open to the Secretary of the Interior to approve, deny, postpone, or accept and delay or deny part of the proposal; effects of gas deregulation and conservation; other natural gas sources; alternative energy sources and modes of transportation; and one major alternative transportation system involving an all-Alaska gas pipeline, liquefaction plants, and LNG tanker transport to the conterminous United States.

5. Comments have been received from the following: Comments were received from 23 Federal agencies, 35 State and local governments, Canada, 17 companies representing industry, 16 private organizations, 100 individual citizens, and three members of Congress. Comments from Federal agencies, State and local governments, Canada, private organizations, and members of Congress are reproduced in the Consultation and Coordination volume. Other comments will be reproduced and filed as a supplement to this statement at selected repository sites.

6. Date made available to CEQ and the public:

Draft statement: July 28, 1975
Final statement: MAR 1976

SUMMARY

( ) Draft (X) Final Environmental Statement
United States Department of the Interior, Alaska Natural Gas Transportation System Task Force

1. Type of action: (X) Administrative ( ) Legislative

2. Brief description of action: Action pending is granting right-of-way permits for crossing Federal lands. A [illegible]-mile 50-inch pipeline has been proposed to transport natural gas from Prudhoe Bay oilfield to markets in the lower United States. The pipeline, as proposed, would cross all, or portions of, Alaska; Yukon Territory, Northwest Territories, British Columbia, Alberta, and Saskatchewan (Canada); and Idaho, Washington, Oregon, California, Montana, North Dakota, South Dakota, Minnesota, Iowa, Illinois, Indiana, Ohio, West Virginia, and Pennsylvania. As proposed, all activities necessary for pipeline construction and operation will be phased over a seven-year period. Of all lands traversed by the proposal, 40% miles will involve land under the jurisdiction of nine Federal agencies, all of whom have permitting authority. Other permits or licenses also must be issued before construction may begin or the project becomes operational.

3. Environmental impact and adverse environmental effects: Because of the linear nature of the proposal, a wide spectrum of environmental impacts will occur as the pipeline is built. Impacts, which are detailed in the overview and geographically-related volumes, will occur on climate, topography, geology, soils, water resources, vegetation, fish and wildlife, social and economic environments, land use and productivity, cultural resources, recreation and aesthetics, and air quality (including noise). All impacts will not be adverse.

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6. Date made available to CEQ and the public:

Draft statement: Apr. 22, 1975
Final statement:

Note for Readers

This environmental impact statement was prepared in response to applications made to the Secretary of the Interior for permits to cross Federal lands with a natural gas pipeline. It identifies and evaluates environmental impacts that could be expected from construction and operation of the "Alaska Natural Gas Transportation System" as proposed by the consortium of companies listed in the Consultation and Coordination volume. It was prepared by an interdisciplinary team, most of whom are employees of the United States Department of the Interior.

Detailed construction designs and detailed plans for site restoration and system operation are not complete at this (proposal) stage of the project. For this reason, some of the impacts and mitigating measures are expressed in ranges of magnitude or qualified to reflect alternative situations.

The Secretary of the Interior considers a number of factors in reaching his decision regarding issuance or denial of right-of-way permits. The environmental impact analysis presented in this statement is an important but not necessarily the deciding factor. Alternative gas transportation systems proposals, United States-Canada diplomatic relations, national economic and risk analyses, national defense implications, energy efficiency analyses, and other factors must also be considered.

This statement is presented in nine volumes as follows:

Overview Volume	North Border Volume
Alaska Volume	Alternatives Volume
Canada Volume	Consultation and Coordination Volume
San Francisco Volume	
Los Angeles Volume	Glossary Volume

Alaska, Canada, San Francisco, Los Angeles and North Border Volumes are geographically oriented. The Overview Volume, Alternatives Volume, and Consultation and Coordination Volume are not geographically oriented in their coverage.

The following subject groupings are covered sequentially in each of the geographically oriented volumes and Overview:

1. Description of the proposal.
2. Description of the environment.
3. The environmental impact of the proposed action.
4. Mitigating measures proposed and additional measures considered.
5. Adverse effects which cannot be avoided should the proposal be implemented.

6. The relationship between local short-term uses of (man's resources) and the maintenance and enhancement of long-term productivity.
7. Irreversible and irretrievable commitments of resources associated with the proposed action.
8. Alternatives to the proposed route.

The reader can review particular segments of the proposed project selectively. For example, a reader interested only in impacts on North Dakota, could use the Overview Volume for the system "big picture," and the North Border Volume for coverage of his particular State. Similarly, a person interested primarily in ways of transporting natural gas could refer to the Alternatives Volume and satisfy his needs.

Following is a brief description of the coverage of each part:

Overview Volume - The Overview covers the Arctic Gas System proposal in its entirety. It will be most useful to those readers who want a system view and a broad concept of anticipated environmental impacts of the entire pipeline project.

Alaska Volume - This volume covers the 195-mile proposal of the Alaskan Gas Arctic Pipeline Company originating at Prudhoe Bay and terminating at the Alaska-Yukon Border and alternative routes.

Canada Volume - This portion of the environmental impact statement analyzes the 2,435-mile pipeline proposal of Canadian Arctic Gas Pipeline, Ltd., beginning at the Yukon-Alaska Border and proceeding generally southward to Caroline Junction in Alberta where it forks, one leg entering Idaho, near Kingsgate, British Columbia, and the other entering Montana, near Monchy, Saskatchewan. Discussions of route alternatives are also presented.

San Francisco Volume - This volume analyzes the 917-mile portion proposed by the Pacific Gas Transmission Company which passes through Idaho, Washington, and Oregon to Antioch, California. Discussions of route alternatives are presented.

Los Angeles Volume - This volume relates to the 414-mile portion proposed by Interstate Transmission Associates (Arctic) extending from the point of United States entry in Idaho to Rye Valley, Oregon. It also involves modifications to existing compressor stations in Oregon, Idaho, and Colorado. Discussions of route alternatives are presented. This volume also contains a discussion of the applicant's future proposal for an additional 760-mile pipeline passing through Idaho, Oregon, Nevada, and terminating at Cajon, California.

North Border Volume - This volume is an analysis of the 1,619-mile pipeline proposed by the Northern Border Pipeline Company. It covers the area from the United States-Canada border, crossing Montana, North and South Dakota, Minnesota, Iowa, Illinois, Indiana, Ohio, and West Virginia, to a termination near Delmont, Pennsylvania. Discussions of route alternatives are presented.

Alternatives Volume - This volume covers courses of action open to the Secretary of the Interior to approve, deny, postpone, or accept and delay or deny part of the proposal; effects of gas deregulation and conservation; other natural gas sources; alternative energy sources and modes of transportation; and one major alternative gas transportation system involving an all-Alaska gas pipeline, liquefication plants and tanker transport to the conterminous United States.

Consultation and Coordination - This volume describes and discusses the efforts made by the Department of the Interior to consult with and coordinate its work in the development of this statement. It includes the gathering of basic information for analysis, public meetings, public hearings, and efforts which have and will be made to assure that environmental impacts are adequately treated.

Glossary - This volume provides the reader with definitions of technical words or phrases used in the environmental impact statement.

the applicant's rights proposal for an additional 700-mile pipeline [illegible] Alaska, and [illegible] at [illegible].

Northern Border Project - [illegible] is an analysis of the [illegible] proposed by the Northern Border [illegible] the area from the [illegible] Montana, North [illegible] Dakota, Minnesota, Iowa, Illinois, Indiana, [illegible], and West Virginia, [illegible] alternatives are presented.

Alternative Systems - This volume covers analyses of systems other than the applicants' routes [illegible] to the [illegible], or any combination of any part of the proposals [illegible] and [illegible] alternatives [illegible] major alternative [illegible] all-Alaska gas pipeline, [illegible] transport to the [illegible].

Comments on the Draft Statement - This volume [illegible] in the development of this statement. It includes the [illegible] of local [illegible], public meetings, public [illegible] which have been and will be made to [illegible] environmental impacts are adequately treated.

Glossary - This volume provides the reader with definitions of technical words or phrases used in the environmental impact statement.

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1 DESCRIPTION OF THE PROPOSED ACTION

1.1 ARCTIC GAS PIPELINE PROJECT

1.1.3 Northern Border Pipeline

1.1.3.1 Introduction

The Northern Border Pipeline is a part of the proposed Alaska Natural Gas Transportation System (ANGTS) which will initially transport 4.50 bcf/d (billion cubic feet per day) of natural gas, 2.25 bcf/d from the Prudhoe Bay Field in Alaska and 2.25 bcf/d from the MacKenzie Delta area of the Northwest Territories, Canada, to industrial and population centers in Canada and the United States. The revised applications from the applicants are based on the assumption that the 2.25 bcf/d from MacKenzie Delta area will be transported to Canadian markets and the 2.25 bcf/d from Prudhoe Bay will be transported to market areas in the United States. The Canadian Arctic Gas mainline can deliver 4.50 bcf/d when fully powered while delivery and supply laterals have greater capacity. The total capacity of connecting facilities applied for also exceeds 4.50 bcf/d. Quantities above this will require additional facilities.

The 1,619-mile Northern Border Pipeline will provide transportation for natural gas from a point on the Canada-United States border near Morgan, Montana, to pipeline companies that serve a 29-state area of the north-central and northeastern United States.

The Northern Border Pipeline Company is a partnership composed of affiliates of the following six interstate natural gas pipeline companies:

Northern Natural Gas Company
Michigan-Wisconsin Pipe Line Company
Natural Gas Pipeline Company of America
Panhandle Eastern Pipe Line Company
Columbia Gas Transmission Corporation
Texas Eastern Transmission Corporation

The applicant's flow diagrams show inlet volumes to the Northern Border Pipeline of 1.655 bcf/d, initially, and 2.184 bcf/d when fully powered. These volumes reflect ideal conditions with all equipment in service. The delivery volumes were computed to reflect amounts: a) not delivered because of downtime for equipment maintenance, b) used as fuel for compressors and other pipeline facilities, and c) attributable to other unaccountable losses.

The Northern Border Pipeline will deliver natural gas to the 6 member companies through 10 delivery points at a rate of 1.530 bcf/d, less fuel for operation. When fully powered, the delivery capacity could be increased to 2.020 bcf/d, less fuel for operation.

The fully powered capacity of 2.020 bcf/d would serve a residential community with a population of approximately 17.3 million or about 5 million residences.

The applicant estimates that for the average daily delivery rate of 1.530 bcf/d available at the Canadian border, a total of 33 MMcf/d (million cubic feet per day) of natural gas from the Northern Border Pipeline will be used for fuel for compressors and operation of the system and is about 2.2 percent of the average daily delivery rate.

Refer to the Overview, Section 1.0V.1 for additional discussion of the ANGTS, natural gas reserves and deliverability.

1.1.3.2 Location

Specific Route

Origin, Proposed Route and Terminus

The proposed route of the Northern Border Pipeline extends from a connection with the Canadian Arctic gas pipeline at a point on the Canadian-United States border near Morgan, Montana, to a terminus near Delmont, Pennsylvania, about 20 miles southeast of Pittsburgh. The proposed route is shown on Figure 1.1.3.2-1. The proposed route is described in the following paragraphs by state and county.

Montana

The initial heading of the proposed route from the Canadian-United States border is southeast. Within Montana it crosses Phillips, Valley and Roosevelt Counties in that order.

The proposed route crosses the Fort Peck Indian Reservation and enters North Dakota at a point approximately 10 miles southeast of Bainville, Montana.

North Dakota

After entering North Dakota in Williams County, the proposed route turns southward and crosses the Missouri River at a point about 20 miles upstream (southwest) from Williston. The proposed route then resumes its southeastern course, crosses the Little Missouri River, and continues on through a pass in the Killdeer Mountains toward a crossing of Oahe Reservoir just north of the mouth of the Cannonball River at the northeastern corner of the Standing Rock Indian Reservation.

Before entering Emmons County on the east bank of the Missouri, the proposed route crosses the Oahe Reservoir after which it again resumes a southeasterly course toward South Dakota, crossing the state line 13 miles southwest of Ashley. North Dakota counties to be crossed west of the Missouri River are Williams, McKenzie, Dunn, Mercer, Oliver and Morton; in addition, Emmons and McIntoch Counties east of the Missouri River will be crossed.

South Dakota

The proposed route traverses South Dakota in an essentially straight southeast line. It passes about 3 miles south of Aberdeen and 5 miles south of Watertown, and leaves the state near Hendricks, Minnesota. Within South Dakota it will pass through McPherson, Edmunds, Brown, Spink, Day, Clark, Codington, Hamlin, Deuel and Brookings Counties.

The first proposed delivery point is in South Dakota in the general vicinity of Aberdeen, where Northern Natural Gas Company plans to take the first of three deliveries.

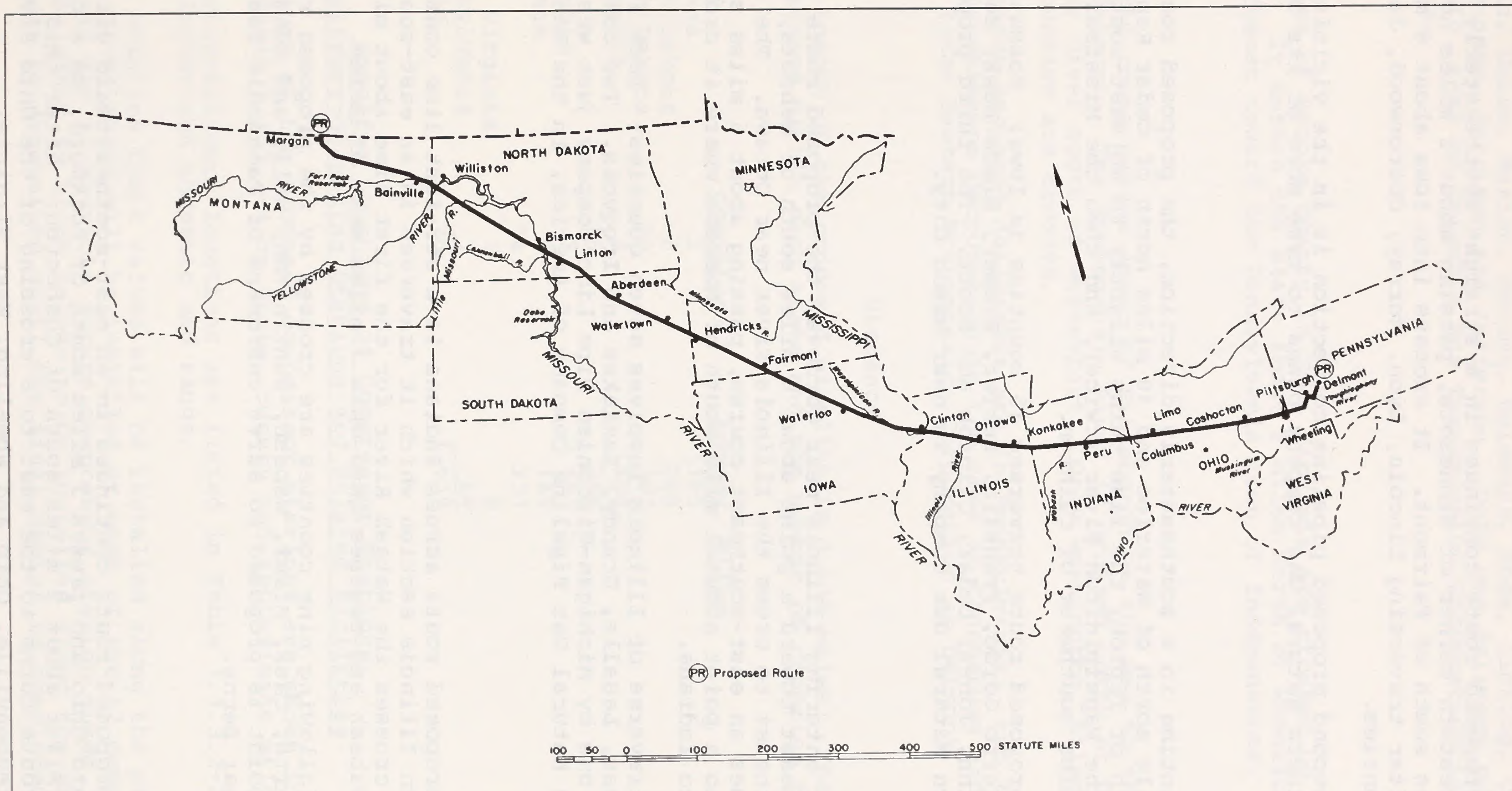


Figure 1.1.3.2-1 Project location map

Minnesota

The proposed route continues in a straight southeasterly path across the southwestern corner of Minnesota, passing about 2 miles north of Windom and 3 miles south of Fairmont. It crosses into Iowa about 8 miles west of Elmore, after traversing Lincoln, Lyon, Murray, Cottonwood, Jackson and Martin Counties.

The second proposed pipeline connection is in the vicinity of Fairmont, where Northern Natural Gas Company plans to take more of its delivery.

Iowa

Continuing in a southeasterly direction, the proposed route passes about 1 mile north of Waterloo and 10 miles north of Cedar Rapids. About 9 miles north of Tipton, the line turns slightly to an east-southeast heading crossing the Wapsipinicon River (twice), and then the Mississippi River, about 7 miles southwest of Clinton.

The proposed route traverses 15 counties in Iowa: Kossuth, Winnebago, Hancock, Cerro Gordo, Franklin, Butler, Bremer, Black Hawk, Buchanan, Benton, Linn, Jones, Cedar, Clinton and Scott. The third proposed delivery to Northern Natural Gas Company is near Mason City.

Illinois

After entering Illinois near Cordova, the proposed route continues east-southeast toward a point about 8 miles south of Mendota, after which it turns southeast to cross the Illinois River near Ottawa. The proposed route then resumes an east-southeast course, passing about 6 miles south of Kankakee to a point about 1 mile south of Morocco where it crosses the border into Indiana.

The traverse of Illinois involves seven counties: Rock Island, Whiteside, Bureau, LaSalle, Grundy, Kankakee and Iroquois. Two connections are proposed, one by Michigan-Wisconisn Pipe Line Company just west of Mendota, and one by Natural Gas Pipeline Company of America, in the Kankakee area.

Indiana

The proposed route across Indiana is a straight line continuation of the eastern Illinois section which it traverses in an east-southeast direction. It crosses the Wabash River for the first time about midway between Peru and Wabash and crosses into Ohio 7 miles east of Berne.

The following nine counties are crossed by the proposed route: Newton, Jasper, White, Cass, Miami, Wabash, Huntington, Wells and Adams. One delivery point is proposed to serve customers of Panhandle Eastern Pipe Line Company near Berne.

Ohio

The proposed route continues in an east-southeastward direction from Indiana into Ohio and passes 3 miles south of Rockford, to a crossing of the Muskingum River about 2 miles south of Coshocton. After this crossing, the proposed route turns to the east to a crossing of the Ohio River midway between Steubenville, Ohio and Wheeling, West Virginia.

Fourteen counties in Ohio are traversed by the proposed route: Mercer, Auglaize, Hardin, Union, Marion, Morrow, Delaware, Knox, Licking, Coshocton, Tuscarawas, Guernsey, Harrison and Jefferson. Only one delivery point is proposed for Ohio, that of Columbia Gas Transmission Corporation in the Mount Vernon area.

West Virginia

Only 8 miles of Brooke County in West Virginia are crossed by the proposed route. It enters the state about 8 miles north of Wheeling and bears east-northeast toward the Pennsylvania town of Independence.

Pennsylvania

The proposed route passes south of Pittsburgh on the way to the terminus near Delmont. The Monongahela River is crossed north of Donora and the Youghiogheny River south of McKeesport. Only Washington, Allegheny and Westmoreland Counties are crossed.

The last three proposed deliveries are in Pennsylvania: two to Columbia Gas Transmission Corporation in the area of Canonsburg and Delmont, and one to the Texas Eastern Transmission Corporation at Delmont.

Distance

The total length of the proposed pipeline is 1,619 miles. The approximate distance within each state and the number of counties to be crossed are:

State	Counties	Approx. Miles
Montana	3	180
North Dakota	8	269
South Dakota	10	182
Minnesota	6	131
Iowa	15	244
Illinois	7	161
Indiana	9	149
Ohio	14	231
West Virginia	1	8
Pennsylvania	3	64
Totals	76	1,619

Specific Locations of Compressor Stations, Delivery-Measuring Stations and Related Facilities

The locations of the proposed compressor stations are shown in Figure 1.1.3.2-2 and Table 1.1.3.2-1 by state, county and approximate milepost.

The measuring-delivery locations are listed in Table 1.1.3.2-2 by approximate milepost and township and range.

A total of 100 mainline block valves will be installed along the proposed pipeline. One block valve will be installed at each of the 12 compressor station sites and the 13 possible future compressor station sites. The locations of the other 75 block valves to be installed along the proposed pipeline will not be determined until the final design is completed.

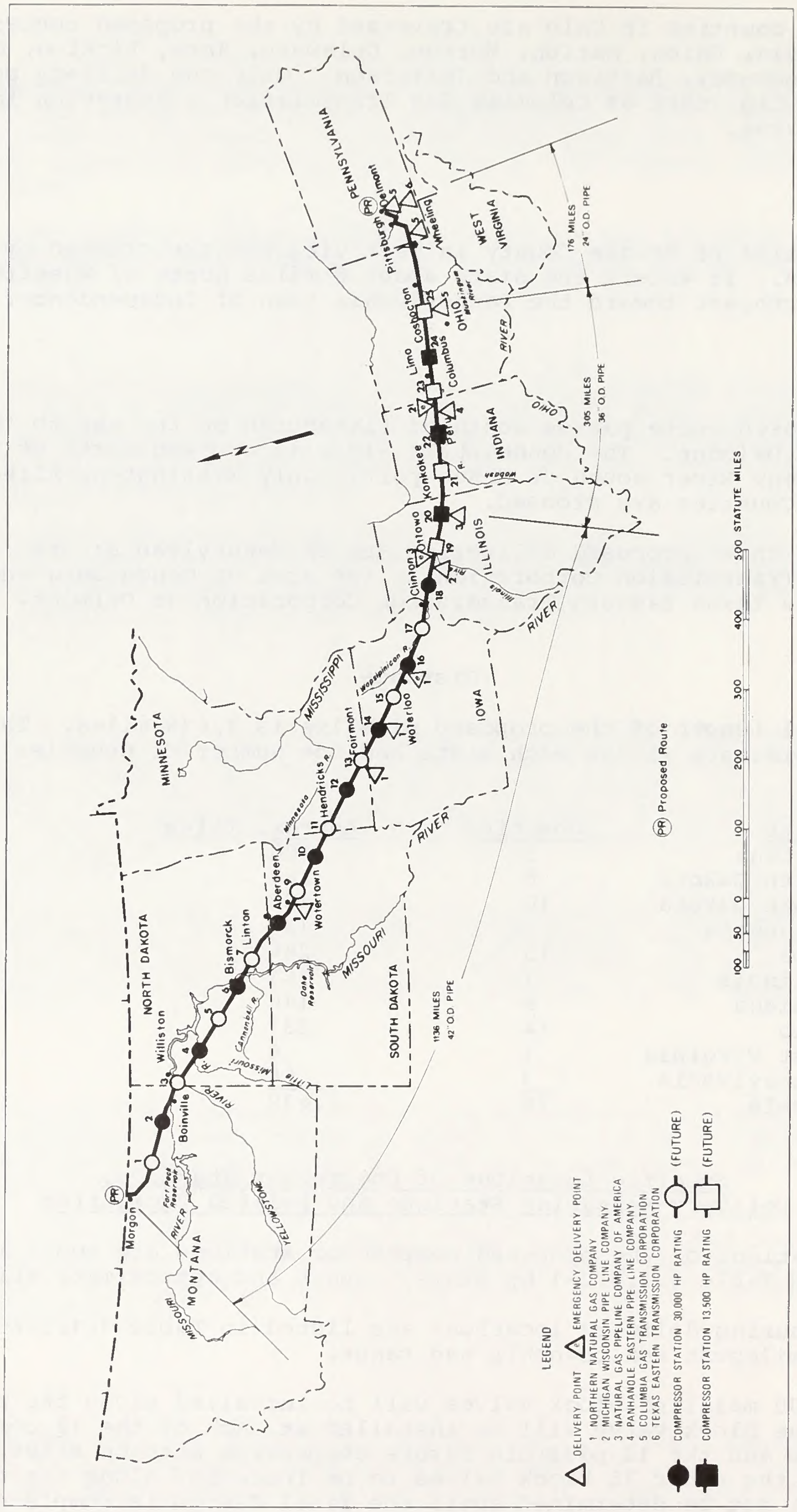


Figure 1.1.3.2-2 System map

Table 1.1.3.2-1 Compressor station sites

Section No.	Station No.	Approximate Mile Post	State	County	Horsepower Rating
1	1	61	Montana	Valley	*
1	2	127	Montana	Roosevelt	30,000
1	3	185	North Dakota	Williams	*
1	4	238	North Dakota	McKenzie	30,000
1	5	299	North Dakota	Merler	*
1	6	355	North Dakota	Morton	30,000
1	7	414	North Dakota	Emmons	*
1	8	469	South Dakota	McPherson	30,000
2	9	529	South Dakota	Brown	*
2	10	581	South Dakota	Codington	30,000
2	11	634	Minnesota	Lincoln	*
2	12	691	Minnesota	Cottonwood	30,000
3	13	747	Minnesota	Martin	*
3	14	801	Iowa	Hancock	30,000
4	15	858	Iowa	Butler	*
4	16	914	Iowa	Benton	30,000
4	17	971	Iowa	Cedar	*
4	18	1027	Illinois	Whiteside	30,000
5	19	1084	Illinois	LaSalle	*
6	20	1138	Illinois	Kankakee	13,500
6	21	1201	Indiana	White	*
6	22	1262	Indiana	Wabash	13,500
7	23	1324	Ohio	Mercer	*
7	24	1384	Ohio	Hardin	13,500
8	25	1443	Ohio	Licking	*

(*) Possible Future Compressor Station Sites.

Table 1.1.3.2-2 Measuring delivery locations

Approximate Milepost	Company	FPC Interconnection Petition Docket No.	State	County	Township, Range
520	Northern Natural Gas Co. I	CP76-45	South Dakota	Brown	T121N,R63W
742	Northern Natural Gas Co. II	CP76-45	Minnesota	Martin	T102N,R31W
809	Northern Natural Gas Co. III	CP76-45	Iowa	Hancock	T96N,R23W
902	Northern Natural Gas Co. (Emergency)	CP76-45	Iowa	Buchanan	T88N,R10W
1061	Michigan-Wisconsin Pipe Line Co.	CP76-43	Illinois	Bureau	T17N,R10E
1077	Natural Gas Pipeline Co. of America (Emergency)	CP76-44	Illinois	La Salle	T34N,R1E
1138	Natural Gas Pipeline Co. of America	CP76-44	Illinois	Kankakee	T30N,R10E
1294	Panhandle Eastern Pipe Line Co.	CP76-54	Indiana	Wells	T26N,R12E
1309	Michigan-Wisconsin Pipe Line Co. (Emergency)	---	Indiana	Adams	T26N,R14E
1443	Columbia Gas Transmission Corp I	CP76-42	Ohio	Licking	T4N,R13E
1573	Columbia Gas Transmission Corp II	CP76-42	Pennsylvania	Washington	N/A
1618	Columbia Gas Transmission Corp III	CP76-42	Pennsylvania	Westmoreland	N/A
1619	Texas Eastern Transmission Co.	CP76-43	Pennsylvania	Westmoreland	N/A

Note: All sites will require an area of 2 acres.

Key

T=Township E=East
R=Range S=South
N=North W=West

Refer to Figure 1.1.3.3-3 for an artist's concept of a typical measuring station.
See Figure 1.1.3.2-2 for system map.

A communication system will be installed, which will require 87 transmission/reception towers, 200 to 300 feet maximum height. Twenty-five of the towers will be located on the proposed or possible future compressor station sites. The remaining 62 towers will be installed along, or close to, the proposed pipeline 15 to 20 miles apart.

Relationship to Present and Potential Energy Sources

Coal Gasification in Northern Great Plains Area

The Northern Border Pipeline is so located geographically as to permit advantageous use for transportation of synthetic natural gas from possible future gasification of coal from large coal deposits in Montana, North Dakota, and South Dakota.

While at least two Northern Border companies have acquired coal reserves for possible future gasification, the volume and timing of any synthetic natural gas production from these reserves cannot be accurately assessed at this time. Moreover, adequate transportation facilities do not presently exist to move synthetic natural gas from plants constructed in the coal reserve areas to markets of the Northern Border companies.

At the present time there is only a small pilot coal gasification plant in operation. The first large scale production gasification plant is yet to be constructed and proven.

"The Report on Water for Energy in the Northern Great Plains Area" by the U.S. Department of the Interior, January 1975, is the source of the following information regarding coal reserves and coal use for gasification.

The estimated coal reserves in the Northern Great Plains Area (Montana, Wyoming, North Dakota, and South Dakota) is 68.1 billion tons which could be recovered by surface mining. Of this amount, 54.4 billion tons are economically recoverable by present technology.

It is estimated that the annual coal consumption, to supply a gasification plant producing 250 MMcf/d (million cubic feet per day), would be 10.0 to 10.9 million tons annually in North Dakota, 8.0 to 8.7 million tons annually in Montana, and 8.3 to 8.7 million tons annually in Wyoming.

The table below shows the estimated coal gasification plants in operation in 1985 and 2000 in the Northern Great Plains area.

Estimate for Projection	State	1985	2000
Intermediate rate of development	Wyoming	2	3
	Montana	3	4
	North Dakota	2	7
	Total	7	14
High rate of development	Wyoming	6	9
	Montana	8	15
	North Dakota	6	17
	Total	20	41

Assuming that each gasification plant would produce 250 MMcf/d of synthetic natural gas (SNG), it is possible that a total of up to 1.26 trillion cubic feet (intermediate rate of development estimate) or up to 3.69 trillion cubic feet (high rate of development estimate) of SNG could be produced in the years 1985 and 2000, respectively.

Two partner companies in the Northern Border Pipeline Company have plans to construct and operate coal gasification plants. The information regarding these plants is contained in the "Little Missouri" Grasslands Study (southwestern North Dakota) by North Dakota State University, January 1974, and is discussed below.

Michigan-Wisconsin Pipe Line Company has filed an application with the Federal Power Commission to construct and operate one coal gasification plant in the general area of Garrison Reservoir, North Dakota. The plant is proposed to be in operation by 1980. As part of its long-range gasification program, the company expects to develop coal reserves sufficient to support the construction and operation of 22 coal gasification plants in North Dakota. The company has substantial coal lease holdings in close proximity to Lake Sakakawea. The initial plant will be capable of producing at least 250 MMcf/d of synthetic gas. An estimated 10 million tons of coal per year will be required to support the first 250 MMcf/d coal gasification complex.

The Natural Gas Pipeline Company of America has extensive lignite coal resources in Dunn County, North Dakota. The company considers these reserves to be adequate to support the construction and operation of eight 250 MMcf/d coal gasification plants. The operating life of the plant is approximately 30 years. The first plant would be in operation by 1980 with additional plants at 3-year intervals or as otherwise directed by market requirements. Each plant would consume about 9.9 million tons of lignite coal annually.

Although the existence of the Northern Border Pipeline may accelerate somewhat the development of these coal gasification proposals, and the possible development of such proposals may extend the life of the proposed pipelines, this reciprocal relationship is considered tenuous at best. The proposed pipeline and possible coal gasification are independent actions. Any impacts of future coal gasification plants, associated coal mining operations, or future synthetic natural gas pipelines will be addressed in detail in other environmental statements if and when their development becomes more certain.

Oil and Gas Fields

Several oil and gas fields are located in Montana, North Dakota, South Dakota, Illinois, Indiana, Ohio, West Virginia and Pennsylvania. There are no plans for the use of the proposed pipeline to transport oil or gas products from these fields. See Section 2.1.3.3 for the locations of these fields.

1.1.3.3 Facilities

The proposed system will consist of 1,619 miles cf mainline pipe up to 42 inches in diameter, 12 compressor station sites, 13 delivery-measuring stations, a communications system requiring 87 transmission/reception (microwave) towers, and 100 mainline block valves. The system will operate at a maximum pressure of 1,435 psig (pounds per square inch, gauge). The compressor piping and appurtenances will be designed for 1,440 psig.

Pipeline Description

Length, Diameter and Thickness

The mainline pipe will have an outside diameter ranging from 24 to 42 inches with a wall thickness ranging from 0.368 to 0.930 inch. The basic pipe material will be American Petroleum Institute (API) grade X-65 steel. The pipe will be fabricated from plate by the double submerged-arc welding process. Pipe specifications will fully meet or exceed the requirements of Part 192, Title 49, Code of Federal Regulations, Transportation of Natural and Other Gas by Pipeline, federal safety standards and in addition those of API Standard 5LX, API Specification for High-Test Line Pipe, latest edition or API Standard 5LS, API Specification for Spiral Weld Line Pipe, latest edition. The nominal strengths of this pipe has a yield strength greater than or equal to 65,000 psi and tensile strength greater than or equal to 77,000 psi. The reaches of pipe length and diameter by states traversed are shown in Figure 1.1.3.2-2 (System Map). The following table shows the dimensions of the mainline pipe in greater detail.

Pipe Size O.D. (inches)	Wall Thickness (inches)	State	Approximate Length (miles)
42	0.644	Montana N. Dakota S. Dakota Minnesota Iowa Illinois	1,138
36	0.552	Illinois Indiana Ohio	305
24	0.368	Ohio W. Virginia Pennsylvania	176
Total Pipe Length			1,619

Operating Pressure and Temperature

The natural gas will initially enter the proposed Northern Border pipeline at the United States-Canadian border at a temperature of about 70 degrees F and a pressure of about 1,435 psig. The initial system includes 12 compressor stations. The average pressure leaving each compressor station will be 1,435 psig and the flowing temperature will be 56 degrees F. Once all compressor stations are in operation, the pressure leaving the stations will generally be 1,435 psig and the flowing temperatures will range from 46 to 111 degrees F in the summer. During the winter the flowing temperatures will range from 31 to 97 degrees F. Present plans do not anticipate gas cooling facilities at any compressor stations; however, such coolers are considered to be optional by the company.

The basic pipeline will be designed for a maximum allowable operating pressure of 1,435 psig. The compressor piping and appurtenances will be designed for 1,440 psig.

Refer to Table 1.1.3.3-1 for average gas flowing temperatures compared with average ambient air temperatures at various locations along the pipeline.

Table 1.1.3.3-1 Gas flowing temperatures compared with ambient air temperatures

Approximate Milepost	Average Ambient Air Temp °(F)*		Average Gas Flowing Temperature °(F)	
	Summer	Winter	Summer	Winter
0	--	--	70	70
61	64	14	60	40
127	64	14	48	31
184	64	14	64	50
238	64	14	55	39
299	65	14	74	65
355	65	15	56	42
414	65	16	74	67
469	66	16	52	38
529	67	17	70	64
581	66	18	61	51
634	66	19	71	67
691	66	20	63	56
747	66	21	71	69
801	66	21	61	54
858	66	22	76	76
915	68	23	62	55
971	70	23	74	71
1027	71	25	57	47
1084	71	27	66	60
1138	--	--	59	50
1201	--	--	61	53
1262	69	29	52	40
1324	69	30	62	51
1384	69	30	55	43
1443	--	--	66	66
1619	--	--	50	38

(*) These temperatures were developed by the applicant from data obtained from the National Climatic Centers of the U.S. Department of Commerce. Winter average day is the historic average temperature for December, January, February, and March. Summer average day is the historic temperature for June, July, August, and September.

Installation Description

The design calls for almost the entire pipeline to be buried, with only short above-ground portions located at compressor stations, delivery-measuring stations and block valve sites. Generally the pipeline will be buried in a ditch or trench having a maximum width of 8 feet with the top of the pipe 30 to 36 inches below the original ground surface in soil and 18 to 24 inches in rock. The excess spoil material will be spread over the right-of-way. At all stream and river crossings, the pipeline will be buried below the scour depth of the stream or riverbed and where necessary will be weighted by use of a continuous concrete coating or by using bolt-on concrete weights to resist buoyancy. The Oahe Reservoir and five major rivers - the Youghiogheny, Ohio, Illinois, Mississippi, and Missouri - will be crossed with two pipelines the same size as the mainline.

Description and Operating Characteristics of Plants, Compressor Stations and Related Facilities

Compressor Stations

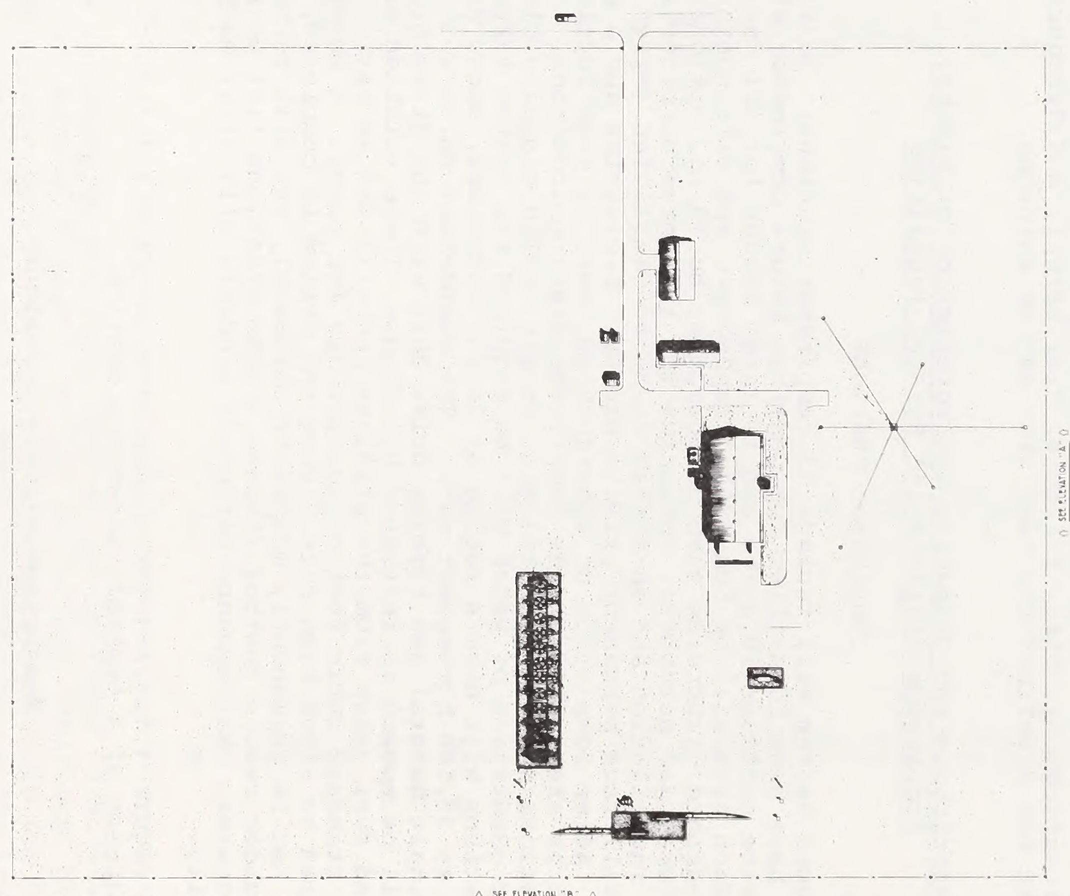
The proposed system will include 12 compressor stations. In addition, 13 more sites have been identified for possible future compressor station needs. Each site encloses 20 acres and is large enough for all ancillary facilities. Each site will be fenced and landscaped and will contain several above-ground structures such as equipment building, optional gas cooling structure, gas scrubbers, communication transmission/reception towers, valve installation and on-stream cleaning facilities ("pig" traps). Each station will have permanent private sanitary facilities and a potable water supply. After completion of construction, surplus construction materials will be stockpiled at the compressor station locations. The compressor stations will be operated with an air cooled closed cycle system, and only minor quantities of water will be required for system makeup. Nine compressor stations will have a rating of 30,000 horsepower each, and three will be rated at 13,500 horsepower each. The compressor units will be driven by a single natural gas turbine drive unit with the given horsepower rating and will be housed in insulated buildings. These turbines will obtain required fuel (gas) from the pipeline and will use an estimated total of 25 million standard cubic feet of gas per day for power. A powerline will be required to serve each site. When the system is completed, the stations will not be permanently manned by personnel, but will be monitored and operated under remote control through a communications link with the main control center. Maintenance personnel probably will visit each site at least once daily.

Refer to Figure 1.1.3.3-1 for a plan view and Figure 1.1.3.3-2 for an artist's conception of a typical compressor station.

Measuring-Delivery Locations

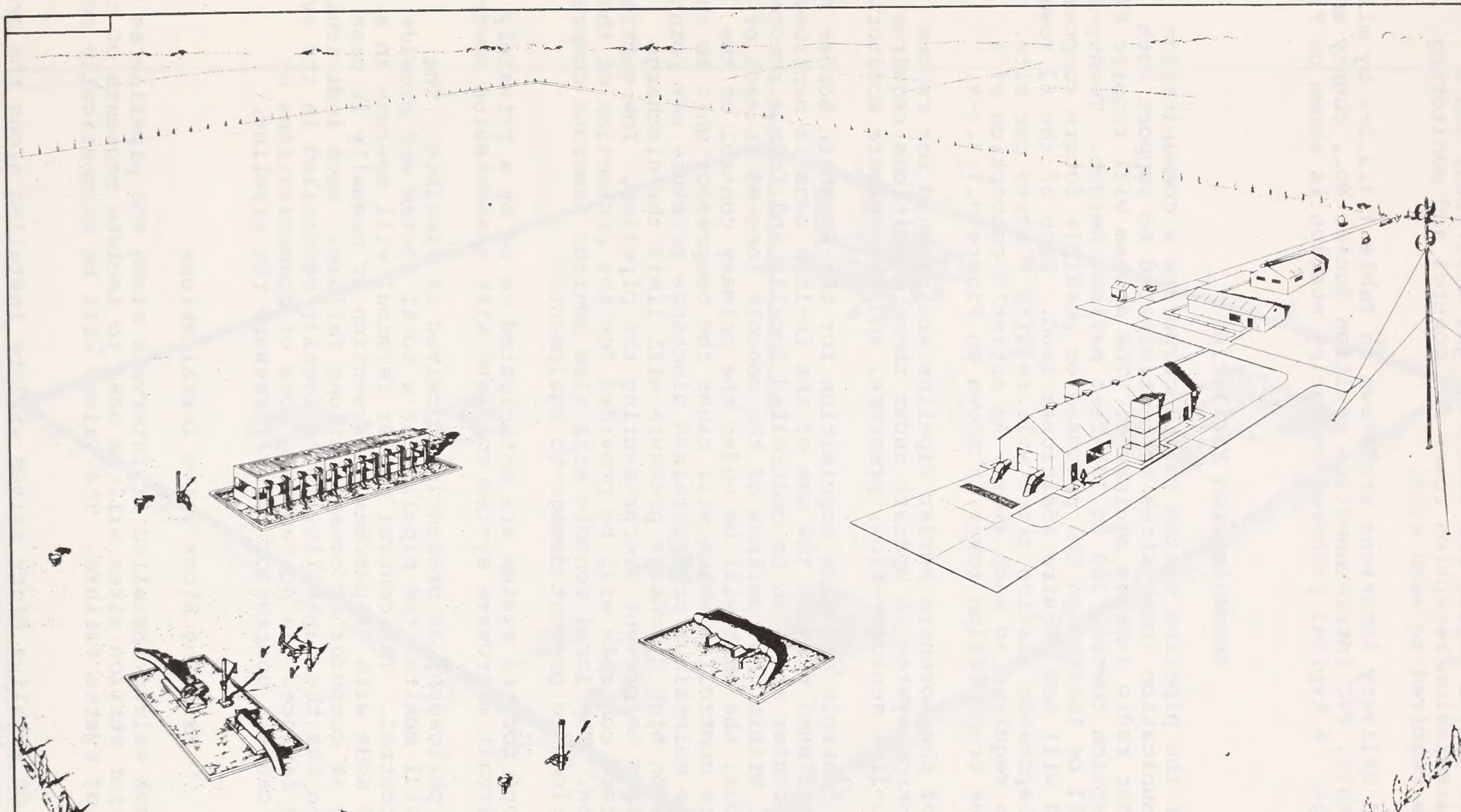
Six companies have applied to the FPC for permission to construct interconnections between their existing pipelines and the proposed Northern Border pipeline.

Upon completion of the proposed system, there will be 13 delivery locations of which 3 will be emergency delivery locations. Each delivery location will have a measuring station. Each delivery-measuring site will enclose an area of 2 acres and will be fenced and landscaped. Each site will include above-ground structures such as small buildings for control equipment, gas heating equipment (if required, to prevent freezing of



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.3-1 Drawing of compressor station, plan view



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.3-2 Drawing of typical compressor station regulators), above-ground piping for measuring gas delivered, and a communication transmission/reception tower for control and monitoring. A powerline will be required to each site.

The proposed delivery locations are shown in Table 1.1.3.2-2 by milepost, company, state, FPC interconnection petition docket No., county and township and range. A typical proposed measuring station is shown on Figure 1.1.3.3-3.

Communication Facilities

Operation of the pipeline system will incorporate a communication system. The communication tower sites are anticipated to support both microwave and other radio antenna equipment. The system will require 87 transmission/reception towers, 200 to 300 feet maximum height. Twenty-five of the towers will be located on the proposed or possible future compressor station sites and will not require additional land. Each of the 62 towers not located on compressor station sites will require 4 acres per site. A powerline will be required to each site. An artist's conception of a proposed microwave transmission tower is shown on Figure 1.1.3.3-4.

All phases of the Northern Border Pipeline are planned for remote operation. A control system to operate under these conditions requires three types of in-line sensors--flow, pressure, and temperature monitoring.

Supervisory controls and data acquisition for the Northern Border Pipeline can be accomplished through the use of the in-line sensors mentioned above. Each compressor unit can be controlled locally and from a remote dispatch center. Within the confines of the console located at each of the compressor stations, the unit will be under the primary control of the discharge pressure controller which will cause the compressor unit to speed up or slow down to maintain a predetermined discharge pressure set point. Override controls on high discharge pressure will limit the discharge pressure controllers to prevent overpressuring the pipeline. Low suction and high temperature controls will be provided for the protection of the compressor station. The local console will also monitor numerous compressor and station functions to prevent damage to equipment.

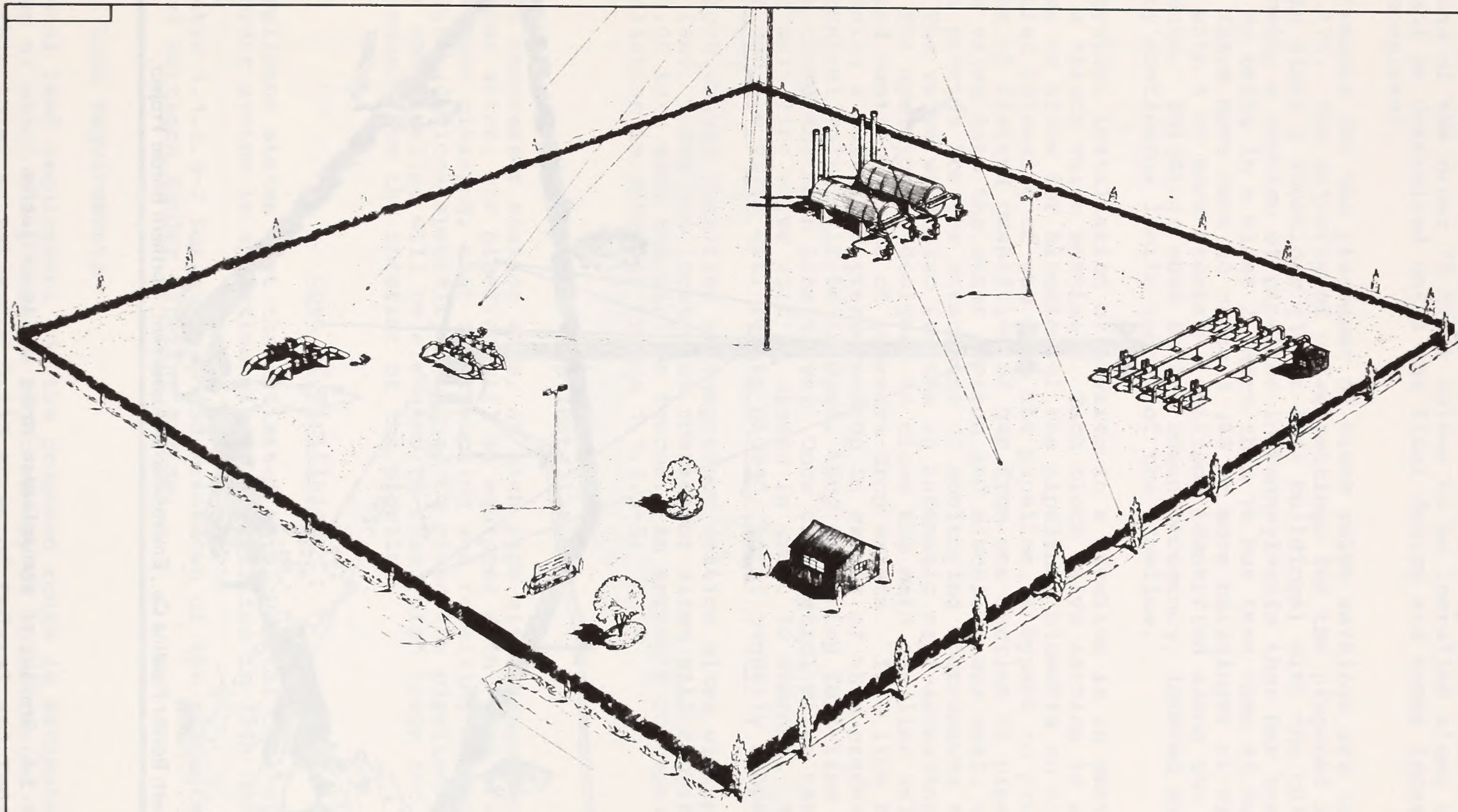
Communications for the system are anticipated to be by a privately owned multiple circuit microwave system complete with transmission towers.

The control philosophy as presently conceived is flexible. The computer system will monitor the pipeline as a total system and provide information for control. The central master terminal will operate in a computer assisted mode with dispatcher intervention or manually in case of an emergency such as computer or communications failure. Each individual compressor station has the capability to be locally controlled in the event of communications failure. In no case can loss of communications or computer control cause a compressor to overpressure the pipeline.

Mainline Block Valve Installations

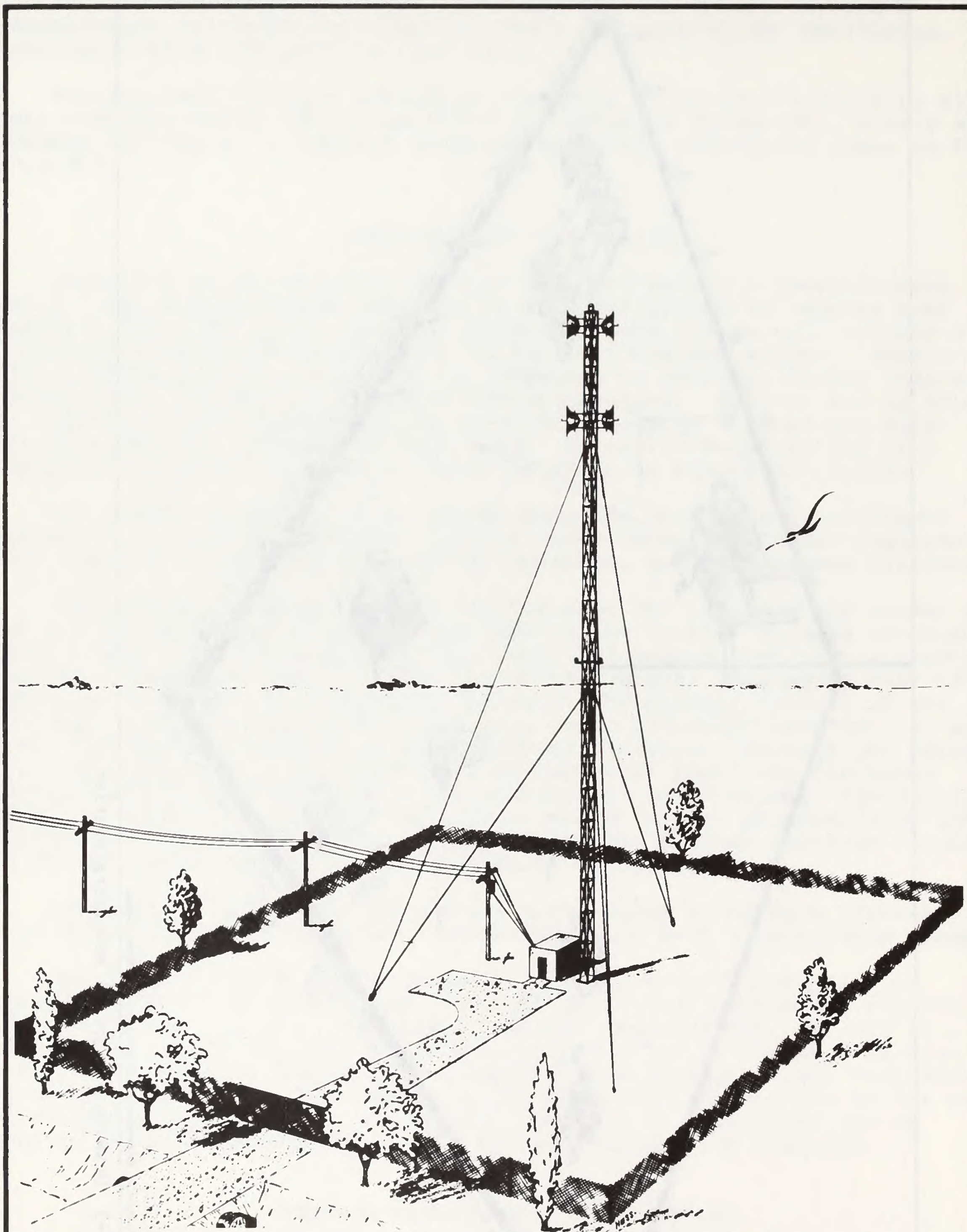
Mainline block valves installed at intervals along the pipeline as well as at the compressor station sites will be used to isolate segments of the pipeline in case of system failure. The valves will be automatically remote self-actuated.

A total of 100 mainline block valves will be installed along the proposed pipeline. One block valve will be installed at each of the 12 com-



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.3-3 Drawing of typical measuring station



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.3-4 Drawing of transmission tower and installation pressor station sites and the 13 possible future compressor station sites. The locations of the other 75 block valves to be installed along the pipeline will not be determined until the final design and exact location of the route are completed.

Requirements for the placement of block valve settings are contained in 49 CFR 192.179. The majority of valve settings for the proposed route are installed in class 1 locations (10 or less buildings) with the only exception being a section of pipeline in Pennsylvania that has been identified as being in a class 2 (more than 10 but less than 46 buildings) location. There have been no class 3 (46 or more buildings) or class 4 (buildings with 4 or more stories) locations identified along the pipeline's proposed route. Buildings must be for human occupancy, located within 220 yards of any continuous 1-mile length of the pipeline.

The physical installation of a valve in a pipeline is in what is defined as a "block valve setting." Each block valve setting is composed of a main valve to allow for blocking of the pipeline, blowoffs to allow for the controlled releasing of gas from the pipeline, a bypass to provide for the transfer of limited quantities of gas from one section of pipe past the closed main valve into the other section and miscellaneous small valves and fittings to provide for the attachment of monitoring instruments to the pipeline. The valve will also include an automatic self-actuating gas operator. The operator is designed to close the main gas line valve when a predetermined sustained rate of pressure-drop exists. If a line break occurs, causing a sustained pressure-drop in excess of this predetermined rate, the control valve will be tripped, thus admitting full-line gas pressure to close the main line valve. Once the control valve has been tripped the main line valve will be closed in about 30 seconds. This action is positive and the valve will remain closed, until manually reopened.

The block valves installed at compressor station sites will not require additional land; those not located at compressor sites will require an estimated 0.08 acre each and will be fenced. An artist's conception of a valve installation is shown in Figure 1.1.3.3-5.

"Pig" Trap Installations

At each compressor station site, at each pipe size change location, and at three other sites, the pipeline will be equipped with "pig" traps to permit in-stream cleaning, that is, launching and receiving mechanisms for passing "pigs" (devices specially designed to clean the pipeline). Short portions of the pipeline will be elevated to form "pig" traps for removal of material cleaned from the interior of the pipeline.

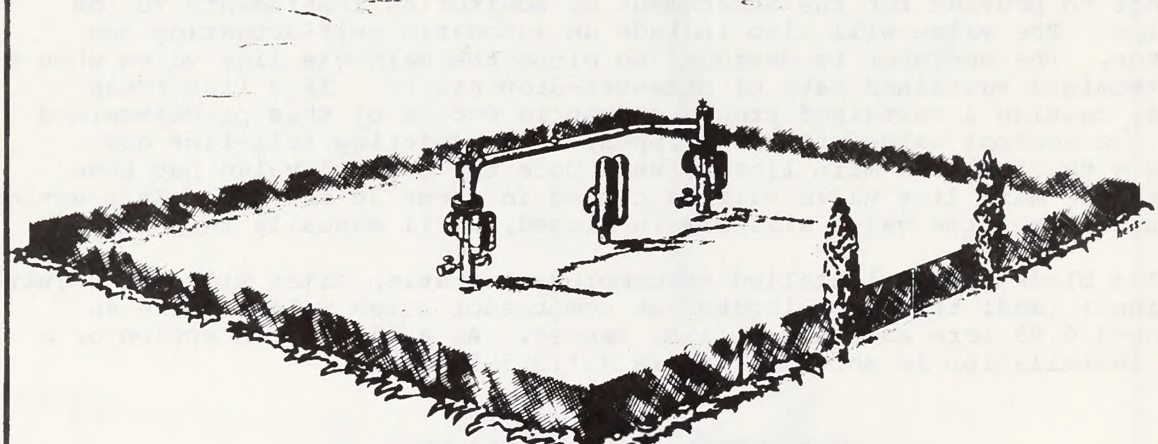
Cost of Facilities

The applicant states that the estimated total capital cost of the Northern Border system is approximately $1.347 billion in 1974 dollars.

See Table 1.1.3.3-2 for summary and breakdown of the estimated cost of the proposed Northern Border Pipeline system.

1.1.3.4 Land Requirements

The total land requirement for the proposed route is estimated at 20,736 acres of which the permanent right-of-way is an estimated 11,516 acres. Of this total an estimated 1,213 acres of Federal and Indian land is



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.3-5 Drawing of mainline block valve installation

Table 1.1.3.3-2 Northern Border Pipeline Company - cost of facilities ($1,000)

Column	A	B	C	D	E	F
Line Number	Description	Quantity	Units	Material	Installation	Total
1	Pipeline					
2	42-Inch O.D.	1138	Miles	507,900	165,700	673,600
3	36-Inch O.D.	305	Miles	96,600	33,900	130,500
4	24-Inch O.D.	176	Miles	25,800	26,900	52,700
5	River Crossings	12	Rivers	8,000	9,700	17,700
6	Subtotal					874,500
7	Compressor Stations					
8	Compressor Units	12	Stations	34,200	3,900	38,100
9	Auxiliaries and Piping	12	Stations	12,700	9,300	22,000
10	Subtotal					60,100
11	Other Direct Costs					
12	Right-of-Way and Damages	1619	Miles			47,800
13	Land in Fee	Lump Sum				2,400
14	Measurement Stations	13	Stations	3,700	2,500	6,200
15	Communication System	1619	Miles	9,700	2,900	12,600
16	Survey and Mapping	1619	Miles			4,900
17	Operation and Maintenance Equipment	Lump Sum				4,400
18	Subtotal					78,300
19	TOTAL DIRECT COSTS					1,012,900
20	Indirect Costs					
21	Engineering and Construction Management	Lump Sum				37,600
22	Contingencies	Lump Sum				62,700
23	Commitment Fee for Long Term Debt	Lump Sum				12,300
24	Commitment Fee for Short Term Debt	Lump Sum				5,200
25	Allowance for Funds Used during Construction	Lump Sum				213,700
26	TOTAL INDIRECT COSTS					331,600
27	TOTAL DIRECT AND INDIRECT COSTS					1,344,400
28	Filing Fee	Lump Sum				2,600
29	TOTAL COST OF FACILITIES					1,347,000

required. The existing land use is discussed in detail in Section 2. Listed in the following table are land requirements by feature and by land ownership:

Type of Land Use	Miles
Urban (residential, industrial, commercial)	4
Agriculture	
Cultivated	1,231
Range	259
Woodland	74
Rights-of-Way (roads, railroad, utility)	27
Waterways and Floodplains	24
Total	1,619

Right-of-Way

Construction Right-of-Way Length, Width and Acreage

The proposed route will have land requirements which are larger during the short term construction phase than during the long term operational phase.

The total estimated construction right-of-way is 20,736 acres. The breakdown of construction right-of-way is shown in Tables 1.1.3.4-1 and -5.

Normal pipeline construction practice is to "string" the pipe as soon as possible after delivery; thus, pipe stockpile site requirements tend to be minimal. Delivered pipe is stockpiled temporarily on private property available for use as commercial storage. The major portion of the pipe will be shipped to the pipeline project by rail and barge. Table 1.1.3.4-2 sets forth pipe stockpile locations and approximate pipe tonnages anticipated to be stored at each site along the proposed route; each site has been selected to provide access to the construction operation. Each stockpile site is estimated to require about 20 acres of land, of which the majority of sites are expected to be leased or rented temporarily from railroads serving the locations.

Along the pipeline a nominal 100-foot wide working right-of-way will be required during the construction phase. The land requirements for the pipeline broken down by states are shown in Table 1.1.3.4-3. After completion of construction and restoration, only a narrow right-of-way, 40 feet of the permanent 54-foot right-of-way, will be maintained and kept clear of tall shrubs and brush. The normal 46-foot wide construction right-of-way will revert to the landowner.

Access roads will be required for the construction of the pipeline and related features. Primary access for construction crews will be public roadways. The right-of-way will be used as a service road. Additional access roads will be required in certain areas to minimize travel between supply points, or in areas where natural features such as a number of stream and river crossings or steep slopes make extensive travel along the right-of-way impractical. Upon completion of the construction phase, the temporary access roads will be restored in a manner similar to that planned for the pipeline right-of-way.

The proximity of existing roads and natural terrain barriers will dictate locations and lengths of access roads both temporary and permanent.

Table 1.1.3.4-1 Land requirements by feature

Feature	Construction R.O.W. (Acres)	Permanent R.O.W. (Acres)
Pipeline (1,619 miles)	19,626	10,584
Compressor Stations		500
Communication Towers		248
Mainline Block Valves		6
Delivery-Measuring Stations		26
Stream Crossings	165	
Major River Crossings	200	
Pipe Stockpiles	600	
Access Roads	145	152
Total	20,736	11,516

Table 1.1.3.4-5 Land requirements by ownership

Land Ownership	Permanent R.O.W. 54' Width (Acres)	Temporary R.O.W. (Acres)	Total Approximate (Acres)
Bureau of Land Management	140	103	243
Indian Trust Lands	243	227	470
Bureau of Indian Affairs	10	9	19
U.S. Corps of Engineers	41	61	102
U.S. Fish and Wildlife Service	193	165	358
U.S. Forest Service	11	10	21
Sub Total - Federal and Indian Land	638	575	1,213
All Others (State, County, Private)	10,878	8,645	19,523
Total	11,516	9,220	20,736

Table 1.1.3.4-2 Pipe stockpile location and tonnages

Location	Pipe Quantity (Tons)	Location	Pipe Quantity (Tons)
Cole, Montana	39,000	Rockwell, Iowa	42,000
Nashua, Montana	36,000	Dewar, Iowa	37,000
Macon, Montana	42,000	Central City, Iowa	35,000
Hoffmanville, Montana	52,000	Grand Mound, Iowa	42,000
Killdeer, North Dakota	42,000	Normandy, Illinois	41,000
Antelope, North Dakota	40,000	Grand Ridge, Illinois	33,000
Breien, North Dakota	51,000	Papineau, Illinois	31,000
Ashley, North Dakota	45,000	Royal Center, Indiana	37,000
Wetonka, North Dakota	41,000	Warren, Indiana	36,000
Crocker, South Dakota	40,000	Buckland, Ohio	35,000
Castlewood, South Dakota	35,000	Richwood, Ohio	29,000
Arco, Minnesota	37,000	Mt. Vernon, Ohio	24,000
Westbrook, Minnesota	33,000	Fostboy, Ohio	13,000
Trimont, Minnesota	30,000	Power, West Virginia	15,000
Lakota, Iowa	36,000	Jeanette, Pennsylvania	19,000

Table 1.1.3.4-3 Pipeline land requirements

State	Miles	Right-of-Way Construction (100 Feet Wide)	Right-of-Way Permanent (54 Feet Wide)
Montana	180	2,182	1,180
North Dakota	269	3,261	1,760
South Dakota	182	2,206	1,190
Minnesota	131	1,588	858
Iowa	244	2,958	1,590
Illinois	161	1,952	1,050
Indiana	149	1,806	975
Ohio	231	2,800	1,510
West Virginia	8	97	52
Pennsylvania	64	776	419
Total	1,619	19,626	10,584

Based upon preliminary review of aerial mosaics it is estimated that some 50 temporary roads, with an average length of less than 1 mile, will be required during construction of the entire project. Over 50 percent of these will be located in the less populated areas of Montana and North Dakota where existing roads do not traverse the pipeline route as often as in the more populated areas further east. The applicant states that based on past experience it is anticipated that more than half of these temporary roads may remain for the use of the landowners. The width of the temporary roads will vary up to 24 feet. The acreage of land required for access roads is 145 acres, based on 50 roads, each 1 mile long and 24 feet wide.

Additional working space will be required at each stream crossing. The applicant states that the required acreage at each crossing will approximate the width of the water crossing. However, it is estimated that the actual area will be much greater and will be about 165 acres.

The applicant states that an estimated total of 37.4 acres of land will be required for working space at the 12 major river crossings. However, it is estimated that river crossing area will actually be about 200 acres which includes the area required for pipe storage, equipment storage and temporary storage of excavated material during the construction cf these crossings.

Permanent Right-of-Way Length, Width and Acreage

The permanent land requirements for maintenance of the pipeline and for permanent access roads are shown below.

Feature	Estimated Acres
Pipeline (54-foot width)	10,584
Permanent Access Roads	152
Total	10,736

The permanent pipeline land requirement based on a 54-foot width is shown by state in Table 1.1.3.4-3.

Continued use of some access roads will be required to permit the operation and maintenance of the pipeline and related facilities. Permanent access roads may be required for maintenance of the right-of-way in certain areas, and will be required for access to compressor stations, delivery-measuring stations, block valve installations and communication tower sites.

Permanent access roads to compressor stations will normally have an 18-foot hard surface over a 24-foot base. Access roads to remote valve sites must be all-weather and may be single lane. With few exceptions, compressor stations are located adjacent to existing public roads and will require only short access roads. The land area for these roads is estimated to be 152 acres.

Except for fenced areas of above-ground facilities, the majority, if not all the permanent right-of-way will be available for use by the landowner. However, the erection of buildings or similar installations by the landowner will be prohibited on the permanent right-of-way.

In uncultivated land areas, 40 feet of the permanent pipeline right-of-way width will be maintained as grassland free of large shrubs and trees which would interfere with inspection and pipeline maintenance.

Existing Rights-of-Way to be Utilized

The proposed route is found to adjoin or abut 23.6 miles of existing rights-of-way; these are listed in Table 1.1.3.4-4.

Rights-of-Way on Federal and Indian Lands

The proposed route will cross an estimated 61 miles of public lands and 37 miles of Indian Trust Lands. These lands are identified in Tables 1.1.3.4-5 and -6.

Plant, Station and Related Facilities Site Acreages

Land will be required for permanent above-ground facilities such as compressor stations, communication towers located at other than compressor stations, delivery-measuring stations and mainline block valves. The following table lists the requirements:

Feature	Total Estimated Acres
Compressor station sites (includes future sites)	500
Communication towers (52 not located at compressor station sites)	248
Mainline block valves	6
Delivery-Measuring stations	26
Total	780

The system design provides for a total of 12 compressor stations. Thirteen additional sites were identified for possible future compressor stations. The land will be purchased for these sites and used for communication tower sites. Each compressor station site is planned to be 20 acres, large enough for all ancillary facilities. The total amount of land required for the proposed and possible future compressor station sites in each of the states is shown in the following table:

State	Acres
Montana	40
North Dakota	100
South Dakota	60
Minnesota	60
Iowa	80
Illinois	60
Indiana	40
Ohio	60
West Virginia	0
Pennsylvania	0
Total	500

Operation of the pipeline will incorporate a communication system. The communication towers are anticipated to jointly support microwave and other radio antenna equipment. This will require 87 transmission/reception towers. Twenty-five of these towers will be located on the proposed and possible future compressor station sites and will not require additional land. The land required for the 62 towers not at compressor station sites is 4 acres per site.

Table 1.1.3.4-4 Joint rights-of-way

Type of Existing R.O.W.	Distance	Location
1. electric powerline	1.2 miles	Princeton Township, Scott Co., Iowa
2. electric powerline	0.6 mile	Cordova Township, Rock Island Co., Ill.
3. electric powerline	1.9 miles	Newton Township, Whiteside Co., Ill.
4. two pipelines	1.8 miles	Fenton Township, Whiteside Co., Ill.
5. electric powerline	0.2 mile	Wells Township, Jefferson Co., Ohio
6. electric powerline	0.5 mile	Buffalo District, Brooke Co., W. Va.
7. electric powerline	3.0 miles	Carroll Township, Washington Co., Pa.
8. electric powerline	5.6 miles	Elizabeth Township, Allegheny Co., Pa.
	extending to:	North Huntingdon Township, Westmoreland Co., Pa.
9. pipeline	0.8 mile	Carroll Township, Washington Co., Pa.
10. pipeline	1.4 miles	Elizabeth Township, Allegheny Co., Pa.
	extending to:	North Huntingdon Township, Westmoreland Co., Pa.
11. pipeline	6.6 miles	Hempfield Township, Westmoreland Co., Pa.
	through:	Pennsylvania Township, Westmoreland Co., Pa.
	extending to:	Salem Township, Westmoreland Co., Pa.

Table 1.1.3.4-6 Federal and Indian lands crossed by proposed pipeline

State	Land Ownership	Approx. R.O.W. Length (Miles)	R.O.W. Width (Feet)	Perm. R.O.W.(54') (Acres)	Temp. R.O.W. (Acres)	Total (Acres)
Montana	Bureau of Land Management	18	100	134	97	231
	Bureau of Indian Affairs	2	100	10	9	19
	Indian Trust Lands	37	100	243	227	470
North Dakota	Bureau of Land Management	1	100-200	6	6	12
	Forest Service	2	100	11	10	21
	Corps of Engineers	1	100-200	8	19	27
	Fish and Wildlife Service	11	100	70	60	130
South Dakota	Fish and Wildlife Service	20	100	123	105	228
Iowa	Corps of Engineers	2	100-200	10	19	29
Indiana	Corps of Engineers	1	100	5	4	9
Ohio	Corps of Engineers	2	100-200	17	15	32
West Virginia	Corps of Engineers	1	200	1	4	5

The land required for delivery-measuring stations is 2 acres each. The land required for the 13 delivery points including 3 emergency delivery points is estimated to be 26 acres and is tabulated below by state:

State	Acres
South Dakota	2
Minnesota	2
Iowa	4
Illinois	6
Indiana	4
Ohio	2
Pennsylvania	6
Total	26

The land requirement for each of the mainline block valve installations along the pipeline is about 3,000 square feet. A total of 100 valves will be installed along the pipeline, 25 of which will be installed on the proposed and possible future compressor station sites obviating additional land requirements. A total of about 6 acres will be required for the remaining valves. The fenced area for these valves will be within the 54-foot permanent right-of-way width for the pipeline.

The land for the facilities discussed in this section will not be available for use by the landowner after construction is complete.

Related Land Areas Affected

Roads

The land for temporary roads will revert back to the landowner after construction is completed. Permanent access roads will be required for the life of the system to facilitate operations and maintenance.

Housing

Construction camps are anticipated by Northern Border for the segments in Montana, North Dakota, and northern South Dakota.

1.1.3.5 Schedule

Duration of Project Construction

The proposed Northern Border Pipeline System will be constructed in order that facilities will be ready for operation July 1, 1980.

A spread is a discrete construction unit (men and equipment) responsible for construction of one or more segments. A segment is a particular continuous length of pipeline to be installed in a given construction season. All of the pipeline and related facilities will be completed during two summer seasons and 2 months of a third season. The first summer season construction will consist of laying approximately 40 percent of the pipeline and the second will incorporate completion of the pipeline, construction of compressor stations, communication systems, and delivery-measuring stations. The system maps, Figures 1.1.3.2-1 and -2 indicate the pipeline segments and system components to be constructed.

Periods of pipeline construction are scheduled during the following months:

May 1978 through November 1978
May 1979 through November 1979
May 1980 through June 1980

This schedule does not contemplate any winter construction. The construction will involve 15 segments, 6 in the summer of 1978 and 9 in the summer of 1979 plus May and June of 1980.

Individual Facility Construction Times

Compressor Stations

All compressor stations will be constructed from May 1979 through June 1980. The construction time for a compressor station is estimated to be 6 months.

Communication Towers

All of the communication towers will be constructed from May 1979 through April 1980. Each tower will be completed in approximately 6 to 8 weeks.

Delivery-Measuring Stations

The delivery-measuring stations will be completed in conjunction with the construction of the mainline spreads.

Time Required for Preparatory Functions

Relocations of Housing, Business and Public Facilities

The proposed route avoids all houses and industrial/commercial establishments; therefore, no relocations of this nature are anticipated.

Roads

The requirements for these access roads were discussed previously in Section 1.1.3.4. The estimated 50 miles of temporary access roads will be required at various points along the pipeline to facilitate construction. These roads will be built in conjunction with the appropriate construction spread. Temporary road construction will probably begin about 1 month prior to the clearing and grading of a particular spread. These temporary roads would not be restored to the condition of the surrounding area until completion of all construction activities, including hydrostatic testing, along the pipeline.

The estimated 52 miles of permanent access roads will be required at various points along the pipeline to provide access to compressor stations, communication towers, delivery-measuring stations and mainline block valves and in certain areas for maintenance of the right-of-way. These roads will be constructed in conjunction with the schedule for each individual site. However, construction will probably begin about 1 month ahead of actual site work.

Maintenance of Public Services During Construction

The construction of the proposed pipeline will involve the use of many Federal and State highways as well as county roads. Many of these roadways will be crossed by the pipeline, most crossings will be bored underneath the roadbed without disturbing the traffic flow. Many of the less traveled county roads will be crossed by opencut methods. It will be the responsibility of the applicant to obtain the necessary permits from the appropriate regulatory agencies and each individual spread contractor must comply with those agencies' regulations and requirements for detours, methods of construction and repair.

All underground utilities will be located, carefully exposed and protected during trenching and other construction operations.

Schedule of Currently Proposed Future Construction

Thirteen possible future compressor station sites have been identified by the applicant, but there are no present plans to develop these sites except for the construction of a communication tower and a block valve at each site. Additional compressor facilities could be constructed at these sites in the future if required for the transportation of larger volumes of natural gas.

1.1.3.6 Construction Procedures

The construction of the proposed pipeline route will require no relocations of structures or public roads.

The construction of the pipeline will begin with surveying of the route, clearing of access roads and the pipeline route, work on existing or new fences to accommodate construction operations and building of required roads to that particular portion of the work to provide access for construction equipment, personnel and pipe hauling trucks. In those areas involving river or road crossings, work on the crossing will begin prior to or about the same time as the initial clearing, so that the crossing will be completed at approximately the same time as installation of other pipe in that reach of pipeline occurs.

The next operation would be grading the right-of-way and excavation of the ditch or trench. At this time the pipe will be transported to the site and strung along the trench.

Once the trench is ready for pipe installation, the pipe will be bent to conform to the contour of the trench and the individual units will be lined up and welded.

Immediately following the welding, the welded joints will be inspected, the pipe exterior cleaned, and a protective coating will be applied to the outside of the pipe, unless the coating was applied in the pipe plant or storage area.

The pipe will then be lowered into the trench and all necessary tie-ins will be completed. The backfilling of the trench can now be accomplished.

At this time the pipeline is ready for hydrostatic testing. Water will be introduced into the pipe, raised to the required test pressure, and held for the prescribed length of time. Any leaks will be repaired, and the pipe retested. When the adequacy of the pipeline is assured, the final cleanup and restoration of the right-of-way can begin.

Preparatory Procedures

Relocations

The proposed route is situated so that there is no need to relocate houses, industrial and commercial buildings or public roads.

Road and Site Clearings

Road Clearing

The permanent access roads will normally consist of at least a 24-foot base width and an 18-foot roadway width. The procedures discussed below will generally apply to access road construction. New road construction will begin with work on existing fences and clearing vegetation, brush, and trees. Where it is not possible to locate the roads in order to avoid steep gradients or sidehill slopes, the route must be cut to maintain minimum grades for trucks hauling supplies, equipment and pipe. In areas where the existing material is rock, or soft, unstable or wet material, suitable base material must be imported. This borrow material would be obtained from the nearest existing borrow site where possible.

Pipeline Right-of-Way and Site Clearing

The clearing and grading stage is initiated by a fence crew. This crew leads the spread and installs temporary openings in fences to provide access to the right-of-way for the pipeline-laying operations. Braced posts are set on both sides of the point where a temporary gate is to be installed in an existing fence and the existing fence strands are securely attached to these posts before the fence is cut. A temporary gate is installed across the gap to allow passage of the ditching machine and other vehicles.

The next step in the operation entails removing obstacles such as trees, large rocks, brush and logs, as well as partially leveling and smoothing abrupt changes in ground contours. Measures will be taken, and operations will be conducted in a manner that will minimize disturbance to the existing environment.

The width of right-of-way normally required for the construction of the pipeline is approximately 100 feet and this entire width will be cleared. This width of right-of-way is needed to provide sufficient room for construction activities, and temporary storage of excavated material. Excavated material is stored in a 25-foot strip along one side of the right-of-way. The remaining portion of the right-of-way is used to provide access for construction equipment, to permit the passage of equipment, to store supplies and to construct the pipeline.

The grading operation consists of only that amount of surface disturbance necessary to prepare a relatively level strip along the right-of-way. The 100-foot strip will be a minimum. It must be smooth enough to provide a safe passage of heavy vehicles such as the stringing trucks that haul pipe to the site, the trenching equipment and the tractors and welding vehicles associated with the spread.

A minimum amount of grading is done when crossing croplands. When the field is ridged with cultivated windrows, the right-of-way is lightly bladed to eliminate the washboard surface.

In crossing grassland and rangeland, enough grading is done to provide only a level passageway for the spread. When gullies or intermittent watercourses are encountered, steep banks will be cut to permit vehicle transport.

When steep lateral slopes are encountered along the route, the right-of-way will be graded to a sufficient width to provide a relatively level surface across the right-of-way for the operation. This will involve cuts into the uphill slope and fills on the downhill slope. The width will, in many locations, exceed the customary 100 feet of construction right-of-way and additional right-of-way will be required. Steep slopes, banks at stream and river crossings and ridges along the route will require considerable cutting to provide usable slopes for the equipment and for the pipelaying operations. Where large areas of hard rock are encountered, drilling and blasting will be necessary if the rock cannot be removed otherwise.

Where construction crosses areas that include dry grasslands or vegetated fields, a firebreak will be graded along the edges of the right-of-way to help prevent the spread of field fires.

Stream, road and railroad crossings will require clearing of additional temporary working space for fabrication of the crossings.

Pipeline Construction Techniques

A typical pipeline construction spread is illustrated in Figure 1.1.3.6-1, and a typical pipeline construction profile is shown on Figure 1.1.3.6-2.

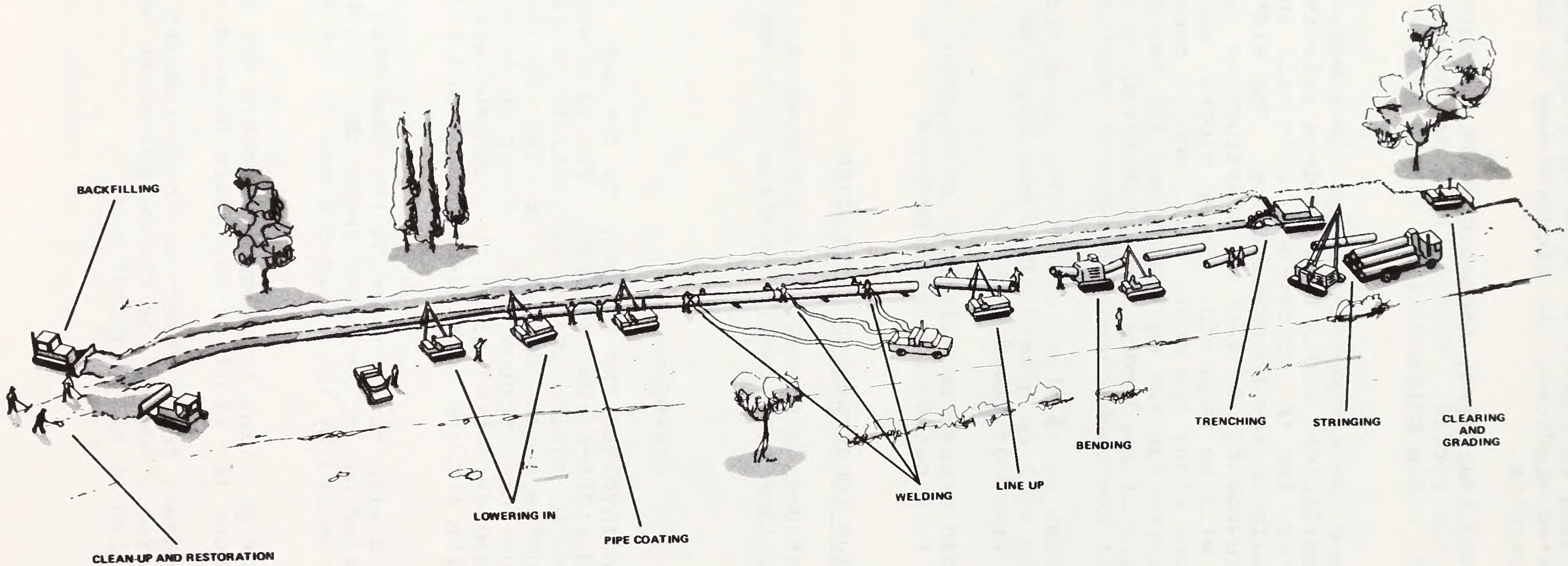
Stringing

The stringing operation involves the movement of the pipe from the storage area to the prepared right-of-way for use. The pipe will be delivered to the project area by rail or barge and will be stored at the storage areas in various lengths up to 80 feet. It will then be trucked from the storage areas to the construction zone. The pipe is moved by trucks or tracked vehicles and deposited along the right-of-way merging in a continuous line in preparation for the subsequent lineup and welding operation.

Stringing is coordinated with the advance of the trenching and pipelaying crews and is carried out so as to minimize the length of time a specific tract of land is occupied by the various crews of the construction spread.

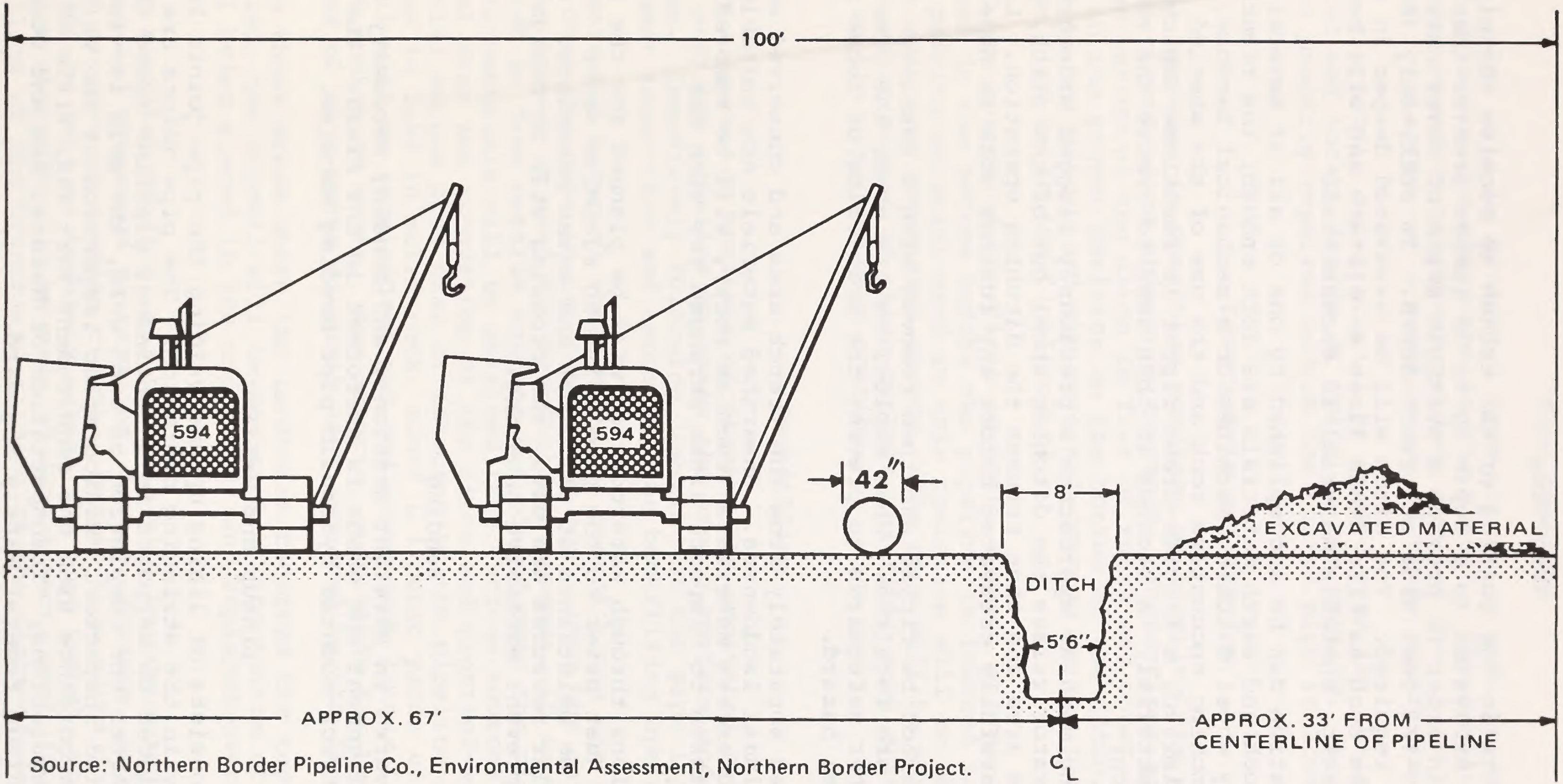
Gaps will be left as the pipeline is strung to permit the passage of farm stock and equipment across the right-of-way where necessary.

The amount of pipe necessary for a stream or road crossing is stockpiled at the crossing area. Access for the construction vehicles is provided by the cleared portion of the right-of-way.



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.6-1 Drawing of a typical pipeline construction spread



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.6-2 Drawing of a typical pipeline construction profile

Trenching

This operation entails the cutting of the trench to receive the pipe. The ditch normally is excavated to a depth 30 to 36 inches greater than the diameter of the pipe in order to provide a suitable depth of cover material, and is approximately 5-1/2 feet wide at trench depth. In rock, only 18 to 24 inches of cover is required. The ditch will be excavated deeper in areas where existing features such as tile drain lines so dictate and will be wider in areas where soft, unstable material is encountered.

The trench excavation can be accomplished by one or all of several methods. Where the rock and earth materials are soft enough, the trench is cut by means of rotary wheel ditching machines or a mechanical backhoe. In those areas where trenching encounters rock and the use of the wheeled ditching machine is limited, a tractor-drawn ripper is sometimes employed to break and loosen the material. A backhoe is then used to remove the rock and soil from the ditch.

Where the ditching machine approaches a previously flagged underground utility line, the operator raises the ditching wheel out of the ditch, moves the machine across the area and then resumes the ditching operation. Later, these crossings are carefully excavated before any further work is done in the area.

Where the rock cannot be ripped and then removed with a backhoe, drilling and blasting are required. When explosives are used, the area is covered by mats or other safeguards to prevent the scattering of loose rock and to reduce personnel hazard.

Topsoil is removed separately from the trench area and conserved as required by the individual landowners. Unearthed materials not suitable for trench backfilling and excess materials (such as rock), will be removed from the right-of-way and taken to disposal areas arranged for with the individual landowners.

Trenching operations through watercourses will be planned for the final trench cut to be made just prior to the pipelaying to minimize water pollution. Flow will be maintained at all ditch and water crossings. Where fluming or other similar measures are used, the crossing will be designed to pass flood flows and prevent excessive scouring.

Bending

The pipe is delivered in straight sections, and bending necessary for minor variations in alignment and grade is performed in the field. The bending is done by a track-mounted hydraulic pipe-bending machine.

Lineup and Welding

This operation consists of lining up and welding the pipe joints laid along the right-of-way in the stringing operation. The pipe joints are welded together and placed on supports in a continuous pipeline along the side of the trench. After the completion of each weld, the weld is visually inspected by a qualified inspector. Radiographic inspection of the welds will be performed in accordance with the requirement Part 192, Title 49 of the Code of Federal Regulations, "Transportation of Natural Gas and Other Gas by Pipelines: Minimum Federal Safety Standard."

Pipe Coating

All pipe will be protected from corrosion with an external coating applied prior to its placement in the trench. The coating material will be a coal tar or other petroleum product applied hot, a chemical epoxy material, a plastic, or a combination of these materials.

An electronic detector will be passed over the entire length of pipe to check for and locate faults or voids in the coating. All faults or voids are then properly repaired before the coated pipe is lowered into the ditch.

Lowering-In and Tie-Ins

The lowering-in operation consists of lowering the welded pipeline into the open trench using side-boom tractors. Inspections are made to assure that the bottom of the ditch is free of rocks and other debris, the pipe is placed in its proper position on the bottom of the ditch, all bends properly conform to the ditch, and the external coating on the pipe is not damaged when the pipe is in its final position.

If the bottom of the ditch is rock, a sand, gravel or soil padding will be placed in the bottom before the pipeline is lowered in. The sand or gravel padding material used in this operation will be obtained from the nearest existing commercial source. The pipe will be wrapped, if necessary, with an outer shield of thick asphalt and fiber rock shield to prevent damage to the pipe and pipe coating.

Backfilling

This operation consists of placing the excavated material from the trench over the pipeline to renew the ground surface and protect the pipeline. Immediately following lowering of the pipe into the ditch and subsequent inspection and approval, the backfilling operation begins.

Excavated material which has been stored along the right-of-way is placed over the pipe in the ditch. In most cases the material excavated from the trench is used for backfilling; however, if necessary, material may be hauled in from outside sources and placed over the pipe. Replacement backfill materials will be obtained from various sources such as excess material from the excavation of the ditch and right-of-way cuts or from commercial borrow pits near or adjacent to the pipeline route. Where the pipeline is laid in solid rock, about 1.3 cubic yards of appropriate material will be required to pad and cover each linear foot of 42-inch pipe with 18 inches of cover. Any material unsuitable for backfilling is disposed of in a waste disposal area approved by the landowner.

In those areas where the landowner required the topsoil to be separated, the subsoil will be replaced at the bottom of the trench, with topsoil being placed in the upper part and replaced over the graded right-of-way.

To minimize erosion, all backfill will be compacted solidly at opencut roadways and crossings of terraces, levees, streams, and ditches. To prevent erosion in slcping terrain, burlap-type sacks filled with earth or sand will be laid as breakers across the pipe trench, where necessary, and diversion channels will be made to divert water away from the pipe trench. Backfilling of the trench and grading of the right-of-way will be done to restore the contour of the ground as much as possible to permit normal surface drainage.

Cleanup and Restoration

Cleanup includes two steps: First, all surplus material, equipment, skids, trash, litter and miscellaneous debris are removed and disposed of off the site in existing disposal areas. Second, the surface is graded to conform to the existing surface of the adjoining area except for a slight crown of soil that will compensate for the natural subsidence of the backfill.

Restoration of the right-of-way includes contour furrowing and revegetation. The reestablishment of vegetation along the right-of-way and on streambanks uses appropriate plants, materials and methods for each particular area. The restoration generally includes the reestablishment of grasses, but not brush or trees.

All terraces, levees and watercourses will be restored as near as possible to preconstruction conditions. Special control of construction practices will be used on streambanks and in natural drainage ways. In sloping terrain, erosion-control structures will be constructed to prevent erosion of soil on the right-of-way and other areas that would be disturbed by the construction.

Contouring will be accomplished using suitable excess soil. If sufficient soil is not available, it will be obtained from borrow pits approved by the landowner. Discing, grading and reseeding operations will be implemented after trench backfilling operations have been completed. If seasonal or weather conditions are not favorable for revegetation, it will be delayed until the earliest time in which favorable conditions do exist.

A final step in cleanup and restoration is removal of the temporary fences and gates installed at the beginning of the right-of-way and site clearing. The fence crew will remove all temporary fencing and, if necessary, set new posts for the permanent field fence. New strands of wire will be stretched and secured to blend into the existing section of fence. A pipeline marker will be installed in most fence lines, at roads, rivers, powerlines, and other locations to properly identify location of the pipeline.

After the cleanup, the landowner is contacted to ascertain his satisfaction and approval of the final restoration. Thereafter, periodic inspections of the right-of-way will be made, and additional restoration measures taken as necessary.

Specific Construction Techniques

Road, Highway and Railroad Crossings

Most controlling agencies require that all State, national, and interstate highways and all railroads be crossed by jacking, boring or tunneling. For these crossing methods a pipe casing sleeve or tunnel linear plate is inserted beneath the surface and a complete section of the pipeline is placed in the casing. Whichever method is used, it is necessary to excavate a pit large enough to accommodate the required equipment on each side of the road. The crossing is normally completed ahead of the normal pipe installation.

Unpaved private and public roads as well as paved county roads carrying little traffic are crossed by means of an opencut if approved by the owner or appropriate regulatory agency. An opencut crossing involves either closing the road to all traffic, excavating only one-half of the road at a time, or constructing an adequate detour around the crossing area. The trench for an opencut crossing is excavated with a backhoe or similar equipment, the pipe placed across the roadway, all backfill compacted and the road surfacing replaced as specified by the controlling agency. Because of the delay to traffic and damage to the road surface, most regulatory agencies do not permit using this method for heavily traveled roads.

Drain Tile Field Crossings

Any field drainage lines damaged, cut or removed by construction are repaired temporarily to permit its proper function until such time as the tile can be repaired permanently as shown in Figure 1.1.3.6-3. The locations of drainage lines are commonly not known by the landowner. Most lines do not contain steel and are difficult to locate from the ground surface by metal detection devices. The drain tile will be repaired or replaced so that their function will be restored. Where necessary due to the depth of existing lines, the depth of the proposed pipeline will be lowered to provide adequate clearance.

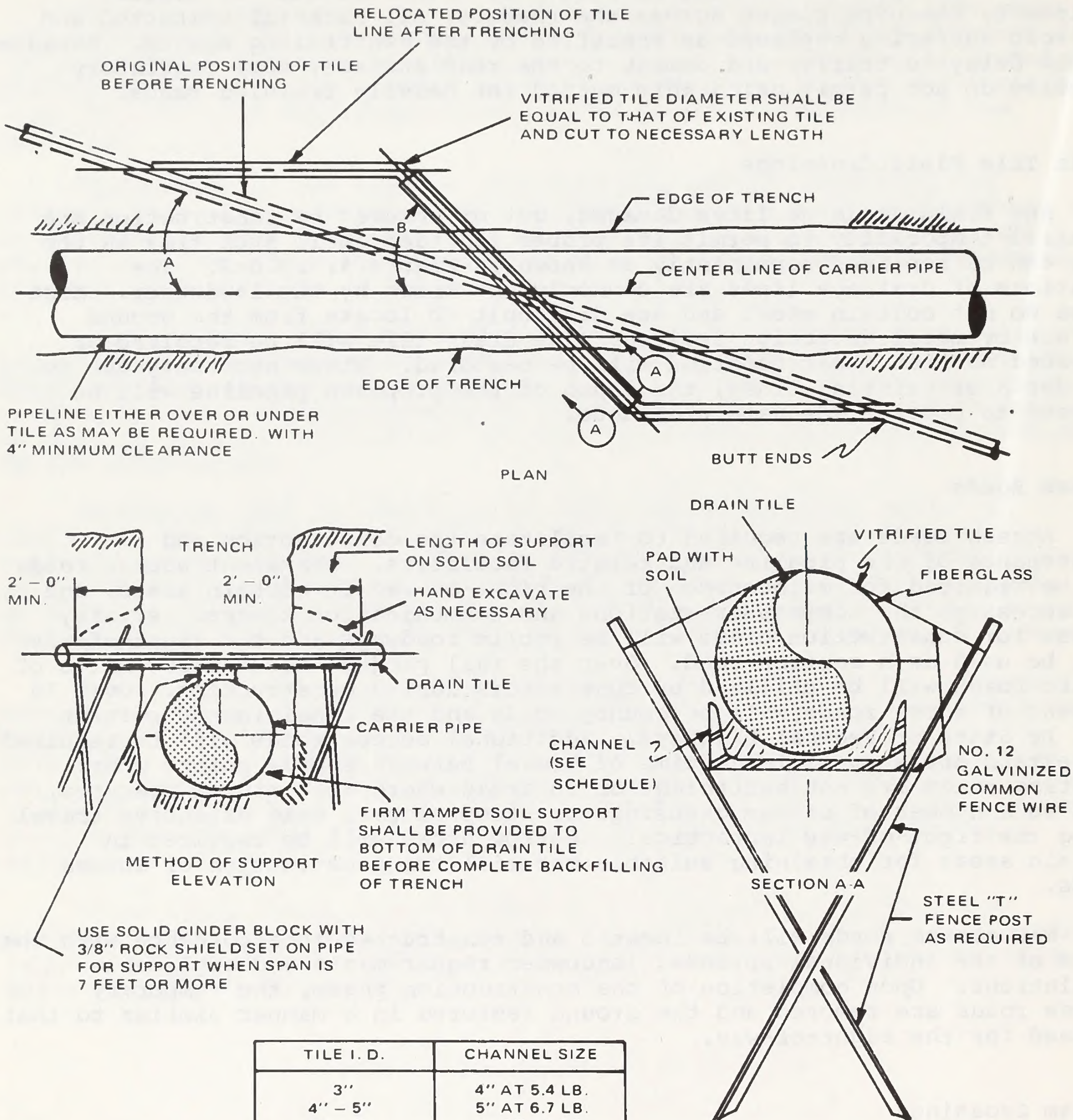
Access Roads

Access roads are required to facilitate the construction and maintenance of the pipeline and related facilities. Permanent access roads may be required for maintenance of the right-of-way in certain areas, and for access to the compressor stations and communication towers. Primary access for construction crews will be public roadways and the right-of-way will be used as a service road. Over the full project about 3,200 miles of public roads will be utilized by contractors during construction. Over 70 percent of these roads will be county roads and the remaining 30 percent will be State or Federal highways. Additional access roads will be required in certain areas to minimize time of travel between supply points where existing roads are not sufficient or in areas where the natural features, such as a number of stream crossings or steep slopes, make extensive travel along the right-of-way impractical. Borrow areas will be required in certain areas for obtaining suitable material for construction of access roads.

New access roads will be located and constructed in accordance with the needs of the individual spreads, landowner requirements and applicable regulations. Upon completion of the construction phase, the temporary access roads are removed and the ground restored in a manner similar to that planned for the right-of-way.

Stream Crossings

In the minor streams along the right-of-way, a backhoe, clam dredge, dragline, or similar equipment will be utilized for instream construction. Should rock be encountered and blasting is necessary, the time necessary to complete the pipeline crossing will increase. However, the instream activity for the minor streams traversed should be completed within a month. The pipe used for stream crossings will be weighted by a continuous concrete coating or by using concrete weights to insure that it will not float. The pipe will also be weighted in floodplains for protection against flotation during high water periods. The sections of pipe prepared in the makeup areas will be dragged or floated along the right-of-way into place. In restricted areas where high cliffs border the larger streams, the pipe will be prepared parallel to the stream and then swung across the stream and lowered into place. During the actual construction of the crossing, the



TILE I. D.	CHANNEL SIZE
3"	4" AT 5.4 LB.
4" – 5"	5" AT 6.7 LB.
6" – 9"	7" AT 9.8 LB.
10" & LARGER	10" AT 15.3 LB.

NOTES:

1. CONTRACTOR SHALL FURNISH ALL MATERIALS.
2. TILE SHALL BE RELOCATED AS SHOWN WHEN ANGLE "A" BETWEEN PROPOSED PIPELINE AND ORIGINAL TILE IS LESS THAN 20°.
3. ANGLE "B" SHALL BE 45° FOR USUAL WIDTHS OF TRENCH. FOR EXTRA WIDTHS IT MAY BE GREATER.

Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.6-3 Drawing of typical drain-tile restorations excavated material removed from the trench will be placed on the streambed or on adjacent banks. In unconsolidated material the pipe will be dragged across the streambed into its proper place. The trench will then be backfilled. In rock-bottomed streams, the pipe will be floated or lifted across and then lowered into place.

To minimize the time required for the stream crossing, the applicant proposes to prepare the right-of-way on either side of the stream crossing prior to construction of the crossing. Where crossing sites are visible from an adjacent thoroughfare or where the stream is of high aesthetic value, applicant proposes mitigative measures, such as alignment modification to reduce line of sight visibility or screening with tree plantings. If the pipeline construction is curtailed for any appreciable length of time, temporary erosion control measures are proposed at the crossings. Flow is to be maintained during the crossing of streams and irrigation canals. The pipeline is to be laid beneath the scour depth of the streams to prevent subsequent exposure.

Streambeds are to be restored to their former elevations and grades. Spoil, debris, piling, cofferdams, construction materials and any other obstructions resulting from construction of the pipeline are to be removed from the crossing to prevent interference with normal water flow and any normal use. Following completion of the grading operation, the banks of all streams are to be stabilized, riprapped with sandbags or other suitable material, and seeded so as to prevent subsequent erosion. The streambanks are to be replanted with shrubbery, where necessary, to preserve the shading characteristics of the watercourse and the aesthetic nature of the streambanks.

Major River Crossings

Twelve major rivers will be crossed by the proposed route. Table 1.1.3.6-1 lists the 12 rivers and the probable dredging and installation techniques that would be used. These techniques will now be described.

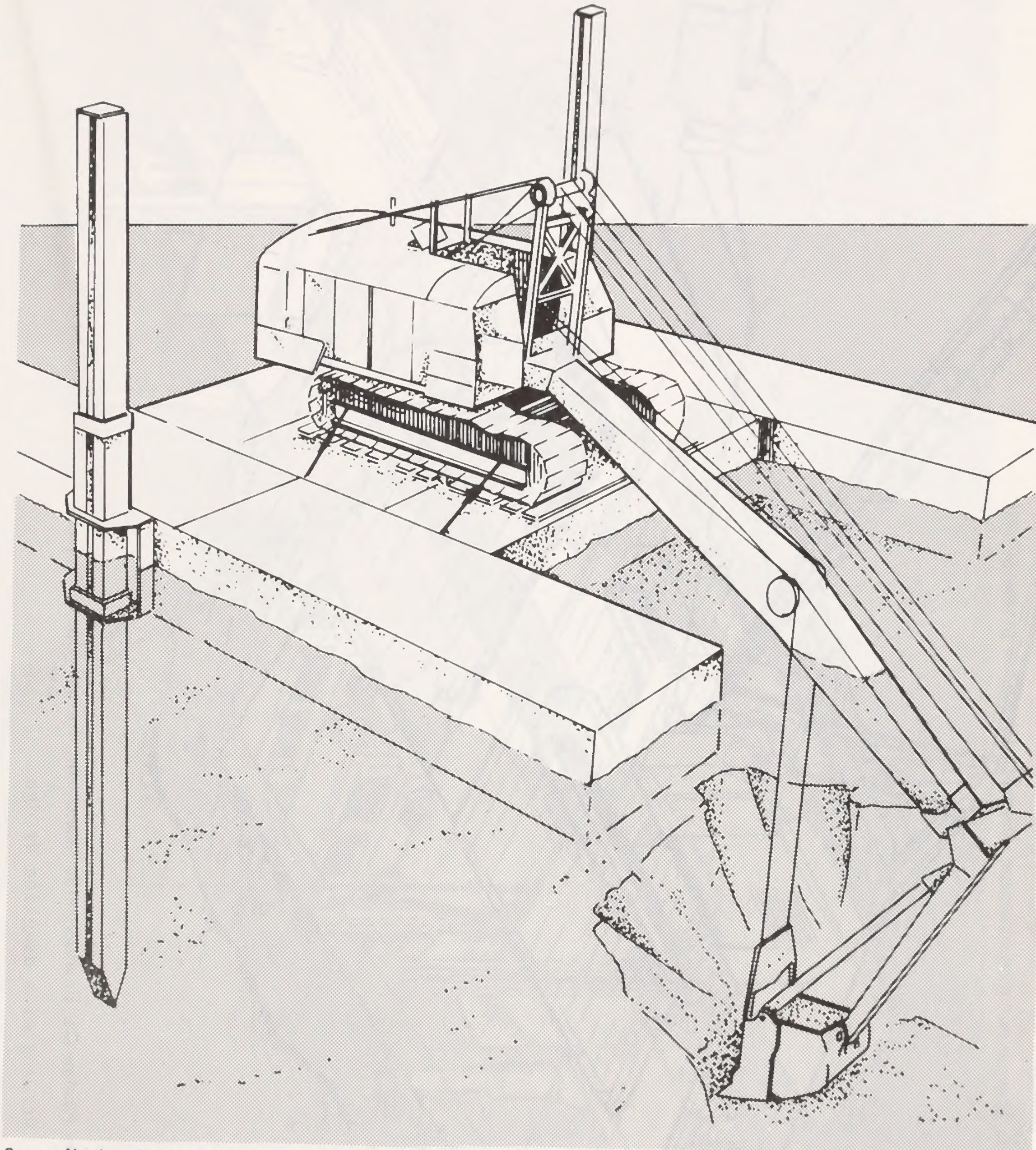
Dredging Methods--The width of these rivers necessitates the use of floating excavation equipment. The trench will be opened using either a backhoe, dragline, clam dredge, dipper dredge, hydraulic dredge, or a combination of these devices. (See Table 1.1.3.6-1 for the type to be used at each crossing.) A backhoe dredge (Figure 1.1.3.6-4) will be used if the river is relatively narrow and the bottom is composed of unconsolidated sediments. A dragline dredge (Figure 1.1.3.6-5) will be used in the larger rivers with unconsolidated sediments and in the rivers that have wide floodplains. To insure the integrity of the pipeline during floods, the pipe will be buried in the entire flood plain. Concrete-coated or weighted pipe will be used throughout. A self-propelled backhoe dredge or clam dredge will be used to open the trench in certain floodplains. In the larger non-navigable rivers a small portable hydraulic dredge will be used to open the pipe trench. In the navigable rivers a large hydraulic dredge will be used.

In rivers with rock bottoms, a rock drilling assembly mounted on a barge (Figure 1.1.3.6-6) will be used to place explosive charges for blasting to open the pipe trench. A clam dredge will then be used to clear the trench.

Installation Methods--The pipeline will be laid using either the bottom pull method, the floating bridge method or a barge method. Each

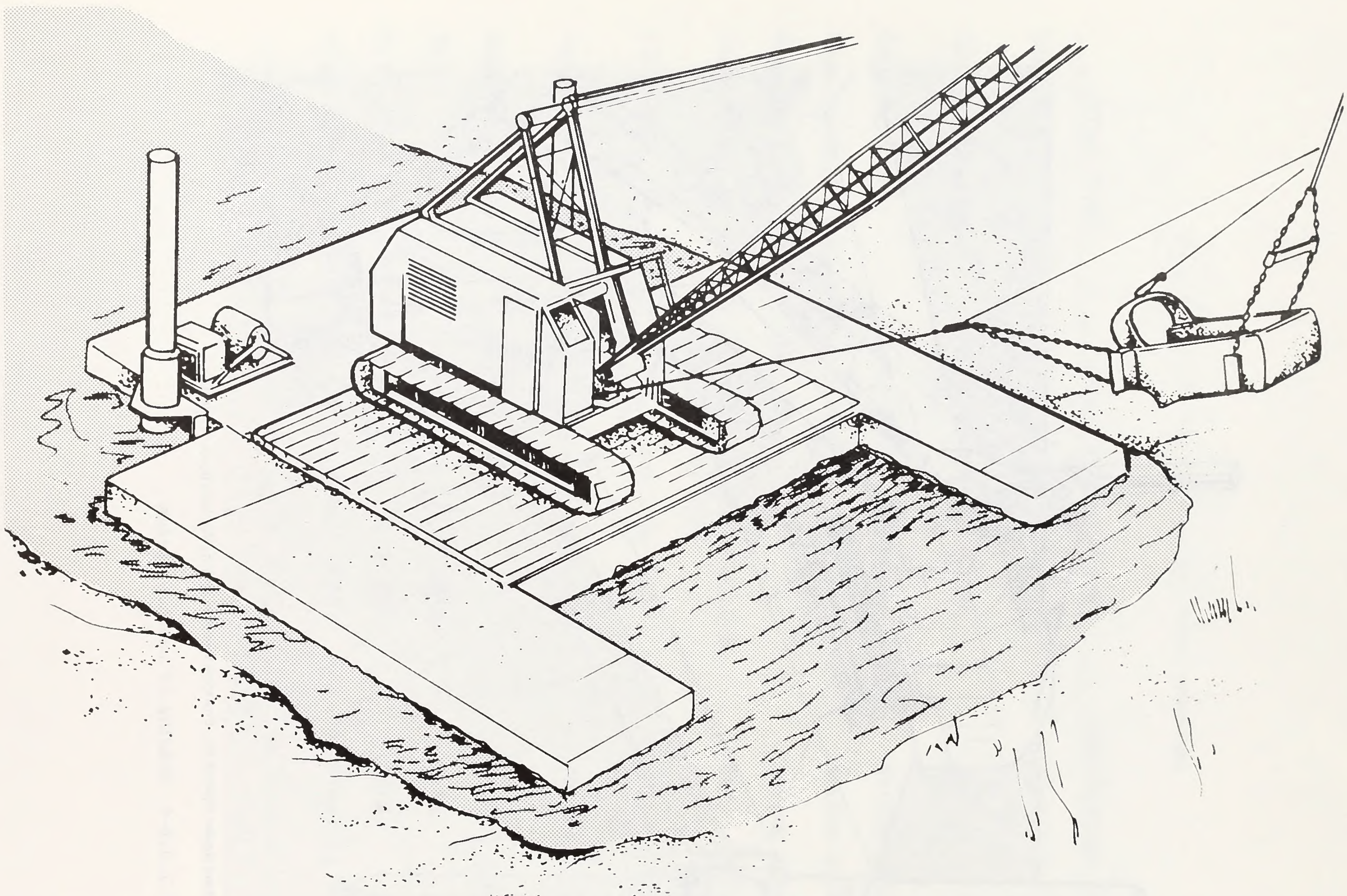
Table 1.1.3.6-1 The twelve major river crossings

River Name	Dredging Technique	Installation Technique
Missouri	Dipper dredge and small hydraulic dredge	Bottom pull
Little Missouri	Dipper dredge and clam dredge	Bottom pull
Oahe Reservoir	Small hydraulic dredge	Bottom pull
Wapsipinicon (West)	Clam dredge	Bottom pull
Wapsipinicon (East)	Clam dredge	Bottom pull
Mississippi	Dipper dredging and large hydraulic dredge	Barge
Illinois	Drill, blast and clam dredge	Bottom pull
Wabash	Dipper dredge and clam digging	Bottom pull
Muskingum	Clam digging	Bottom pull
Ohio	Large hydraulic dredge	Barge
Monongahela	Large hydraulic dredge	Barge
Youghiogheny	Drill, blast and clam dredge	Floating bridge



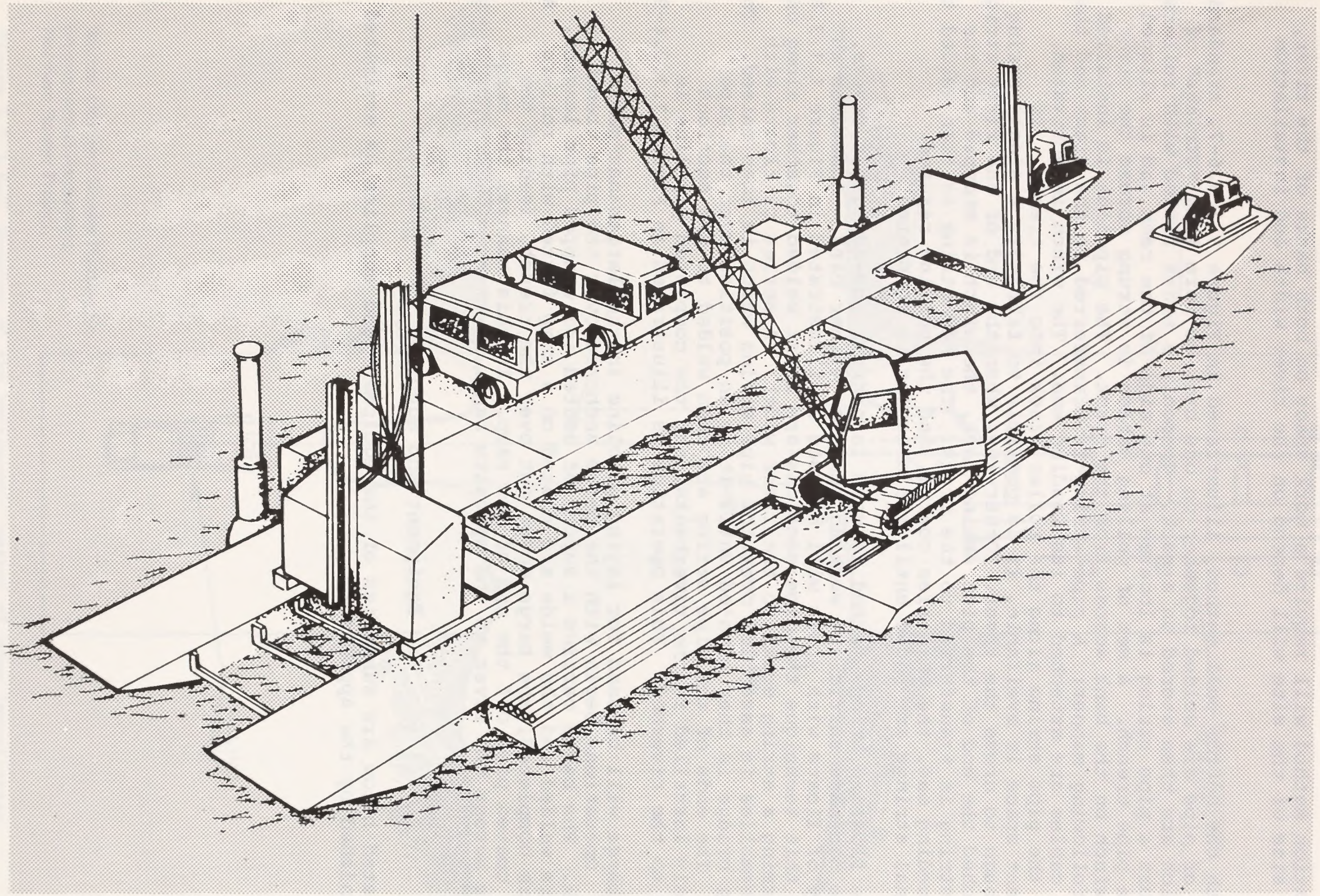
Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.6-4 Drawing of backhoe dredge



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.6-5 Drawing of a dragline dredge



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.6-6 Drawing of a rock-drilling assembly installation method will require a work space on both banks of the river, and the size of the site will depend on the river width and installation method.

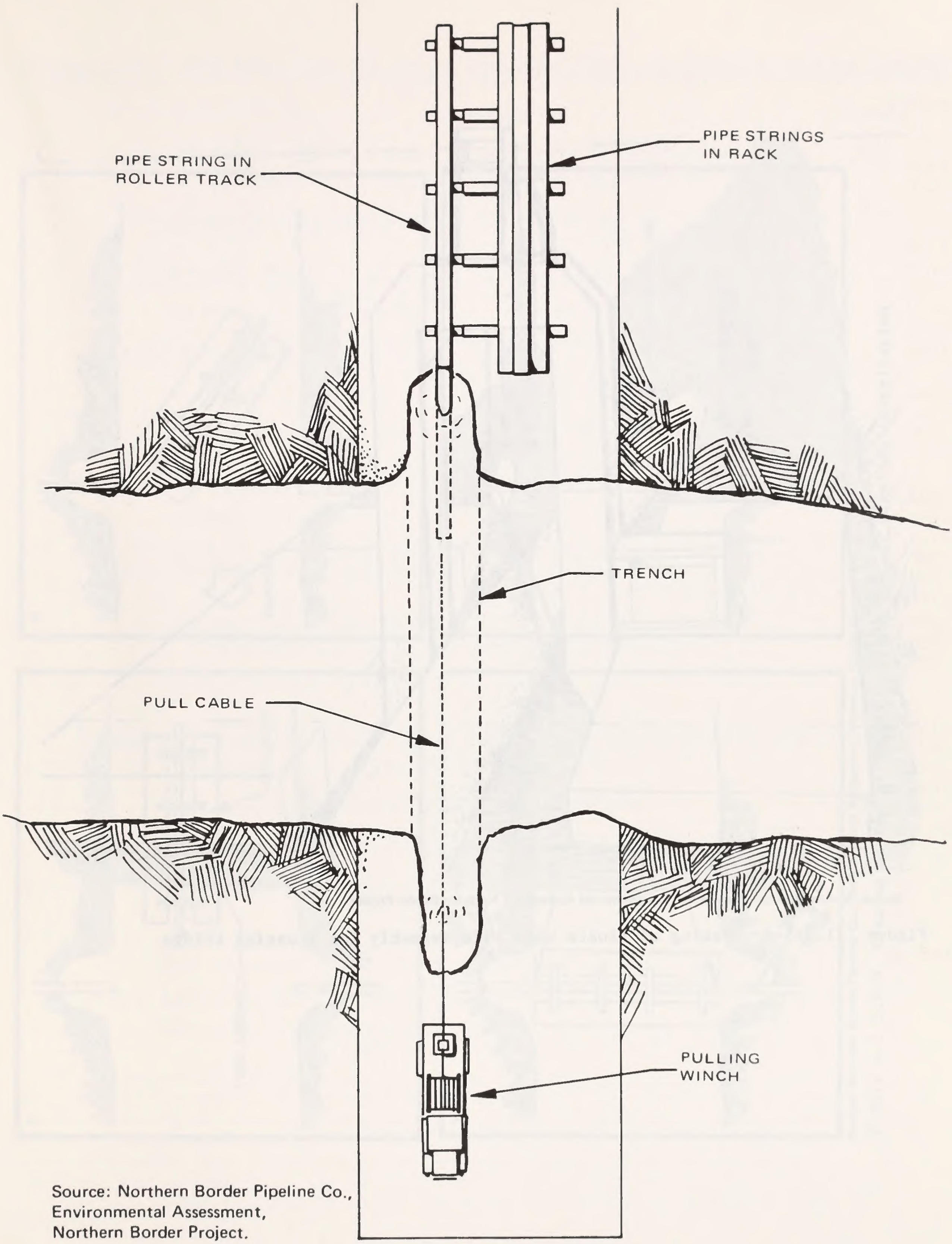
With the bottom pull method, illustrated in Figure 1.1.3.6-7, standard lengths of pipe are welded together on one bank to form long "strings" of pipe which are then stored on a rack. Commonly a track fitted with rollers to support a pipe string is located at one side of the rack and is aligned with the pipe trench. A set of pulling cables is strung across the river from a winch on the bank across from the track. The pipeline is installed in the following manner: A pipe string is transferred to the track and the pulling cables are attached to its leading end. The winch is activated, pulling the pipe string along the roller track into the trench. If sufficient space is available, it is possible to fabricate a single string long enough to cross the river. Otherwise, when the end of the first string has reached the end of the pipe string rack, the winch is stopped and the second string is transferred to the track. The new string is then welded to the preceding one, the weld area coated, and the pulling resumed. Additional strings are added until the crossing is completed.

The floating bridge method is used in narrow, non-navigable rivers, which do not have sufficient working space on either bank. Sometimes an assembly of floats with yokes will be used as illustrated in Figure 1.1.3.6-8. For this technique the pipe sections are first welded together along one bank forming a string equal to the river width. A series of floats with yoke assemblies is assembled over the pipe string which is then raised. The floating bridge is then pivoted until it is in position over the pipe trench. The ends of the pipe string are then welded to the sections previously installed in the riverbanks, and the completed pipeline is lowered to the riverbed. This operation is illustrated in Figure 1.1.3.6-9.

A barge will be used for laying pipeline in the larger navigable rivers. Operations begin with the barge anchored over the pipe trench at one bank. The barge carries a supply of coated and wrapped pipe lengths. These are welded and the welds are coated on a ramp fitted with rollers. As welds are completed, the barge moves out over the trench, feeding the welded, coated pipe off the end of the ramp. In this manner, the barge proceeds across the river to the opposite bank.

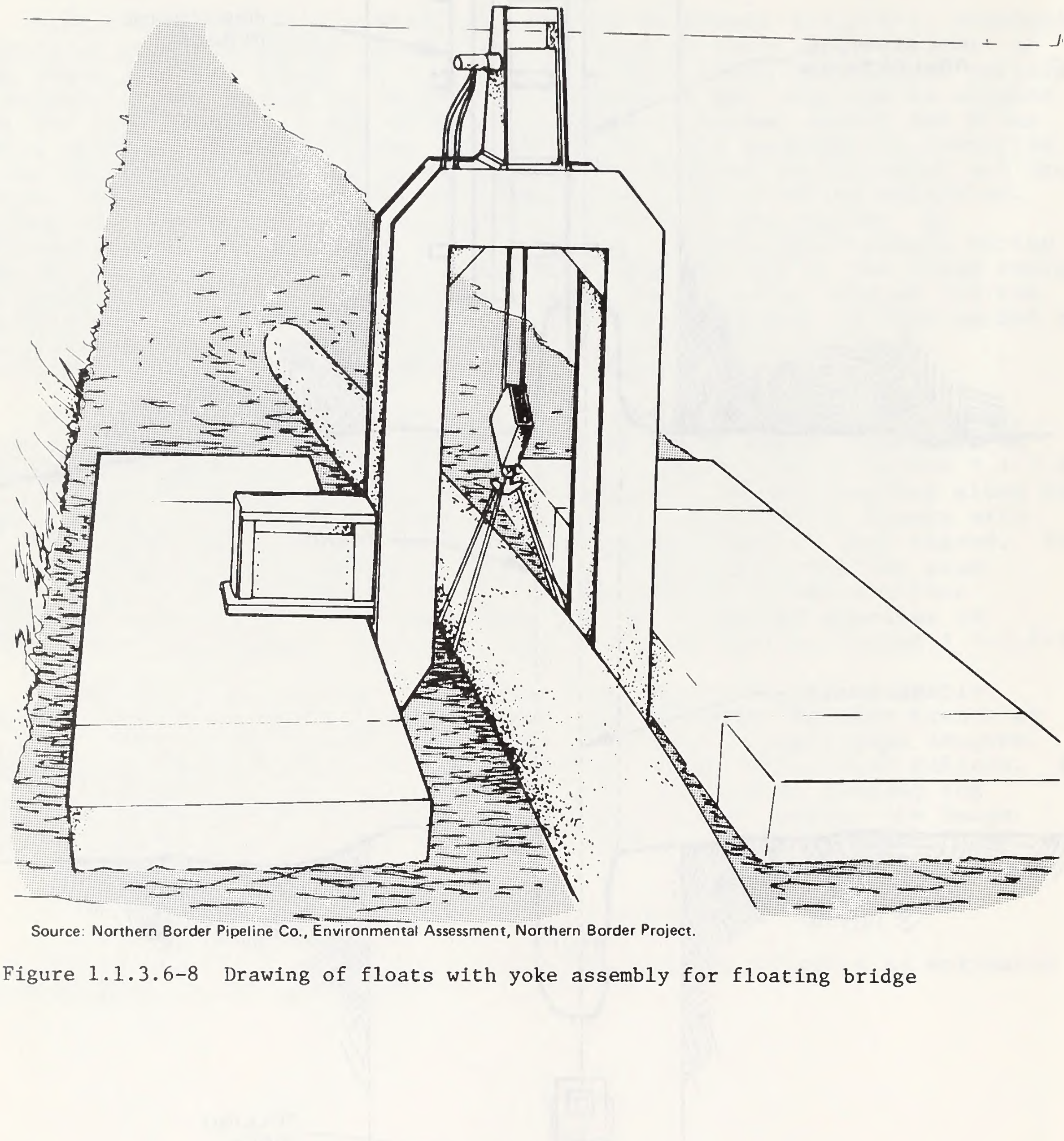
Equipment and Supplies

Listed below are summaries of the equipment and supplies as estimated and furnished by the applicant.



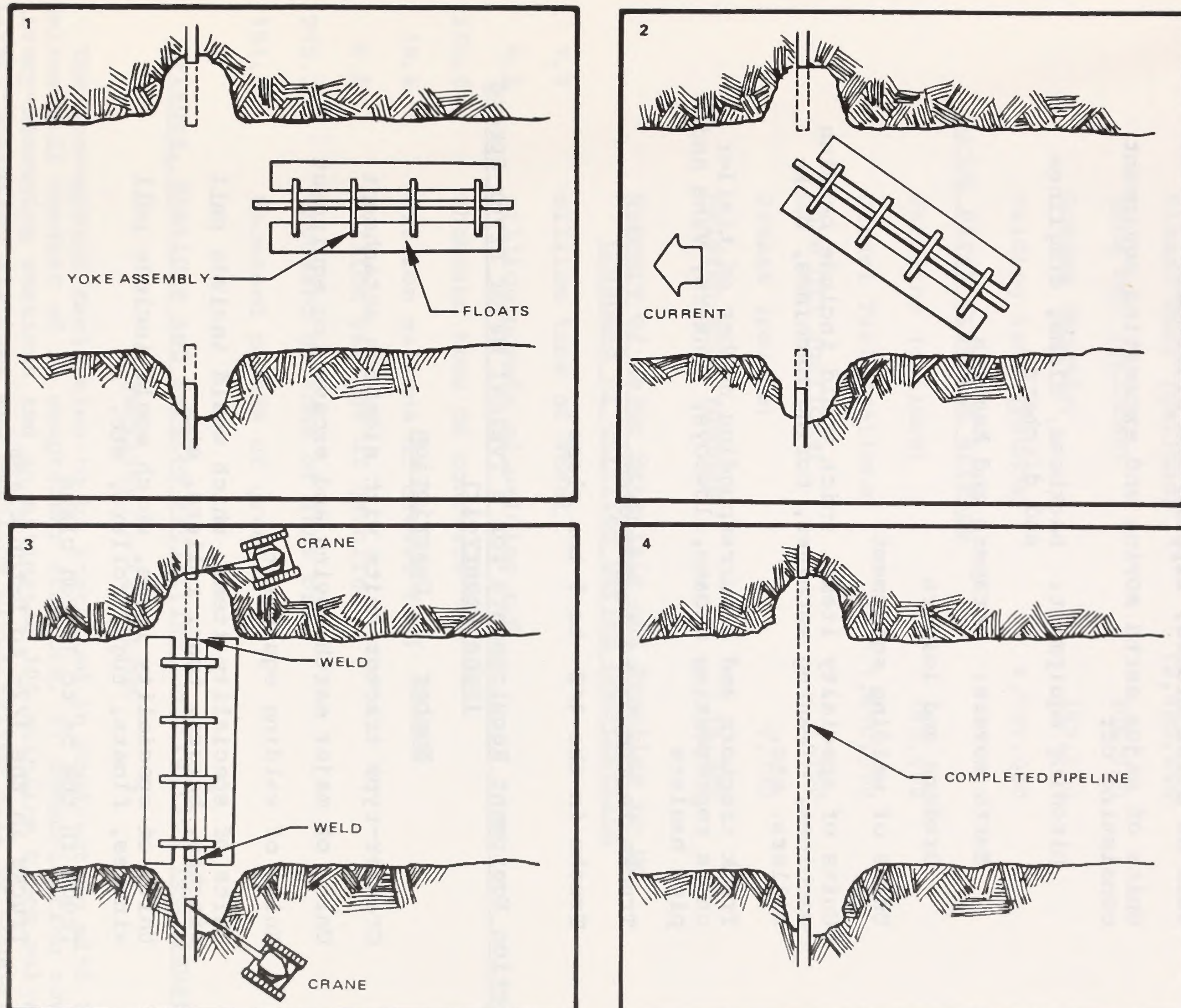
Source: Northern Border Pipeline Co.,
Environmental Assessment,
Northern Border Project.

Figure 1.1.3.6-7 Drawing of the bottom-pull method of pipe installation



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.6-8 Drawing of floats with yoke assembly for floating bridge



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.1.3.6-9 Drawing of the floating-bridge method of pipeline installation

Construction Equipment Requirements for a Typical 42-Inch Mainline Spread

Number	Description
80	Crawler-type tractor units with various attachments such as dozer blades, rippers and sidebooms.
42	Units of major earth moving and excavating equipment consisting of: Ditching equipment: backhoes, clams, draglines and ditchers Earth movers: scrapers and haulers Graders and loaders
29	Units of welding equipment
6	Units of specialty items, which would include bending machines, cleaning machines, boring machines, back-fillers, etc.
51	Truck tractors and a corresponding number of trailer units representing floats, lowboys, tankers, vans and pipe haulers
34	Trucks in the 5- to 16-ton class
73	Trucks in the 1/2- to 5-ton class

Construction Equipment Requirements for a Typical Major River Spread (Oahe Reservoir)

Number	Description
4	Crawler-type tractor units with sideboom attachment
4	Units of major earth-moving and excavating equipment
10	Units of welding equipment
19	Units of speciality items, which would include pull winches, barges, tugs, rollers, etc.
3	Units of speciality items, which would include pull winches, floats, tugs, rollers, etc.
1	Truck in the 5- to 16-ton class
5	Trucks in the 1/2- to 5-ton class

Major Materials and Supplies Estimated for Mainline and River Crossing Spreads

Mainline Spreads

Gasoline (gallons)	6,340,000
Diesel Fuel (gallons)	12,480,000
Lube Oil (gallons)	208,000
Grease (pounds)	142,000
Welding Rods (pounds)	4,500,000

Major River Crossing Spreads

Gasoline (gallons)	140,000
Diesel Fuel (gallons)	1,850,000
Lube Oil (gallons)	7,150
Grease (pounds)	9,130
Welding Rods (pounds)	19,200

Summary of Major Materials and Supplies to be Consumed or Utilized During Construction

1.1	million tons of steel
4.5	million pounds of welding rod
375.0	thousand tons of concrete
14.4	million gallons of diesel fuel
6.5	million gallons of gasoline
215.2	thousand gallons of lube oil
151.0	thousand pounds of grease

Plants, Stations and Related Facilities Construction Techniques

Facility Installation

The aboveground facilities to be installed in conjunction with the pipeline will consist of 12 compressor stations, 87 communication towers, 13 delivery-measuring stations and an estimated 100 mainline block valves. The delivery-measuring stations and mainline block valves will be constructed in conjunction with the pipeline spreads. The compressor stations and communication towers will be constructed at the same time as the pipeline, but probably under contracts separate from the mainline pipeline spread contracts.

Site and Building Construction

Construction of the compressor stations begins with the clearing and construction of an access road to the station site. Clearing and grading the station site is done in conjunction with the work on the access road, or will follow very shortly thereafter. If the site is located in open rangeland or pasture land, the fence around the site will probably be installed immediately following site preparation to prevent livestock from entering the work area. Once the site is graded, trenches or ditches are excavated for all pipelines on the site and for building foundations. Excavation for the footings for the communication towers will be completed.

The pipelines are placed in the trenches, trenches backfilled, and concrete placed for the various structure and building foundations. All large equipment probably will be installed then, prior to erection of the buildings and the prefabricated communication towers will be erected. Roads within the site will be paved, the site revegetated and landscaped and a fence installed if not previously done. The construction at a compressor site will take approximately 6 months.

The delivery-measuring stations and communication towers will be constructed in a manner similar to that described above for compressor stations.

Construction Equipment Requirements for a Typical Compressor Station

Number	Description
1	Grading Equipment
3	Excavating Equipment (backhoes, scrappers)
1	Winch Truck
2	Air Compressors
3	Welding Machines
5	Pickups

Construction Equipment Requirements for a Typical Communication Tower

Number	Description
1	Grader
1	Bulldozer
1	Scraper
1	Backhoe
1	Truck equipped with gin poles
1	Crane equipped with winch
2	Trucks with test equipment

Hydrostatic Testing Procedure

This procedure entails the inplace testing of the completed and cleaned pipeline using water as a medium. Testing of the gas pipeline will be in accordance with the Department of Transportation Regulations, 49 CFR, Part 192, "Transportation of Natural Gas and Other Gas by Pipelines: Minimum Federal Safety Standards." The pipeline is filled with water and held at the required pressure throughout the test. If leaks are detected, the pipeline will be exposed and the pipe repaired. Damage to pipe coating is then repaired, the excavated hole backfilled, and the disturbed right-of-way restored. After a satisfactory test, the pipeline is drained or the water is moved from one test section to another.

Test water is obtained from appropriate and approved sources. If test water is withdrawn from a standing body of water, such as a lake, or from a flowing stream, it is done in accordance with regulations of the appropriate jurisdictional authority. The water intake is screened to prevent entrapment of fish.

Hydrostatic test water is normally discharged into surface watercourses. Test water is discharged at a rate that will minimize erosion. If the test water is discharged into a dry waterway (intermittent stream course), the discharge rate will not be greater than the flow experienced during normal flow periods.

The tie-in locations where water is introduced into the pipeline will be cleaned up and restored after hydrostatic testing. Water-quality analyses conducted by pipeline companies prior to and following hydrostatic testing have indicated that changes in test water quality are negligible. Because the construction is not scheduled to occur during the winter months, methanol or other antifreeze solution will not be required in the test water.

Approximately 380,000 gallons of water will be required to test a 1-mile section of the 42-inch pipeline. The differences in elevation along the proposed route will require the testing of segments approximately 20 miles long. About 7,600,000 gallons of water will be required for testing such a length of 42-inch pipeline.

Work Force

Source, Type, Skill Level and Number

Manpower estimates for the construction are given in the following table.

Construction Manpower Estimates*

Type of Spread	
Total Mainline Spreads	5,330
Total Major River Crossing Spreads	1,060
Total	6,390

*In addition to the estimate, approximately 10 to 20 percent additional manpower will be required for survey, inspection, right-of-way acquisition, engineering and other support functions.

A maximum of about 6,000 jobs will be created in any one year by the construction. Approximately 60 to 65 percent of the construction crew will be skilled workers (welders, operators and foremen), with the remainder being unskilled. Skilled workers will be recruited on a local as well as on a national and regional basis. Unskilled workers are expected to be drawn from local labor forces.

There will be 12 compressor stations, each taking an estimated 6 months to construct. The average number of workers on a station will be 36 with a peak of about 60 for a 1-month period. About 50 percent of these workers will be hired from local labor forces.

There will be 87 communication towers, each taking about 6 to 8 weeks to erect. The number of workers per site will range from 15 to 21, with about 25 percent hired locally.

Listed is a summary of the number and type of personnel for the construction. The number of personnel shown in this list may be duplicated in some instances. For example, the people on river crossings may also be included in those for mainline spreads.

1,619 miles of pipeline
14 months duration (May 1978 through June 1980)
15 mainline spreads (5,330 people total)
12 river crossing spreads (1,060 people total)
12 compressor stations (36 people)
13 delivery points (people included in mainline spread)

The communication towers are scheduled to be erected in conjunction with other work shown in this list.

Housing and Public Facilities Needs

Housing

The migratory work force and their families will place demands on local housing supplies. Construction workers usually make individual housing arrangements and have several types of accommodations to choose from including room, house, motel or trailer-rental parks.

The variety of possible alternatives and the large number of communities along the route which could offer the necessary housing make it difficult to pinpoint the needs for housing in any one community. Fifty miles represent the maximum daily driving distance and defines the approximate area within which the construction crew will obtain lodging.

Approximately 60 to 65 percent of the working personnel are expected to be transient and will require temporary housing. A large proportion of a pipeline construction crew typically owns some form of mobile home, while other crew personnel may rent mobile homes. Mobile homes are usually located in an existing trailer park, where available. In other cases mobile home sites may be arranged with individual landowners or municipalities. Construction camps are anticipated by Northern Border for the segments in Montana, North Dakota, and northern South Dakota.

Public Facilities

Those communities housing construction workers and their families will experience an increase in the demands placed on public services such as schools, health facilities, police and fire protection, recreation areas, waste disposal, utilities and transportation.

In most cases, the workers will be spread out through a number of communities and probably will live for less than 3 months in any one locality. Few workers bring school age children along during the school year. The work schedule that construction workers will follow will minimize the amount of time spent away from the job and thus limit the use of public services.

OSHA Procedures

All applicable provisions of the Occupational Safety and Health Act (OSHA) apply to all construction equipment and construction and maintenance operations.

1.1.3.7 Operational, Maintenance and Emergency Procedures

The proposed pipeline system will be designed so that all facilities can be monitored, controlled and operated in a safe and reliable manner under remote control through a communications system with a remote control center. The facilities will not require full-time maintenance personnel at the sites; however, these personnel under normal operations will visit compressor and delivery sites periodically as required by operating conditions. The other facility sites will be checked on an established schedule.

Personnel will be located along the system so they can reach any area within a short period of time in case of an emergency or malfunction. All equipment containing moving parts, such as compressor engines, will require periodic routine maintenance and major maintenance on a scheduled time-of-use basis.

The pipeline route right-of-way will require scheduled surveillance for erosion damage, right-of-way encroachment, etc. The pipeline will be monitored for corrosion control regularly.

Technical and Operational Description

Valves, Controls and Pipeline

The mainline block valves will be equipped with automatic self-actuated gas operators. These valves will be used to isolate pipeline segments in the event of a system failure.

The pipeline pressures will vary along the pipeline and between compressor stations. The maximum allowable operating pressure in the pipeline will be 1,435 psig.

Process and Treatment Descriptions

There are no natural gas treatment facilities proposed for the Northern Border Pipeline system. The gas being transported will have undergone treatment in processing plants at Prudhoe Bay and Mackenzie Delta. Therefore, it will be of pipeline quality and no additional processing, treating or dehydration will be required by the applicant at the Canadian-U.S. border. The composition of the gas is shown in a table which follows, but this table does not include information on acceptable limits for hydrogen sulfide, total sulfur, particulates and moisture content which must be established in the final design of the system.

The pressure of gas entering the pipeline at the Canadian-U.S. border will be controlled at the last compressor station on the Canadian Arctic Gas Pipeline north of the border. The pressure of the gas in the pipeline will be controlled subsequently at each of the 12 compressor stations. These stations will compress the natural gas to a maximum operating pressure of 1,440 psig with average gas flowing temperatures varying from 48 to 63 degrees F in the summer and 31 to 56 degrees F in the winter.

Composition of Gas

Component	Mol Percent
Methane	89.68
Ethane	5.22
Propane	2.45
Isobutane	0.32
Normal Butane	0.47
Isopentane	0.09
Normal Pentane	0.07
Hexane	0.03
Heptanes plus	0.02
Carbon Dioxide	1.00
Nitrogen	0.65
Total	100.00

An operations and maintenance manual detailing operation and maintenance procedures will be prepared prior to initial operation by the Northern Border Pipeline Company and will include all tests, inspections and procedures necessary to insure that facilities and equipment are maintained in an acceptable manner. The manual will be filed at all necessary locations to insure that it will be available for ready reference and for use in training operating personnel.

Flow Diagrams

Figures 1.1.3.7-1 and -2 reflect the operation of the system at daily design capacity for summer and winter conditions. The daily design capability is developed for summer conditions and the maximum capability is calculated for winter conditions.

All deliveries shown on the diagrams have been calculated assuming that all compressor and cooling units, where applicable, are operating. Because of unanticipated shutdowns, shutdowns for scheduled maintenance of facilities and occasional limitations on supply and market volumes, the annual delivery volume of the system will be something less than the annual volumes that could be derived from the diagrams.

Maintenance Procedures

Corrosion Checks

All pipe will be protected by an external coating that will be applied and checked for full coverage prior to pipe placement in the trench. The coating material is a hot applied coal tar or petroleum product, a chemical epoxy material, a plastic, or a combination thereof. Cathodic protection test stations will be installed along the pipeline for monitoring.

Corrosion Prevention

The pipeline will be monitored for corrosion control. The pipe will be inspected for active internal and external corrosion wherever any portion of the pipeline is exposed or cut for any reason. Corrosion protection equipment will be inspected at intervals of not more than 2 months and a permanent record of operational data will be maintained. Monitoring of the cathodic protection system will be in accordance with 49 CFR 192.456.

Annual surveys will be made to take pipe-to-soil potential readings and to record influences of foreign pipeline or cable crossings. The results of any survey or inspection will become a part of the permanent records. Data will be reviewed and appropriate corrective actions taken.

Route Surveillance

Operation and maintenance plans and schedules will be implemented to monitor and ensure safe operation. Periodic aerial surveys will be made of the line to check for activities that encroach upon the right-of-way and endanger the pipeline. Over-the-ground surveys will be made at least semiannually. These surveys are to identify potential pipeline exposure, mechanical damage to the right-of-way and other activities that might constitute a safety, operaticnal or maintenance hazard. The pipeline route will be checked annually for changes in population density and encroachments. Should location class changes be found, a study will be immediately undertaken to confirm or revise the pipeline's maximum allowable operating pressure and the required changes will be initiated in accordance with 49 CFR 192.611.

Equipment Maintenance, Repair and Work Force

The organizational structure tentatively planned for the operation and maintenance of the pipeline system includes two division offices and seven district offices. It is estimated that approximately 200 employees with an annual payroll of approximately $3 million will be required to operate the completed system.

The equipment and machinery at all compressor stations, delivery-measuring stations, communication towers and the mainline block valves will be maintained under a routine maintenance program. This program will require taking some of the compressor engines out of service periodically at each of the compressor stations. These shutdowns may require interruption of delivery of gas to the various delivery points or delivery at reduced volumes, because the present design calls for one large engine at each compressor station.

Any necessary repairs to the pipe will be made promptly; if necessary, the pipe will be replaced. In making repairs, all safety precautions will be observed. The qualifications of the welders and the qualifications of the welding procedure shall ccnform to American Petroleum Institute 1104, latest edition.

Building, Site and Route Maintenance

Buildings and associated structures at compressor stations, delivery-measuring stations and communication tower sites will require periodic painting. These places as well as the mainline block valve sites will require regular maintenance and care of the landscaping. The permanent pipeline right-of-way in other than agricultural lands will probably require periodic removal of tree and brush growth which might interfere with access for maintenance and surveillance. Any area suffering frcm erosion, especially in the Montana and North Dakota Badlands, will require periodic restoration.

All permanent access roads will require periodic maintenance including erosion control, weed control, and grading or road surfacing repair, or both.

Emergency Features and Procedures

Design Features for Geological, Meteorological and Man-Induced Hazards

Design and construction criteria will be incorporated in the final design of the system to enhance its ability to withstand possible natural and third-party accidents or catastrophes.

The applicant states that contouring, terracing and revegetation of lands subject to erosion will be done during the final cleanup and restoration phase of each construction spread. During routine surveillance of the right-of-way, any areas requiring additional erosicn control will be identified and corrective measures taken. All pipe placed at crossings of streams and rivers will be laid below scour depth, and weights will be used to prevent flotation. Stream and riverbanks at crossings will be covered with vegetation, riprap or other protective material to prevent erosion.

The pipeline will be marked at most road crossings, river crossings, railroad crossings and other specified intervals alerting people of the buried high-pressure gas pipeline. System buildings containing gas transmission facilities will be equipped with gas detectors with appropriate lights and alarms to alert personnel to hazardous conditions and the procedure specified in the emergency plan will be followed.

Facilities will be monitored and operated under remote control through a communications link with the main control center. Compressor stations will be equipped with safety devices to prevent overpressuring natural gas in the pipeline. Additionally, the compressor stations will be provided with safety devices which will shut down the pipeline and isolate the station upon detection of fire or the presence of explosive mixtures of gas. Also these safety devices will shut down the equipment in the event of a mechanical failure that would endanger the integrity cf the equipment and result in consequential hazards. Block valves will be automatic self-actuating and will isolate segments of the pipeline in case of system failure. Safety devices will be of a fail-safe design.

Shutdown and Venting

The detailed steps required to purge a line, part of a line or part of a compressor station will be included in the operation and maintenance manual. These steps will be strictly adhered to when putting any system or part of a system into service or taking it out of service. The operating and maintenance manual will cover the operations of compressor stations and shall incorporate instruction manuals for the equipment.

The compressor station section of the manual will include such items as (1) prestart checklist, (2) start sequence, (3) shutdown instructions for both normal and emergency conditions, (4) pressure relief devices, (5) any other operational or emergency procedures applicable, and (6) operation and testing procedures for the fire protection system.

Emergency Contingency Procedures

An emergency plan outlining all the steps to be taken in the event of system malfunctions or other emergencies will be incorporated in the operations and maintenance manual. Immediately upon the occurrence of a malfunction or failure, that part, piece of equipment, or section of line will be isolated, if necessary. Appropriate action will give priority to the protection of lives and property, permanent repairs and returning the pipeline to service. Maps, diagrams and records will be maintained to assure that the operating personnel can immediately determine how isolation may be effected for any part or parts of the system.

1.1.3.8 Future Plans

The proven and unproven natural gas reserves as well as the volumes of natural gas to be delivered by this project are discussed in Section 1.0V.1 and are used as the basis for the life of the project.

The life of this project can vary over a considerable period of time based on these proven and unproven reserves. On the basis of only the presently committed reserves from the presently proven reserves from Alaska and the delivery rate projected for those reserves initially, the project would have a life in excess of 30 years. These initial delivery rates may be increased, however, should production of the presently proven reserves indicate that larger volumes may be produced without injury to the ultimate recovery of hydrocarbons from the presently known producing reservoirs. In that case (a future increase in production rates above the approximate 2 billion cubic feet per day anticipated initially), the life of the project on the basis of presently proven reserves only would be reduced to something less than 30 years (perhaps 25 years). However, it appears certain that there will be at least some reserves discovered capable of producing into the Arctic Gas system in addition to those reserves presently proven on the North Slope at Prudhoe Bay. Taking into consideration the length of time required to explore and develop reserves in Alaska under the climatic and working conditions there, the additional time required to construct the necessary processing and connecting facilities to connect the gas to the pipelines, and the time required for the necessary regulatory processing for each of these steps (exploration, development and transportation), it is believed that the probable minimum life of the Northern Border pipeline on the basis of Alaskan gas alone would be on the order of 50 years. Should discovery and development of additional reserves in Alaska (other than the presently proven reserves at Prudhoe Bay) be slow, it would be well within the realm of possibility to assign a 100-year life to this project. (Reference: Response by Northern Border Pipeline Company to DOI/FPC Question No. 1--November 22, 1974.)

In addition, the possibility of this system being used to transport coal gas from possible future gasification of coal from the substantial coal deposits located in Montana, North Dakota and South Dakota must be considered in estimating the life of this project. At the present time, it is not possible to establish when the coal gasification process might be developed and how long this system could be utilized in transporting the coal gas.

Abandonment of Facilities

Salvage and Disposal of Equipment

The life of the project could conceivably reach 100 years. If operations are terminated, surface structures at the compressor station, communication tower, mainline block valve, and delivery-measuring station sites could be removed. Most items removed could be salvaged; however, items such as pavement and concrete would have to be disposed of in an approved waste disposal area. The applicant states that if abandonment becomes necessary the pipeline could be removed. The pipe could be reused or sold for scrap steel depending on the condition of the steel.

Whenever abandonment of the facilities may be required, such facilities can only be abandoned by authority of the Federal Power Commission issued pursuant to Section 7(b) of the Natural Gas Act, 15 U.S.C. ss- 717 f(b). Such abandonment must conform to regulations prescribed by applicable local, State and Federal laws in existence at that time, including the regulations of the Materials Transportation Board.

Site Restoration

All sites mentioned above probably could be restored to their original condition. The pipe trench would be restored to original contour with material from the right-of-way, from existing borrow areas, or from commercial sources. The length of time required for complete restoration will vary with the site location.

Future Expansion

Loops and Laterals

The proposed pipeline system does not include any future loops or laterals.

Additions to Processing, Treatment and Measurement Facilities

This system does not include plans for construction of any facilities of this type beyond those now scheduled.

New Plants, Compressor Stations and Related Facilities

Thirteen sites for possible future compressor stations have been identified by the applicant, but there are no present plans to develop these sites except for the construction of a communication tower and a block valve at each site. Additional compressor facilities could be constructed at these sites in the future if required for the transportation of larger volumes of natural gas.

1.1.3.9 Actions Involved

The applicant must apply for and obtain permits, licenses and certificates from all Federal, State, local and private agencies having jurisdiction along the right-of-way for the construction, operation and maintenance of the Northern Border Pipeline. These agencies are listed in the following sections; however, caution is advised in that the lists may not include all agencies which have approval requirements.

Federal Actions

The proposed 1,619-mile pipeline system crosses 98 miles of Federal and Indian Trust Lands. Federal agencies having approval requirements for the pipeline system are listed in Table 1.1.3.9-1. Approximately 1,213 acres of Federal and Indian Trust Lands would be included in right-of-way permits. Of this total 575 acres would be in temporary rights-of-way and 638 would be in permanent rights-of-way. See Table 1.1.3.4-6 for a detailed breakdown of miles of the proposed pipeline system crossing the various Federal land jurisdictions and associated right-of-way acreages.

State and County Actions

The state and county agencies having approval requirements for the pipeline system are listed in Tables 1.1.3.9-2 through -11.

Private Actions

The applicant must purchase rights-of-way from the landowners for the pipeline and related facilities. The individual landowners have not been identified.

The applicant must obtain joint use of right-of-way agreements with many private agencies, such as those listed below, whose existing right-of-way is crossed by the pipeline:

- Railroad companies
- Power transmission companies
- Telephone companies
- Pipeline companies
- Irrigation districts
- Flood control districts
- Conservancy districts
- Mining companies
- Telegraph companies

Table 1.1.3.9-1 Federal Agencies Having Project Approval Requirements

Agency	Responsible Subdivision	Activity Requiring Approval	Form
Federal Power Commission		Construction and operation of an interstate natural gas transmission pipeline	Certificate of public convenience and necessity
		Construction, maintenance and operation of facilities at the Canadian Border for the importation of natural gas	Presidential permit
		Importation of natural gas	Authorization to import natural gas
Environmental Protection Agency		Discharge of water	Discharge permit, where applicable
Federal Communications Commission	Safety and Special Radio Services Bureau	Installation and operation of microwave transmitter and associated tower facilities	Radio station authorization (construction permit and station license)
Department of Agriculture	Forest Service	Pipeline construction across national grass lands administered by the Forest Service	Special use permit

Table 1.1.3.9-1 (cont.) Federal Agencies Having Project Approval Requirements

Agency	Responsible Subdivision	Activity Requiring Approval	Form
Department of the Army	Corps of Engineers	Pipeline construction across navigable waterways	Section 10, Permit for Work in Navigable Waters (1894 Rivers and Harbors Act)
	Corps of Engineers	Dredge material returned to waterways	Permit; PL 72-59, Section 404
Department of the Interior	Bureau of Indian Affairs	Pipeline construction and compressor station location on tribal, individually owned and government owned Indian lands administered by the BIA	Right-of-way
	Bureau of Land Management	Pipeline construction across public lands administered by the BLM	Right-of-way
	Fish and Wildlife Service	Pipeline construction across National Wildlife Refuge System Lands administered by the agency	Right-of-way
	Bureau of Reclamation	Pipeline construction across operation and authorized projects (Montana, North Dakota and South Dakota)	Right-of-way

Table 1.1.3.9-1 (cont.) Federal Agencies Having Project Approval Requirements

Agency	Responsible Subdivision	Activity Requiring Approval	Form
Department of the Interior (cont.)	Bureau of Outdoor Recreation	Pipeline construction across parks and recreation areas where Land and Water Conservation Fund money has been used for acquisition or development	Secretarial approval
	Advisory Council on Historic Preservation	Pipeline construction through lands not surveyed for historic sites, as required by Section 106, Historic Preservation Act of 1966 (80 Stat. 715, as amended)	Council review
Department of Transportation	Federal Aviation Administration	Installation of microwave transmission towers	Per FAA Circular No. AC-70-7460-2D

Table 1.1.3.9-2 Illinois Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Illinois Environmental Protection Agency	Air Pollution Division	Construction of compressor facility; stationary pollutant emission source	Construction permit
		Operation of compressor facility	Operating permit
		Open burning operations	Open burning permit
	Water Pollution Division	Discharge of water	State certification to EPA, where applicable
Illinois Department of Transportation	Water Resources Management Division	Construction of pipeline across public waters in state	Permit
		Withdrawal of water for use in hydrostatic testing	Permit to appropriate water
	Highway Division	Construction of pipeline across state highways	Use and occupancy agreement
		Connection of an access road to a state highway	Access permit
		Use of state highway for overweight or oversize equipment transport	Special vehicle movement permit

Table 1.1.3.9-2 (cont.) Illinois Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Bureau County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Location of compressor facilities and microwave tower in county	Approval
	Township Highway Commission	Construction of pipeline across township roads	Commissioner approval
Grundy County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	Township Highway Commissioner	Construction of pipeline across township roads	Commissioner approval
Iroquois County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	County Zoning Board	Location of compressor facility and microwave tower in county	Zoning variance
	Township Highway Commissioner	Construction of pipeline across township roads	Permit
Kankakee County	County Board of Commissioners	Construction of pipeline across county roads	Permit

Table 1.1.3.9-2 (cont.) Illinois Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
La Salle County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Rock Island County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Whiteside County	County Board of Commissioners	Construction of pipeline across county roads	Permit

Table 1.1.3.9-3 Indiana Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Indiana Department of Natural Resources	Division of Water	Construction of pipeline in a floodway	Certificate of approval
	Division of Land, Forests and Wildlife	Construction of pipeline through a classified forest area	Special permit
Indiana Air Pollution Control Commission	Division of Air Pollution Control, State Board of Health	Location and design of compressor facilities; stationary pollutant emission source	Construction permit
		Operation of compressor facilities	Operating permit
		Open burning operations	Variance
Indiana Stream Pollution Control Commission	Division of Water Pollution Control, State Board of Health	Discharge of water	Division of water pollution control approval, where applicable
Administrative Building Council of Indiana		Compressor facility; building plans and specification development	State Certification to EPA Council approval

Table 1.1.3.9-3 (cont.) Indiana Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Indiana State Highway Commission	Division of Maintenance	Construction of pipeline across state trunk highways	Use and occupancy permit
		Use of state highways for overweight or oversize equipment transport	Permit
Adams County	County Board of Commissioners	Construction of pipeline across county roads	Permit
		Location of pipeline in county	Contingent use permit
	County Drainage Board	Construction of pipeline across county drains	Approval
Cass County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	County Drainage Board	Construction of pipeline across county drains	Permit
Huntington County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	Board of Zoning Appeals	Location of compressor facility and microwave tower in county	Contingent use approval

Table 1.1.3.9-3 (cont.) Indiana Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Huntington County (cont.)	Building Commission	Construction of compressor facility and microwave tower	Permit
Jasper County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	County Drainage Board	Construction of pipeline across county drains	Approval
Miami County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Newton County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	Zoning Board of Appeals	Location of pipeline and microwave tower in county	Special exception permit
Wabash County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	County Drainage Board	Construction of pipeline across county drains	Approval

Table 1.1.3.9-3 (cont.) Indiana Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Wells County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	Zoning Board of Appeals	Location of microwave tower in county	Special use approval
White County	County Board of Commissioners	Construction of pipeline across county roads	Permit
		Construction of compressor and microwave tower	Building permit

Table 1.1.3.9-4 Iowa Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Iowa State Commerce Commission	Utilities Division	Construction, operation and maintenance of pipeline in the state	Permit to construct, operate and maintain pipeline
Iowa Department of Environmental Quality	Air Quality Division	Construction of compressor facility: stationary pollutant emission source	Permit
	Water Quality Management Division	Discharge of water	Discharge permit, where applicable
Iowa State Conservation Commission	Division of Land and Waters	Construction of pipeline across meandered waters in the state	Construction permit
Iowa Natural Resources Council		Construction of pipeline across floodway or floodplain	Council approval
	State Water Commissioner	Withdrawal of water for use in hydrostatic testing	Permit
Iowa State Highway Commission		Construction of pipeline across state highways	Occupancy permit
		Use of state highways for overweight or oversize equipment transport	Permit

Table 1.1.3.9-4 (Cont.) Iowa Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Benton County	County Board of Supervisors	Construction of pipeline across county roads	Permit
Black Hawk County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Construction of compressor facility and microwave tower in county	Approval
Bremer County	County Board of Supervisors	Construction of pipeline across county roads	Permit
Buchanan County	County Board of Supervisors	Construction of pipeline across county roads	Permit
Butler County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Construction of compressor facility and microwave tower in county	Approval
Cedar County	County Board of Supervisors	Construction of pipeline across county roads	Permit

Table 1.1.3.9-4 (Cont.) Iowa Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Cerro Gordo County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Construction of pipeline across organized drainage district lands	Permit
Clinton County	County Board of Supervisors	Construction of pipeline across county roads	Permit
Franklin County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Construction of pipeline across organized drainage district lands	
		Construction of compressor facility and microwave tower in county	Approval
Hancock County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Construction of pipeline across organized drainage district lands	Permit

Table 1.1.3.9-4 (Cont.) Iowa Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Jones County	County Board	Construction of pipeline across county roads	Permit
Linn County	County Board of Supervisors	Construction of pipeline across county roads	Permit
Scott County	County Board of Supervisors	Construction of pipeline across county roads	Permit
Winnebago County	County Board of Supervisors	Construction of pipeline across county roads	Permit

Table 1.1.3.9-5 Minnesota Governmental Units Having Project Approval

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Minnesota Environmental Quality Council		Location of pipeline and associated facilities in Minnesota	Approval
Minnesota Pollution Control Agency	Division of Air Quality	Construction of compressor facilities: stationary pollutant emission source	Construction permit
		Operation of compressor facilities	Operating permit
		Open burning activities	Permit
	Division of Water Quality	Discharge of water	Discharge permit, where applicable
			State certification to EPA
Minnesota Department of Natural Resources	Commissioner of Natural Resources	Location of pipeline and associated facilities in Minnesota	Approval
	Division of Water, Soils and Minerals	Withdrawal of water for use in hydrostatic testing	Permit to appropriate water
		Construction of pipeline across rivers and streams	Permit to construct

Table 1.1.3.9-5 (cont.) Minnesota Governmental Units Having Project Approval

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Minnesota Department of Natural Resources (cont.)		Construction of pipeline across state public lands	Right-of-way lease
Minnesota Department of Highways	Utility Crossing Division	Construction of pipeline across state trunk highways	Utility permit
		Use of state highways for overweight or oversize equipment transport	Transportation permit
Yellow Medicine Watershed District	Board of Commissioners	Construction of pipeline across the watershed district	Permit
Cottonwood County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Compressor station construction and microwave tower installation	Building permit
	County Board of Adjustment	Microwave tower installation	Zoning variance
Jackson County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Location of pipeline in county	Conditional use permit

Table 1.1.3.9-5 (cont.) Minnesota Governmental Units Having Project Approval

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Lincoln County	County Board of Supervisors	Construction of pipeline across county roads	Permit
Lyons County	County Board of Supervisors	Construction of pipeline across county roads	Permit
		Location of pipeline and microwave tower in county	Conditional use permit
		Installation of microwave tower	Building permit
Martin County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	County Board of Commissioners	Construction of compressor facility and installation of microwave tower in county limits	Conditional use permit
			Septic system permit
Murray County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	County Zoning Officer	Construction of compressor facility and installation of microwave tower	Building permit
			Septic system permit

Table 1.1.3.9-6 Montana Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Montana Department of Health and Environmental Sciences	Air Quality Bureau	Construction of compressor facility: stationary pollutant emission source	Construction permit
		Operation of compressor facility	Operating permit
	Water Quality Bureau	Discharge of water	Discharge permit, where applicable
Montana Department of Natural Resources and Conservation	Floodway Management Bureau	Construction of pipeline across designated flood-ways	Permit to construct
	Water Rights Bureau	Withdrawal of water	Beneficial water use permit, where applicable
	Soil Conservation Bureau	Construction of pipeline and compressor facilities; earth moving operations	Approval of erosion and sedi-mentation control plan
Montana Department of State Lands		Construction of pipeline across state lands	Right-of-way easement

Table 1.1.3.9-6 (Cont.) Montana Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Montana Department of Highways		Construction of pipeline across state highways	Right-of-way use and occupancy permit
		Use of state highways for overweight and oversize equipment transport	Permit
Phillips County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Roosevelt County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Valley County	County Board of Commissioners	Construction of pipeline across county roads	Permit

Table 1.1.3.9-7 North Dakota Governmental Units Having Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
North Dakota State Health Department	Division of Air Pollution Control	Construction of compressor facility: stationary pollutant emission source	Permit to construct
		Operation of compressor facility	Permit to operate
	Division of Water Supply and Pollution Control	Discharge of water	Discharge permit, where applicable
			State certification to EPA
North Dakota State Water Commission		Construction of pipeline across rivers and streams	Commission approval
		Withdrawal of water	Permit to divert and appropriate water, where applicable
North Dakota State Land Department		Construction of pipeline across state land	Right-of-way lease
North Dakota State Department of Highways		Construction of pipeline across state and interstate highways	Permit

Table 1.1.3.9-7 (Cont.) North Dakota Governmental Units Having Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
North Dakota State Department of Highways (Cont.)		Use of state highways for overweight or oversize equipment transport	Permit
Dunn County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Emmons County	County Board of Commissioners	Construction of pipeline across county roads	Permit
McIntosh County	County Board of Commissioners	Construction of pipeline across county roads	Permit
McKenzie County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Mercer County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Morton County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	County Engineer's Office	Use of county roads for overweight and oversize equipment transport	Load permit

Table 1.1.3.9-7 (Cont.) North Dakota Governmental Units Having Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Oliver County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Williams County	County Board of Commissioners	Construction of pipeline across county roads	Permit

Table 1.1.3.9-8 Ohio Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Harrison County	County Board of Commissioners	Construction of pipeline across county and township roads	Permit
		Use of county roads for overweight or oversize equipment transport	Special hauling permit
Jefferson County	County Board of Commissioners	Construction of pipeline across county and township roads	Permit
Knox County	County Board of Commissioners	Construction of pipeline across county and township roads	Permit
Licking County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	County Engineer's Office	Construction of pipeline across county roads	Permit
Marion County	County Board of Commissioners	Construction of pipeline across county and township roads	Permit

Table 1.1.3.9-8 (Cont.) Ohio Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Marion County (Cont.)		Use of county and township roads for oversize or overweight equipment transport	Permit
Mercer County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	Center Township Trustees	Construction of pipeline across township roads	Permit
	Dublin Township Trustees	Construction of pipeline across township roads	Permit
	Hopewell Township Trustees	Construction of pipeline across township roads	Permit
Morrow County	County Board of Commissioners	Construction of pipeline across county and township roads	Permit
Tuscarawas County	County Board of Commissioners	Construction of pipeline across county and township roads	Permit
Union County	County Board of Commissioners	Construction of pipeline across county and township roads	Permit

Table 1.1.3.9-8 (Cont.) Ohio Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Ohio Power Siting		Construction, operation and maintenance of pipeline in state	Certificate of environmental compatibility and public need
Ohio Environmental Protection Agency	Air Pollution Division	Construction of compressor facility: stationary pollutant emission source	Construction permit
		Operation of compressor facility	Operating permit
		Open burning activities	Approval
	Waste Management and Engineering Division	Discharge of water	State certification to EPA, where applicable
Ohio Department of Natural Resources	Division of Real Estate	Locating pipeline on Department of Natural Resources land	License for right-of-way
Ohio Department of Transportation	Bureau of Utilities	Construction of pipeline across state highways	Permit to occupy highway right-of-way
		Use of state highways for overweight or oversize equipment transport	Special vehicle movement permit

Table 1.1.3.9-8 (Cont.) Ohio Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Ohio Department of Industrial Relations	Division of Factory and Building	Design, specifications and location of above ground structures in state: compressor facility and microwave tower	Plan approval
Muskingum Watershed Conservancy District		Construction of pipeline across land and waters under the jurisdiction of the district	Permit
Auglaize County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	Duchoquet Township Trustees	Construction of pipeline across township roads	Permit
	Goshane Township Trustees	Construction of pipeline across township roads	Permit
	Moulton Township Trustees	Construction of pipeline across township roads	Permit
	Noble Township Trustees	Construction of pipeline across township roads	Permit
	Union Township Trustees	Construction of pipeline across township roads	Permit

Table 1.1.3.9-8 (Cont.) Ohio Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Coshocton County	County Board of Commissioners	Construction of pipeline across county and township roads	Permit
Delaware County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Guernsey County	County Board of Commissioners	Construction of pipeline across county roads	Permit
	Monroe Township Trustees	Construction of pipeline across township roads	Permit
	Wheeling Township Trustees	Construction of pipeline across township roads	Permit
Hardin County	County Board of Commissioners	Construction of pipeline across township roads	Permit
		Construction of pipeline across drainage fields	Approval
	Hale Township Trustees	Construction of pipeline across township roads	Permit
	McDonald Township Trustees	Construction of pipeline across township roads	Permit
	Roundhead Township Trustees	Construction of pipeline across township roads	Permit

Table 1.1.3.9-8 (Cont.) Ohio Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Hardin County (Cont.)	Taylor Creek Township Trustees	Construction of pipeline across township roads	Permit

Table 1.1.3.9-9 Pennsylvania Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Pennsylvania Department of Environmental Resources	Division of Dams and Encroachments	Construction of pipeline across rivers and streams	Stream encroachment permit
			Erosion and sedimentation control permit
	Division of Soil Resources and Erosion Control	Construction of pipeline and compressor facilities; earth moving operations affecting an area greater than 25 acres	Erosion control permit
	Division of Industrial Waste and Erosion Control	Discharge of water	State certification to EPA, where applicable
	Division of State Forest Management	Construction of pipeline across state forest lands	License for right-of-way
Pennsylvania Game Commission	Division of Land Management	Construction of pipeline across state game lands	License for right-of-way
Pennsylvania Fish Commission	Bureau of Administration	Blasting activities in rivers and streams for construction of pipeline	Permit

Table 1.1.3.9-9 (Cont.) Pennsylvania Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Pennsylvania Department of Transportation	Bureau of Maintenance	Construction of pipeline across state highways and township roads	Highway occupancy permit
Pennsylvania Public Utility Commission	Bureau of Transportation	Use of state and township roads for overweight or oversize equipment transfer	Special hauling permit
Pennsylvania Department of Labor and Industry	Division of Buildings	Compressor facility; building plans and specifications development	Approval
Allegheny County	Bureau of Air Pollution Control	Construction and operation of compressor facility; stationary air pollutant source	Permit
	County Health Department	Installation of sanitary system at compressor facility	Permit
	Forward Township	Construction of compressor facility	Conditional use permit
	Department of Public Works	Construction across roads	Building permit
Westmoreland County	County Parks and Roads Department	Construction of pipeline across county roads	Permit

Table 1.1.3.9-10 South Dakota Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
South Dakota Department of Environmental Protection	Air Pollution Control Division	Construction of compressor facility; stationary pollutant emission source	Department approval
		Operation of compressor facility	Operating permit
	Water Quality Division	Discharge of water	State certification to EPA, where applicable
South Dakota Department of Natural Resources	Water Rights Division	Withdrawal of water	Permit to appropriate water, where applicable
South Dakota Commissioner of School and Public Lands		Construction of pipeline across state lands and public waters	Right-of-way easement
South Dakota Department of Highways	District Highway Engineer	Construction of pipeline across state and interstate highways	Permit
		Use of state highways for overweight or oversize equipment transport	Permit

Table 1.1.3.9-10 (Cont.) South Dakota Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
Brooking County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Brown County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Clark County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Codington County	County Board of Commissioners	Construction of pipeline across county roads	Permit
Day County	County Board of Commissioners	Construction of pipeline across county roads	Permit
McPherson County	County Board of Commissioners	Construction of pipeline across county roads	Permit

Table 1.1.3.9-11 West Virginia Governmental Units Having Project Approval Requirements

Unit	Responsible Subdivision	Activity Requiring Approval	Form
West Virginia Department of Natural Resources	Public Land Corporation	Construction of pipeline across streams	Permit
	Division of Water Resources	Discharge of water	Discharge permit, where applicable
West Virginia of Highways	Division of Maintenance	Construction of pipeline across state and county roads	Highway right-of-way encroachment permit
		Use of state highways for overweight or oversize equipment transport	Load permit

2 DESCRIPTION OF THE EXISTING ENVIRONMENT

2.1 ARCTIC GAS PIPELINE PROJECT

2.1.3 Northern Border Pipeline

2.1.3.1 Climate

Climate and weather are important in evaluating environmental impacts and in determining structural design and construction techniques.

Weather affects such things as erosion hazards, air and water pollution factors, the feasibility of revegetation, crop production levels, wildlife values, construction limitations, etc.

Where climatic factors are important to a specific section of Part V they are discussed in that section. This introductory section discusses common climatic conditions along the 1,600-mile proposed route of the North Border segment of the Alaska Natural Gas Transportation System (ANGTS).

The climatic data in this section indicate the significant climatic changes from west to east along the pipeline route. In general, there is a gradual moderation of climate from Montana eastward. Minimum and average temperatures, length of growing season, and annual precipitation increase from west to east. High winds and blizzards are more prevalent in the west. Ambient air quality generally decreases from west to east. All these climatic factors influence the environment along the route and are important in evaluating impacts on the environment.

Temperature

Normal monthly and annual average temperatures along the proposed route are shown in Table 2.1.3.1-1. While the annual averages are within a relatively narrow 11 degree F range, ie., from 41 degrees F in Fargo, North Dakota, to 52 degrees F in Columbus, Ohio, seasonal extremes are pronounced.

Winters in North Dakota and Minnesota are about 15 degrees F to 20 degrees F colder than those in Ohio and southwestern Pennsylvania. As shown in Figure 2.1.3.1-1, the minimum temperature is 32 degrees F and below 180 days of the year in Montana, North Dakota, South Dakota and Minnesota. This minimum indicates the severity of the cold that envelops this portion of the United States during the winter.

Summer temperatures are fairly constant along the route; monthly averages differ by only 9 degrees F. Figure 2.1.3.1-2 indicates 90 degrees F averages and above. The northward surge of the 30-day line into South Dakota, North Dakota and Montana is notable. This region of the country is generally thought of as being consistently cold.

The length of the freeze-free period in an area indicates the length of the plant growing season. Figure 2.1.3.1-3 shows that the western end of the route passes through a region where the freeze-free period is less than 120 days. Eastward, the freeze-free period increases from more than 150 days in southern Minnesota and Iowa, to approximately 180 days in Illinois, and then gradually decreases to between 120 and 150 days at the extreme eastern portion of the route.

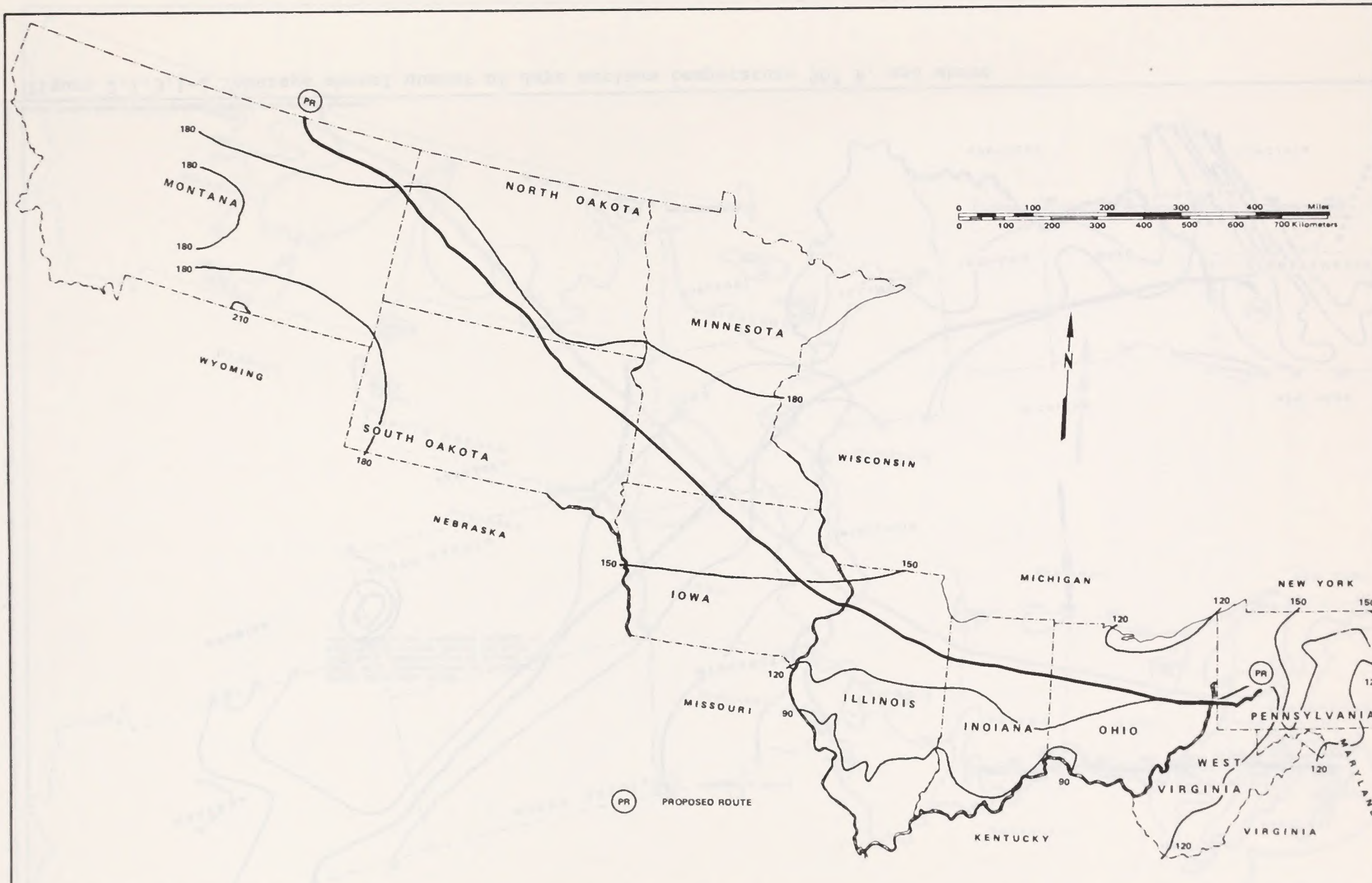
Figure 2.1.3.1-4 shows maximum frost penetrations along the route. Frost penetration is deepest in Montana, the Dakotas and Minnesota; it

FIGURE 2.1.3.1-2

NORMAL AVERAGE MONTHLY AND ANNUAL TEMPERATURE (^{o}F)

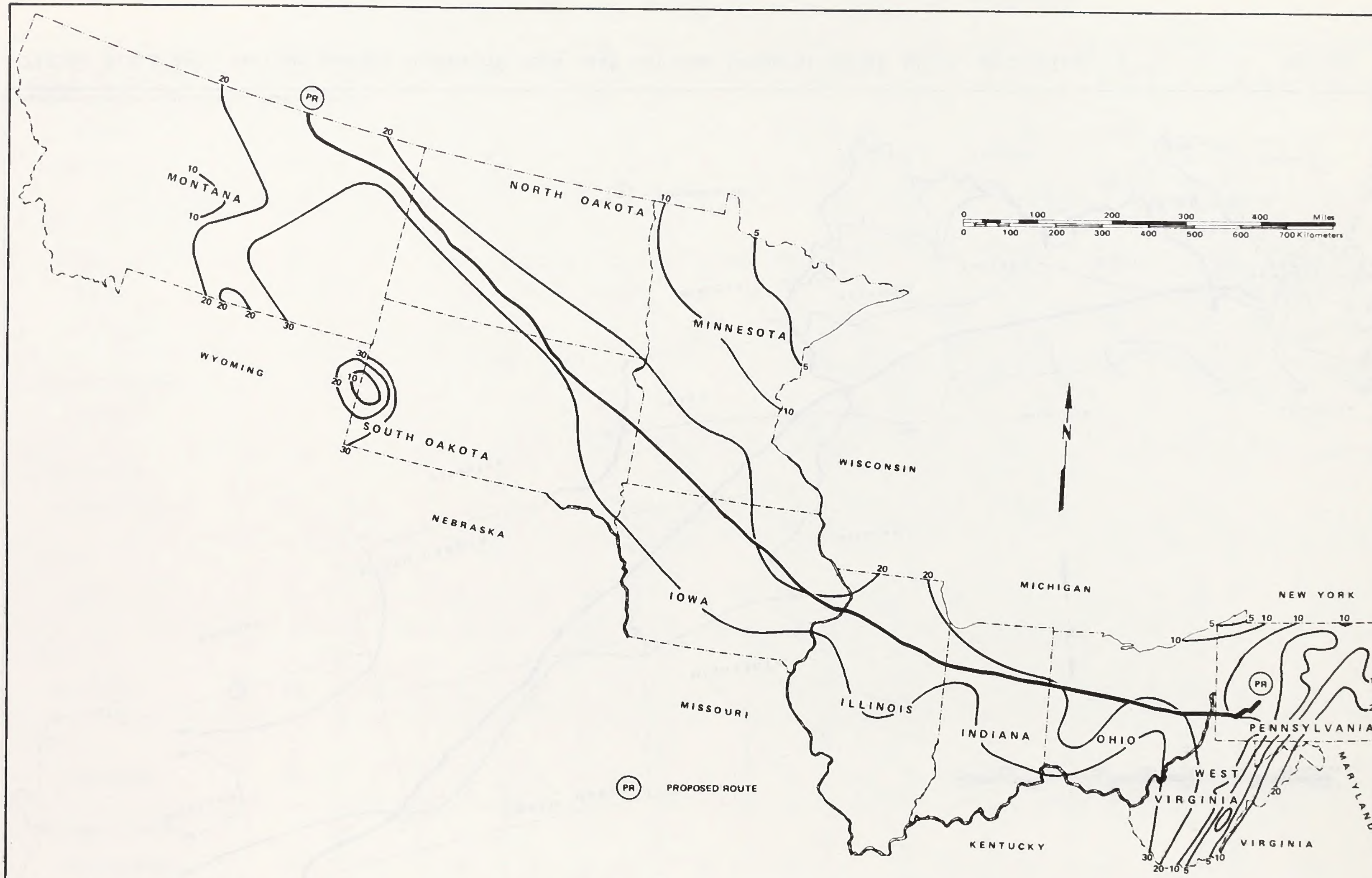
CITY AND STATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
MONTANA													
HAVRE	14	16	27	43	54	61	70	67	56	46	30	21	42
MILES CITY	17	20	31	46	57	66	75	73	61	49	33	23	46
NORTH DAKOTA													
BISMARCK	10	14	26	44	56	65	72	69	59	47	29	18	42
FARGO	7	11	24	42	55	65	71	70	59	47	28	14	41
WILLISTON	10	13	25	43	55	63	72	69	58	46	29	18	42
SOUTH DAKOTA													
RAPID CITY	22	24	31	45	56	65	74	72	62	50	35	27	47
MINNESOTA													
MINNEAPOLIS	12	16	28	45	58	67	73	71	61	48	31	18	44
IOWA													
DES MOINES	21	24	36	50	62	72	78	75	66	54	37	26	50
ILLINOIS													
CHICAGO	26	28	36	49	60	71	76	74	66	55	40	29	51
OHIO													
COLUMBUS	30	31	39	51	62	71	75	73	66	54	41	32	52
PENNSYLVANIA													
PITTSBURGH	29	29	37	49	60	68	72	71	64	53	41	31	50

DATA BASED ON 30-YEAR PERIOD 1931-60. SOURCE: CLIMATIC ATLAS OF THE UNITED STATES.



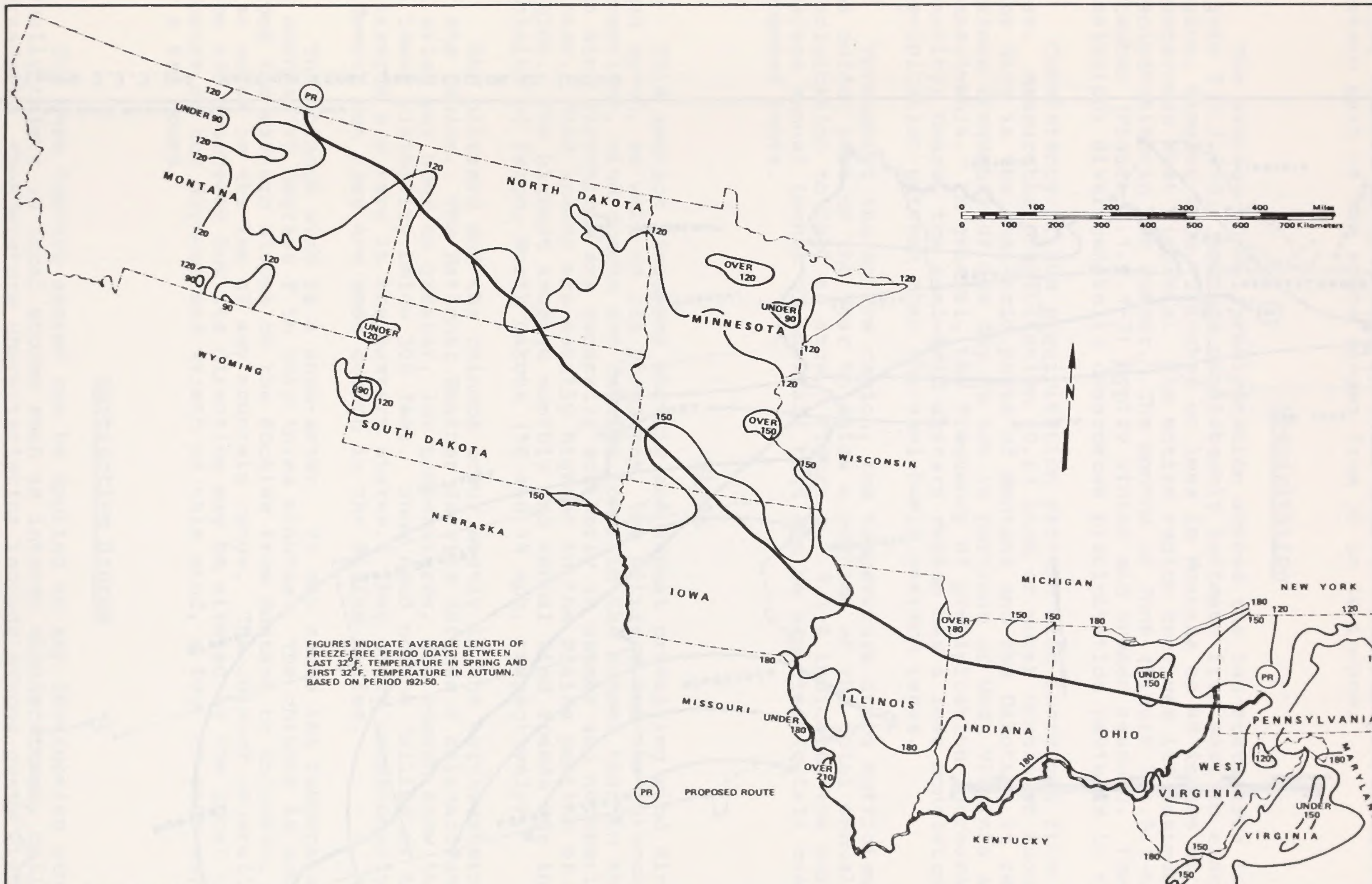
Source: *Climatic Atlas of the United States*, 1968, U.S. Department of Commerce

Figure 2.1.3.1-1 Average annual number of days with minimum temperature of 32° F. and below



Source: *Climatic Atlas of the United States*, 1968, U.S. Department of Commerce.

Figure 2.1.3.1-2 Average annual number of days maximum temperature 90° F. and above



Source: *Climatic Atlas of the United States*, 1968, U.S. Department of Commerce.

Figure 2.1.3.1-3 Average length of freeze-free period

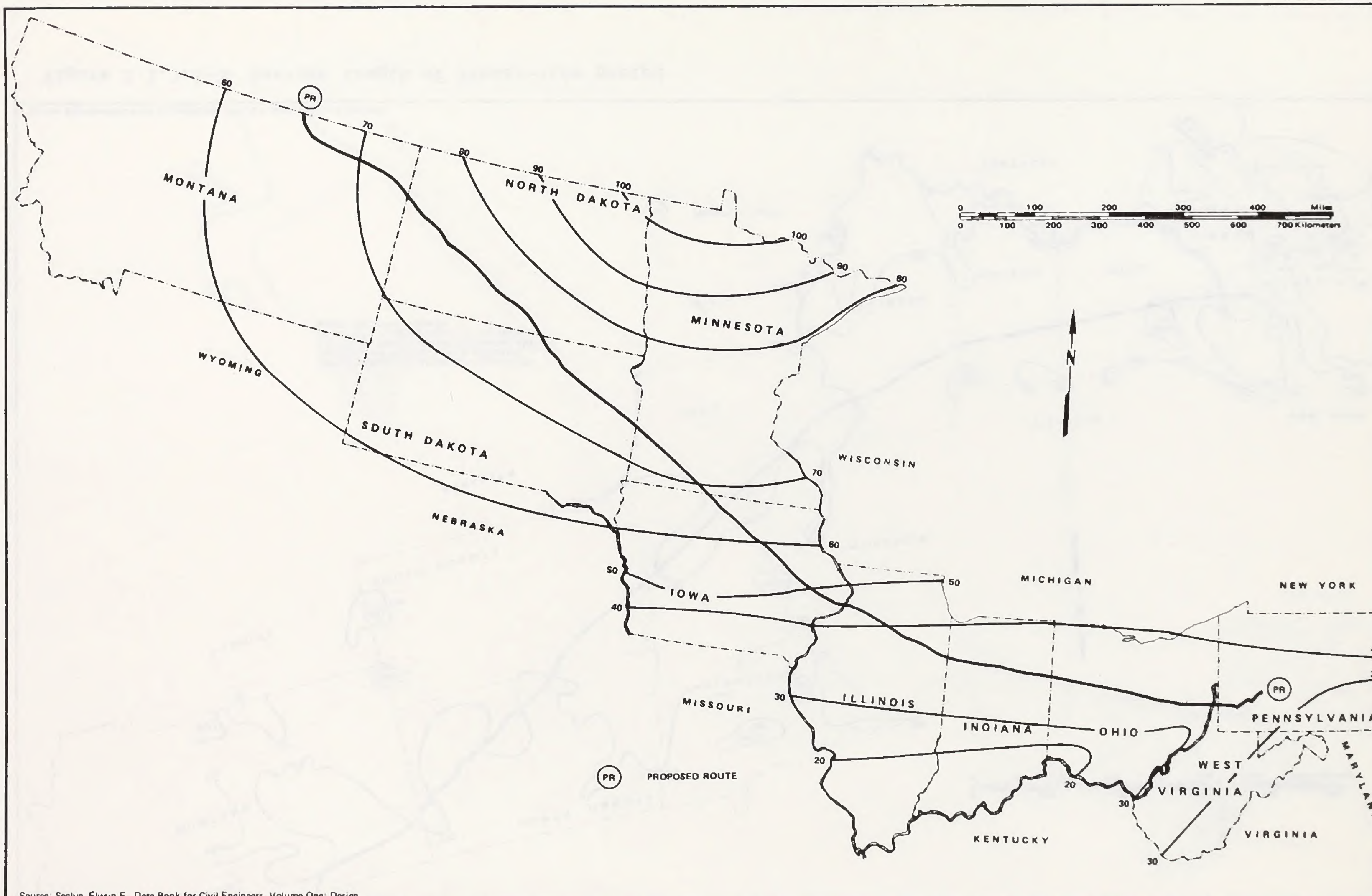


Figure 2.1.3.1-4 Maximum frost penetration in inches

ranges from 70 to 80 inches in these states. Maximum penetration in the eastern part of the route ranges from 30 to 40 inches.

Precipitation

The average annual precipitation across the ten-state area is shown on Figure 2.1.3.1-5. Amounts consistently increase from west to east in the region, ranging from 12 inches or less in Montana to 48 inches or more in mountainous West Virginia. The entire region receives its maximum precipitation in the summer. The months of June (Figure 2.1.3.1-6) and December (Figure 2.1.3.1-7) typify winter and summer seasons. The Mississippi River generally demarcates precipitation patterns in the winter.

Consistency of the precipitation pattern also increases from west to east. Measurable precipitation (0.01 inch or more) occurs on about one of four days in the semi-arid parts of Montana and the Dakotas; it reaches a maximum frequency of one day in two in portions of West Virginia and Pennsylvania. In general, the frequency of precipitation increases with quantity; hence, the semi-arid western region has a less consistent precipitation pattern than the semi-humid eastern range.

Throughout the entire region, the temperature drops sufficiently during the colder part of the year to allow a portion of the total annual precipitation to fall as snow. Figure 2.1.3.1-8 indicates the normal average annual inches of snowfall that can be expected to fall over the proposed route.

Winds

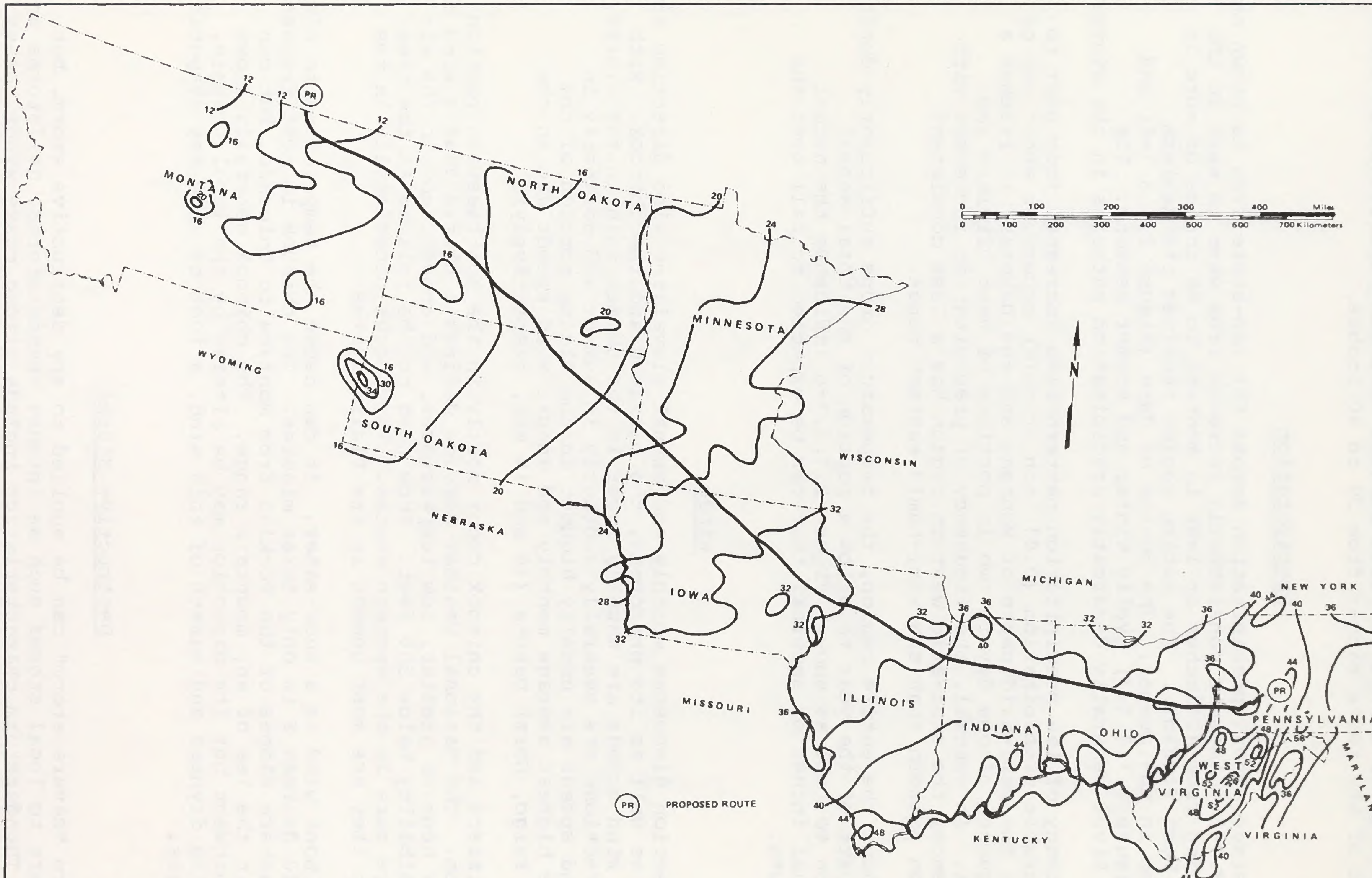
This section discusses monthly and annual prevailing wind direction and mean speed, as well as its phenomena, the blizzard and the chinook. With exceptions, wind speeds are usually lower in the summer than in the winter. The wind directions are generally southerly in summer and northerly in winter. Wind speeds are usually highest in the Plains portion of the region. The highest average monthly and annual wind speeds are in the vicinity of Fargo, North Dakota (16 and 14 mph, respectively).

The blizzard and the chinook occur mostly in the northwestern portion of the region. The National Weather Service defines a blizzard as a wind of 32 miles per hour or greater, low temperatures, and enough snow in the air to lower visibility below 500 feet. Snow need not be falling at the time. Blizzards are rare in the eastern states. They occur occasionally in the Midwest, but they are most common in the Plains states.

The chinook wind is a snow-eater. It can cause the temperature to rise as much as 20 degrees F in only three minutes. The chinook is most frequent along the eastern slopes of the Rockies from Montana to Colorado, but can also occur in the lee of any mountain range. The chinook generally flows from the southwest but its direction may be altered by the local terrain. Because of the dryness and warmth of this wind, a foot of snow may evaporate in a few hours.

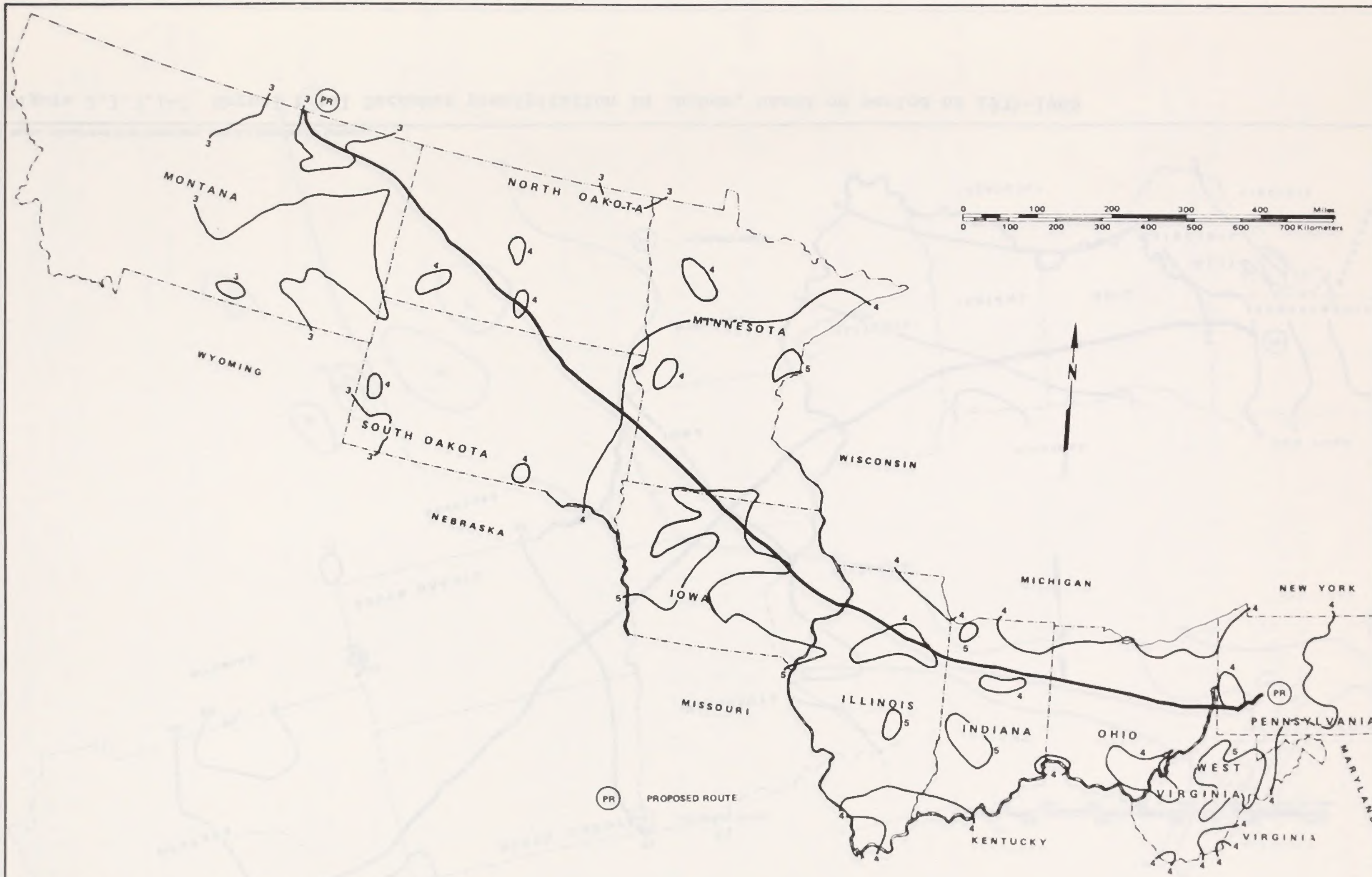
Destructive Storms

The term "severe storm" can be applied to any destructive storm, but usually refers to local storms such as intense thunderstorms, hailstorms and tornadoes. Thunderstorm characteristics include strong gusty winds, heavy precipitation and hail. Tornadoes may accompany thunderstorm activity, but



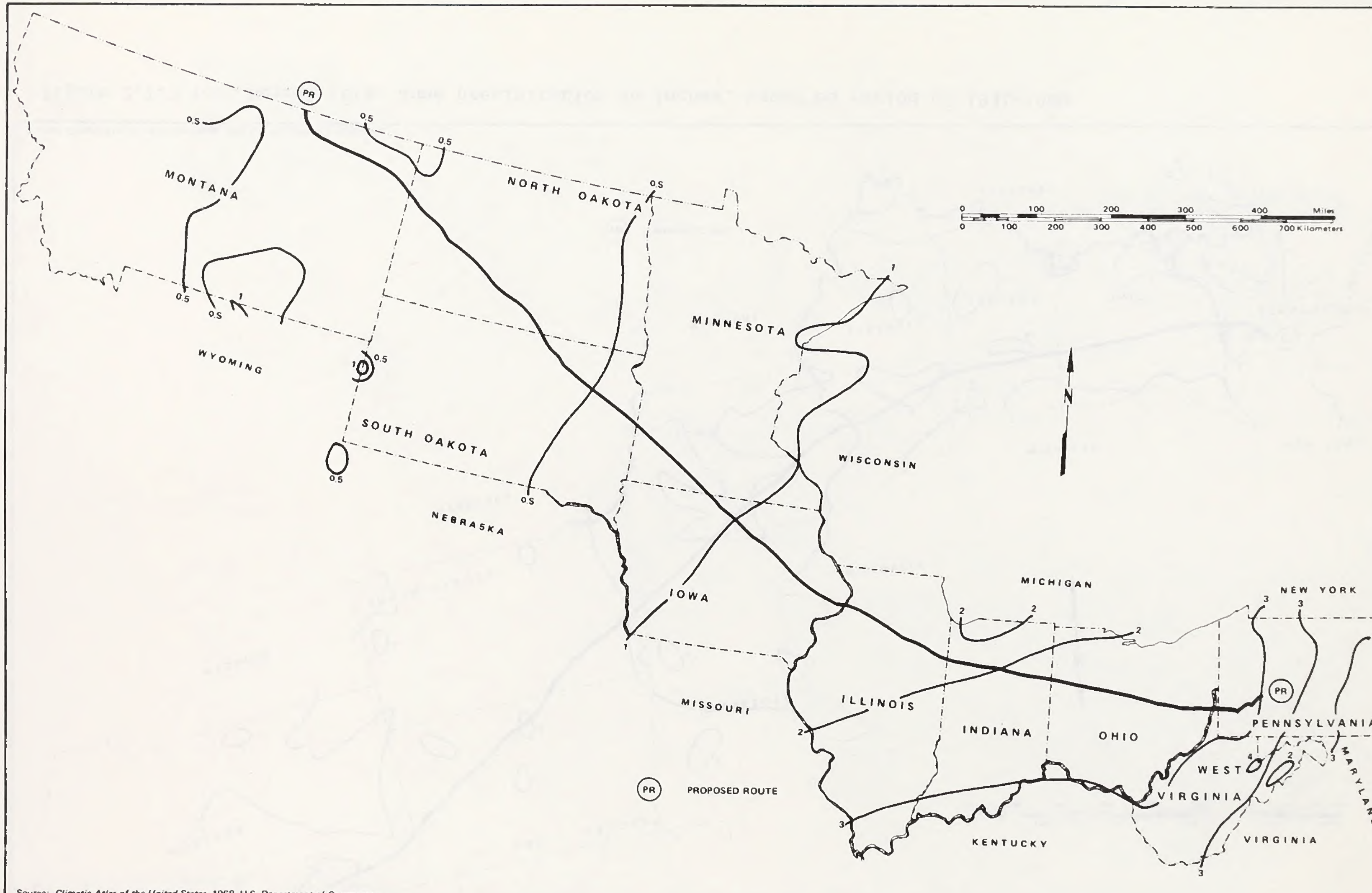
Source: *Climatic Atlas of the United States*, 1968, U.S. Department of Commerce.

Figure 2.1.3.1-5 Normal annual total precipitation in inches, based on period of 1931-1960



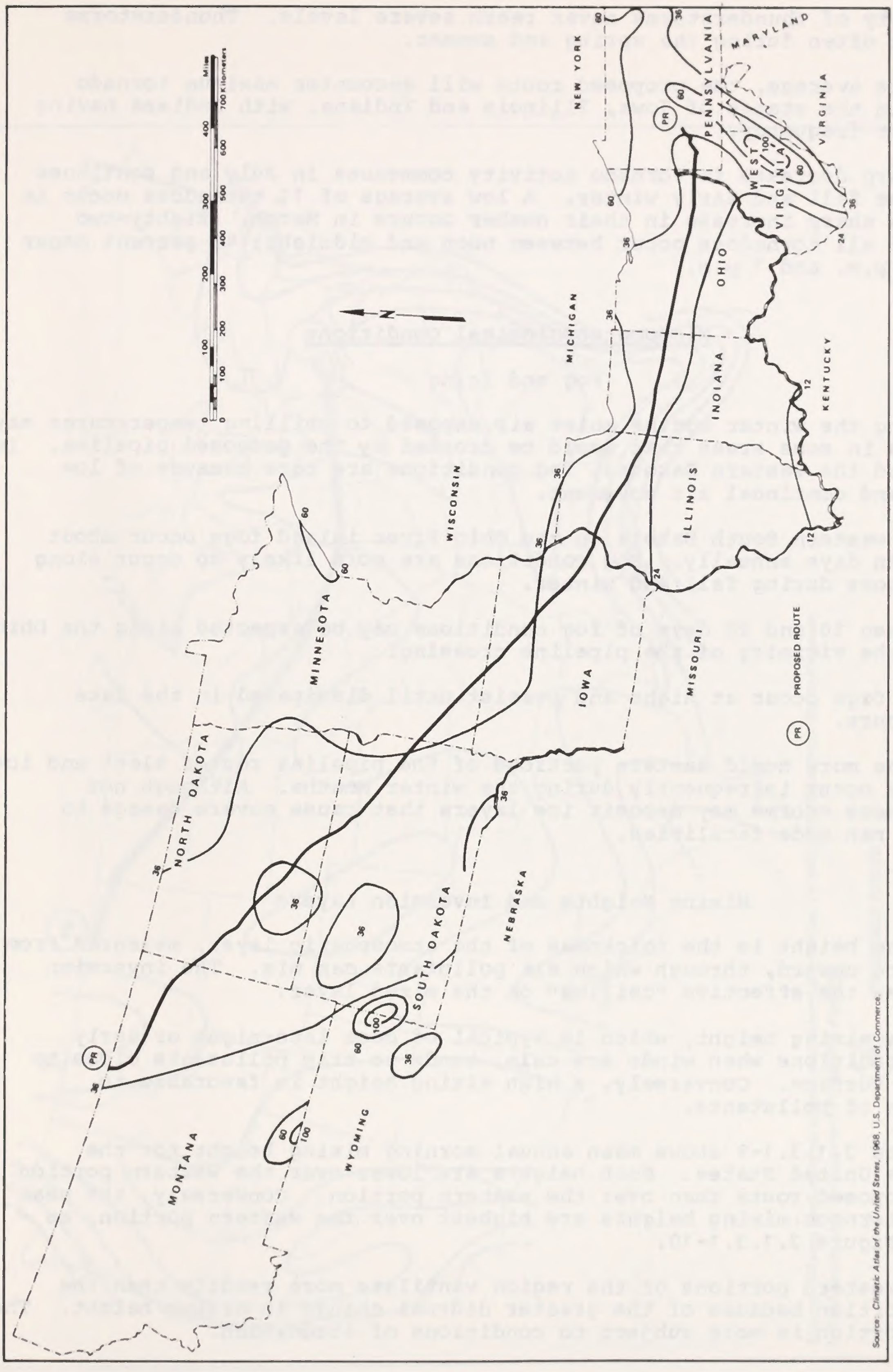
Source: *Climatic Atlas of the United States*, 1968, U.S. Department of Commerce.

Figure 2.1.3.1-6 Normal total June precipitation in inches, based on period of 1931-1960



Source: *Climatic Atlas of the United States*, 1968, U.S. Department of Commerce.

Figure 2.1.3.1-7 Normal total December precipitation in inches, based on period of 1931-1960



Source: Climatic Atlas of the United States, 1968, U.S. Department of Commerce.

Figure 2.1.3.1-8 Average annual total snowfall in inches, for period of record through 1960 the majority of thunderstorms never reach severe levels. Thunderstorms occur most often during the spring and summer.

On the average, the proposed route will encounter maximum tornado activity in the states of Iowa, Illinois and Indiana, with Indiana having the highest frequency.

A sharp decrease in tornado activity commences in July and continues through the fall and early winter. A low average of 11 tornadoes occur in January; a sharp increase in their number occurs in March. Eighty-two percent of all tornadoes occur between noon and midnight; 42 percent occur between 3 p.m. and 7 p.m.

Micrometeorological Conditions

Fog and Icing

During the winter months moist air exposed to chilling temperatures may cause fogs in some areas that would be crossed by the proposed pipeline. In Montana and the western Dakotas, fog conditions are rare because of low humidity and continual air movement.

From western South Dakota to the Ohio River inland fogs occur about five to ten days annually. Fog conditions are more likely to occur along river bottoms during fall and winter.

Between 10 and 20 days of fog conditions may be expected along the Ohio River in the vicinity of the pipeline crossing.

Most fogs occur at night and persist until dissipated in the late morning hours.

In the more humid eastern portions of the pipeline route, sleet and ice storms may occur infrequently during the winter months. Although not common, these storms may deposit ice layers that cause severe damage to trees and man made facilities.

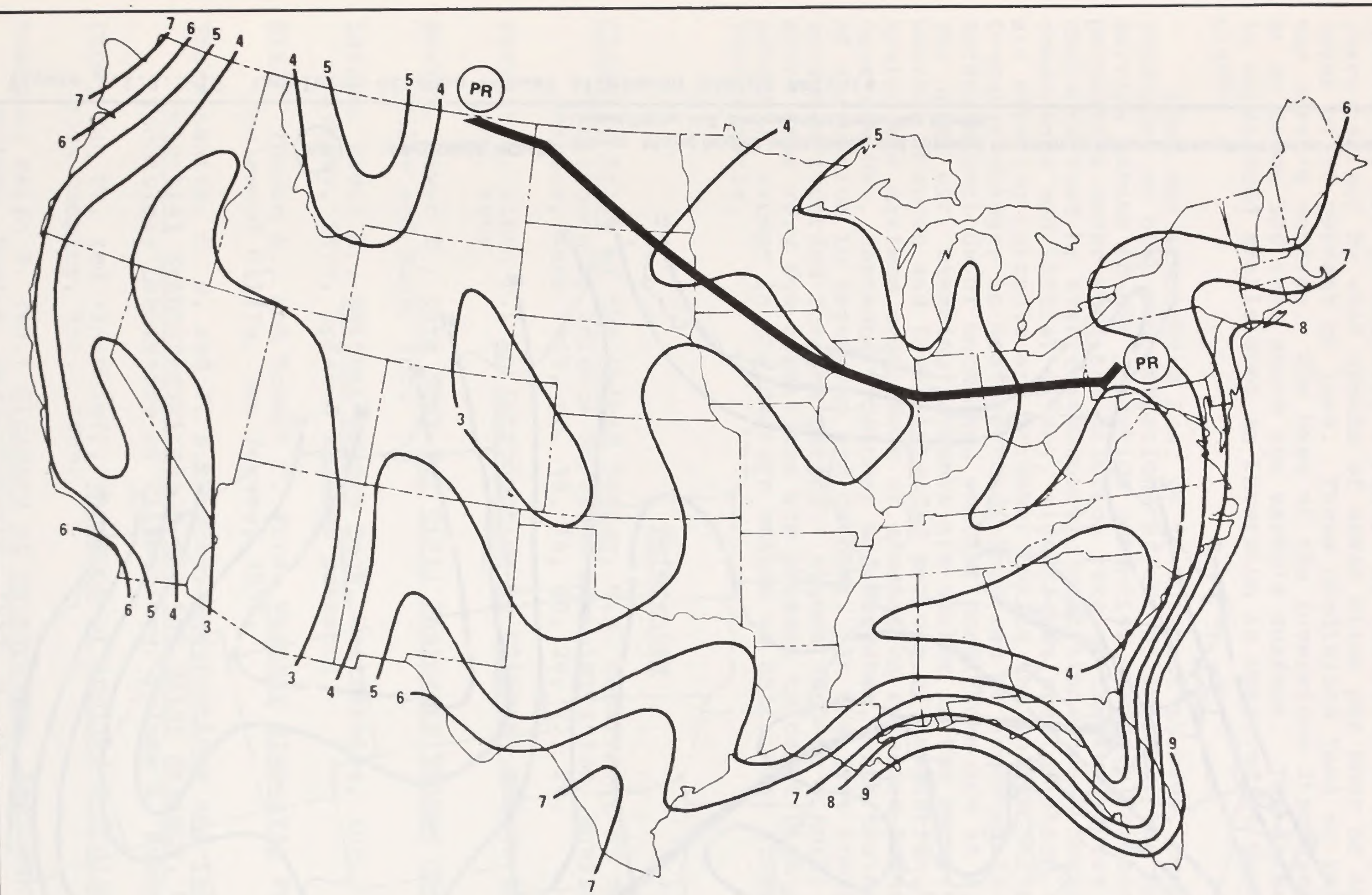
Mixing Heights and Inversion Layers

Mixing height is the thickness of the atmospheric layer, measured from the surface upward, through which air pollutants can mix. The inversion layer fixes the effective "ceiling" on the mixed layer.

A low mixing height, which is typical of cool late-night or early morning conditions when winds are calm, tends to trap pollutants close to the earth surface. Conversely, a high mixing height is favorable to dispersion of pollutants.

Figure 2.1.3.1-9 shows mean annual morning mixing height for the contiguous United States. Such heights are lower over the western portion of the proposed route than over the eastern portion. Conversely, the mean annual afternoon mixing heights are highest over the western portion, as shown in Figure 2.1.3.1-10.

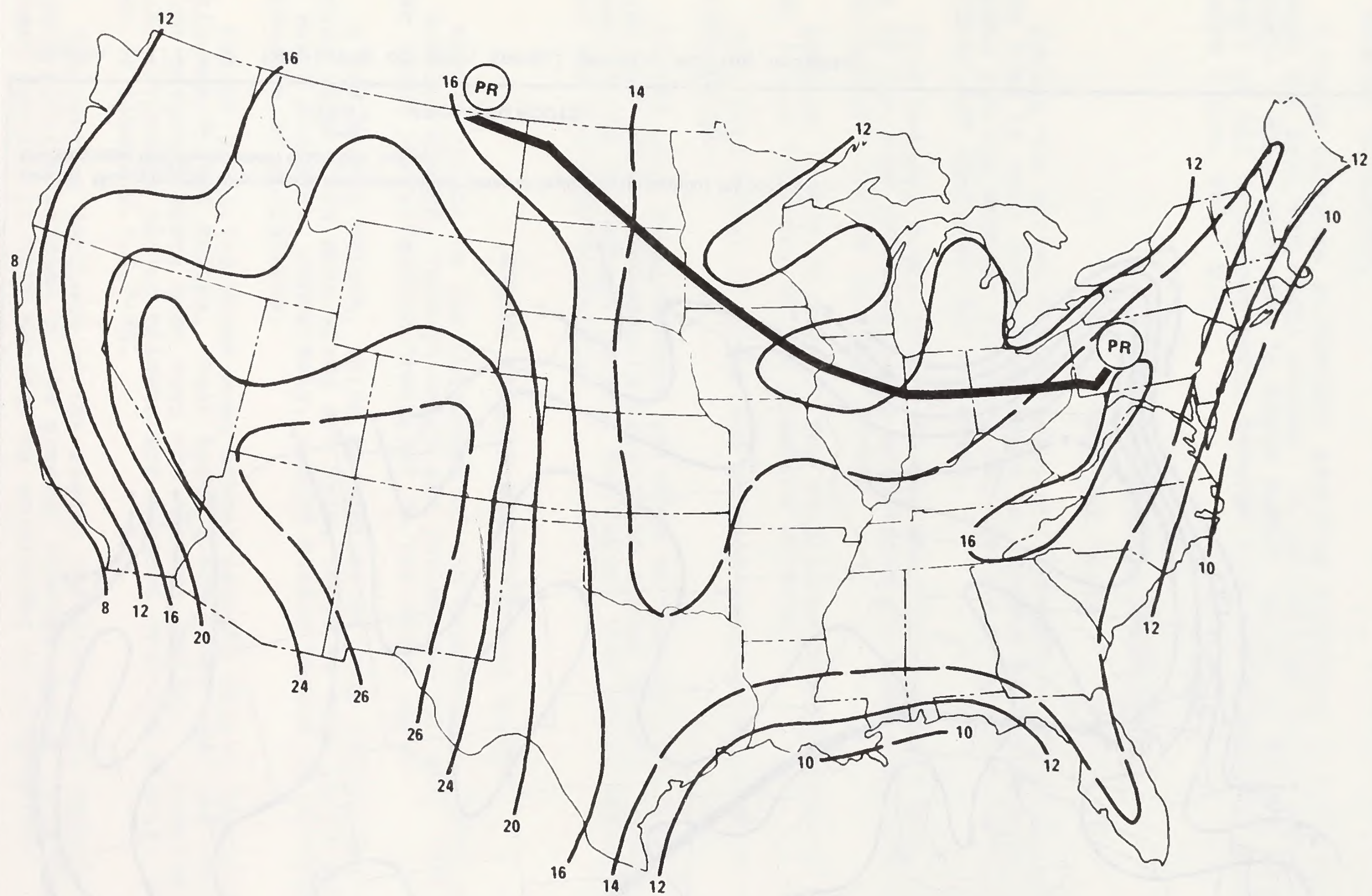
The western portions of the region ventilate more readily than the eastern portion because of the greater diurnal change in mixing height. The eastern portion is more subject to conditions of stagnation.



Source: Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States; U.S. Environment Protection Agency.

(PR) PROPOSED ROUTE

Figure 2.1.3.1-9 Isopleths of mean annual morning mixing heights



PR PROPOSED ROUTE Source: Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States; U.S. Environment Protection Agency.

Figure 2.1.3.1-10 Isopleths of mean annual afternoon mixing heights

An "inversion" occurs when cold air lying near the earth is overlain by warmer air. Pollutants in the cold air are chilled, thus limiting their vertical mixing and dispersion. Inversions usually occur in the coldest hours of the day. Figure 2.1.3.1-11 shows the highest observed percentage of nighttime inversions for the United States on an annual basis. The inversions are principally a result of radiative cooling and are characterized by wind speeds of seven miles per hour or less and a cloud cover of 30 percent or less. These conditions lead to rapid loss of heat by the earth's surface. The base of the inversions discussed in this report is at or below 500 feet above the earth's surface. The entire nighttime period is considered stable when an inversion is observed at any time during the night.

When the atmosphere has, or is forecast to have, properties that are conducive to high concentrations of air pollutants, the National Weather Service issues an air pollution potential advisory forecast. These properties occur when the dilution rate of the atmosphere diminishes and are characterized by stable atmospheric conditions, weak horizontal wind speed components and little, if any, significant precipitation. Since the upper air steering currents are stronger during the colder portion of the year, frequent changes in weather conditions can be expected in the winter. Extended periods of unchanged weather conditions are at a minimum in winter. The upper air, steering currents are weaker in the summer with less frequent weather changes and fewer extended periods of stagnation. The four months having the maximum occurrence of stagnation episodes lasting four or more days are May, September, October and November, with the most likely period of stagnation in September and October. In the East there were actually 75 episodes recorded for the period 1 August 1960 to 3 April 1970. In the 10-state area very few conditions are present to cause high air pollution potential except in the eastern states of Ohio, West Virginia and Pennsylvania.

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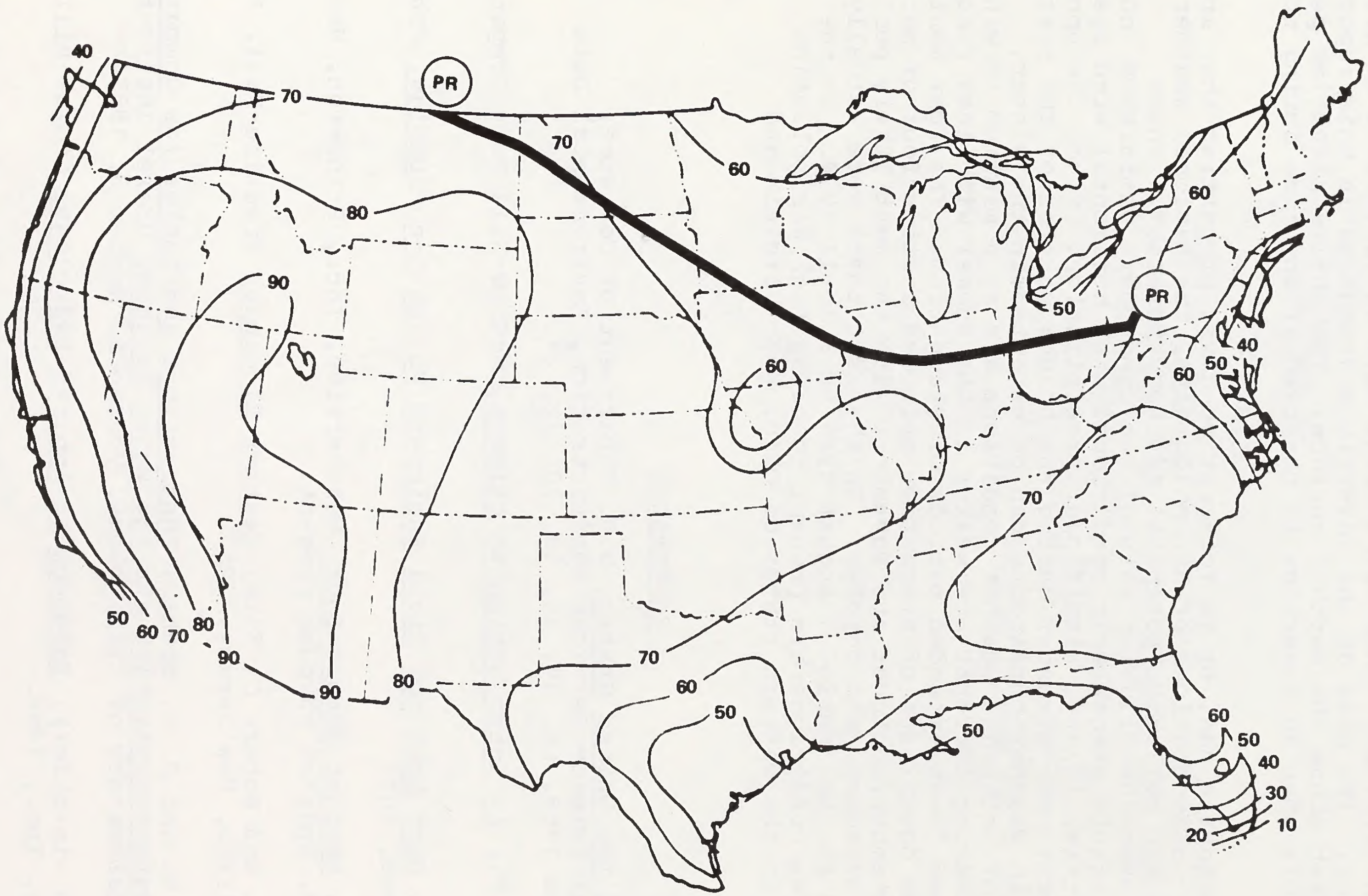

Source: Hosler, Charles R., 1961. Low level inversion frequency in the contiguous United States, *Monthly Weather Review.*

(PR) PROPOSED ROUTE

Figure 2.1.3.1-11 Highest observed percentage frequency of nighttime inversions on an annual basis

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2.1.3.2 Topography

Introduction

In a broad, very general way, if one could slice the earth's crust apart along the proposed route and look at the resulting profile of the land as from a distant rocket, the surface configuration, or topography, would resemble a saucerlike disk that is shallowly depressed near the center. At its natural, unexaggerated scale the profile would appear as a smooth line, for the topographic features that actually stand above the general surface, and the valleys that have been cut down into it, would be too small to be readily distinguishable.

The region crossed by the proposed pipeline alignment owes its topography to many factors, some of them geological. Perhaps the two most important geologic factors are two complex ongoing processes: erosion and deposition.

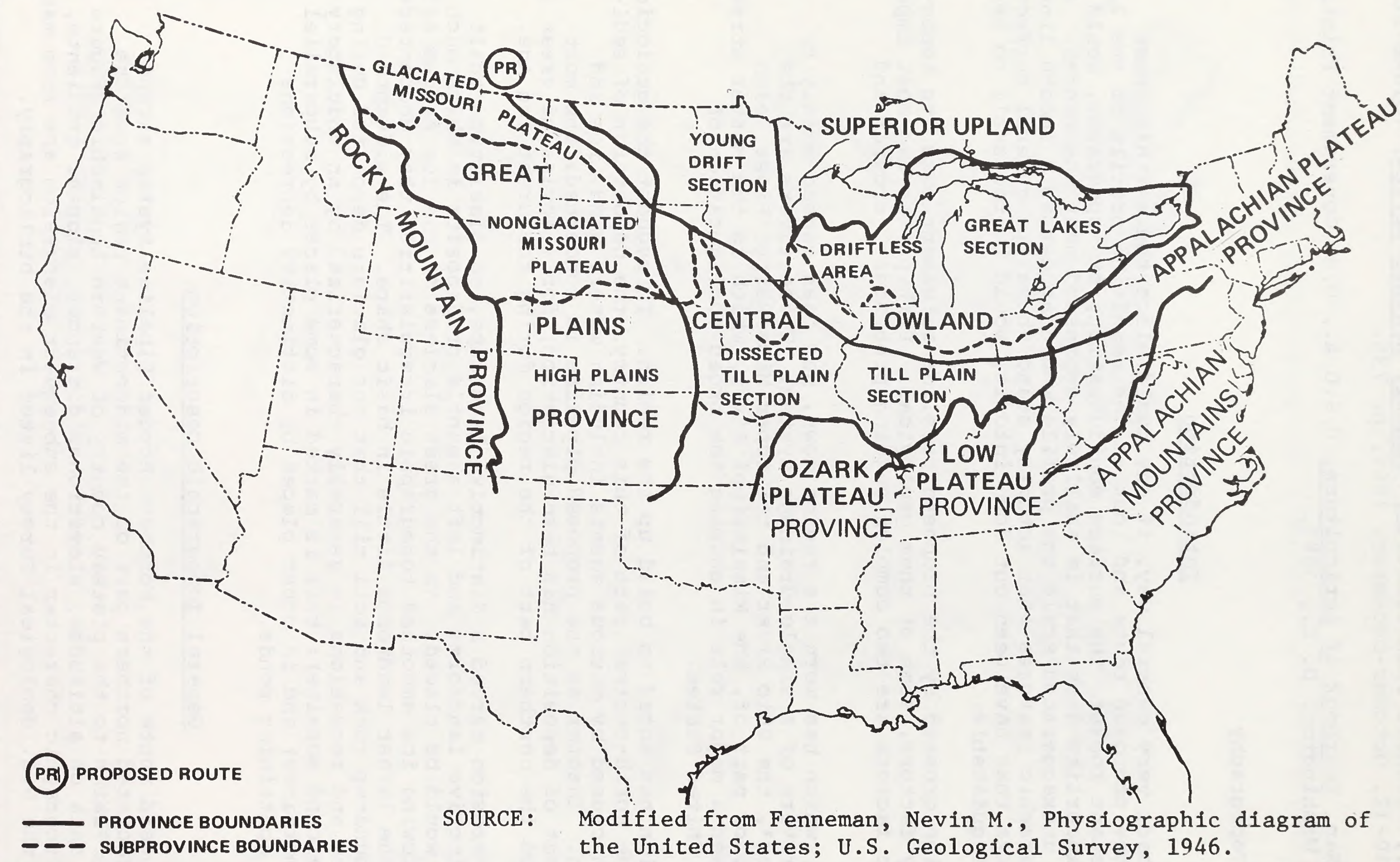
Erosion, which has worn the region down, has been caused mainly by three major rivers of a single drainage system. These rivers are the Missouri River[1], the Ohio River and the Upper Mississippi River, each tributary to, or part of, the Mississippi River, which is the master stream. Theirs has been a major role in shaping the broad configuration of midcontinent United States.

Deposition has acted to build up the region. Throughout the geologic history of the north-central part of this country, the deposition of sediment has been caused by various agents including water, wind, ice and, recently, man. Insofar as the proposed pipeline is concerned, the most important agent of deposition has been glaciation, for a series of great ice sheets covered the northern part of the region during the Great Ice Age.

Just as erosion carved a distinctive landscape, so glaciation built equally distinctive landforms and left a mantle of deposits in which much of the pipeline would be placed. As the great glaciers of the Ice Age spread south, the flowing ice smoothed topographic irregularities they encountered, but changed the larger landforms little in basic shape. The widespread mantle of ground-up rock and soil till that the glaciers deposited during their advances and recessions is generally characterized by an undulatory topography (ground moraine): this is marked in some places by subparallel ridges (end moraines) and in other places by distinctive depressions ("potholes") containing ponds.

General Topographic Description

The proposed route of the Northern Border Pipeline System extends across the glaciated northern part of the midcontinent region from the western Great Plains to the plateau country of western Appalachia (Figure 2.1.3.2-1). Data on altitudes, elevations, distances, slopes, gradients, relief and topographic character in the subsequent discussion are from maps published by the U.S. Geological Survey listed in the bibliography.



SOURCE: Modified from Fenneman, Nevin M., Physiographic diagram of the United States; U.S. Geological Survey, 1946.

Figure 2.1.3.2-1 Physiographic boundaries of north-central United States

The entire alignment will lie at altitudes that range from a minimum of about 460 feet at the crossing of the Illinois River in north-central Illinois to about 3,050 feet at Wendell Ranch Post Office, Montana, some 400 feet higher and about 40 miles east of the point at which the route enters the United States. Eastward from the Illinois River, the route rises to an elevation of about 1,400 feet within 2 miles of the eastern terminus, which is at an elevation of some 1,340 feet.

Locally, relief along the pipeline route ranges from a maximum of about 600 feet in a lateral distance of about 5 miles as at the proposed crossings of both the Missouri River and the Little Missouri River in North Dakota, to a minimum of less than 5 feet per mile as near the crossing of the Rock River in eastern Illinois. Along much of the route, differences in altitude probably average from 25 to 75 feet per mile. Over greater distances, perhaps 25 to 50 miles, the difference ranges from a minimum of roughly 1 foot per mile in Indiana and Ohio to nearly 5 feet per mile on the Flaxville Plain in northeastern Montana.

The most prominent topographic features crossed by the proposed route are the valleys of the three major rivers; these valleys range in depth from about 100 to 300 feet below the adjacent upland surface, and are as much as 4 miles wide. Other steep-walled valleys including those of Frenchman's Creek, and the Little Missouri, Illinois, Monongahela and Youghiogheny Rivers are similar but somewhat narrower. All are cut sharply into the general level of the upland and commonly are not readily apparent to a traveler until he is practically at the valley margin.

Of all the valleys, perhaps the most unusual are those of rivers in northeastern Montana and western North Dakota. With the exception of the valley of the Big Muddy River, each is bordered by intricately dissected, or badland, terrain which is cut into horizontal layers of pale gray to pastel colored siltstone, claystone and sandstone. Locally, layers of sandstone serve as capstones of pillars and buttes; other layers of differing hardness yield erosional goblins of myriad form.

Three other features that are crossed rise strikingly above the general level of the upland traversed. These are the Killdeer Mountains of west-central North Dakota and the prominent escarpments that mark the margins of the Coteau du Missouri and the more distinctive Coteau des Prairies in east-central South Dakota. The Killdeer Mountains are visible for many miles across the upland surface of the Great Plains. These mountains are two prominent tree-covered hills located 10 miles southeast of the crossing of the Little Missouri River. The two crests rise to about 3,300 and 3,100 feet altitude and are separated by a saddle at some 2,750 feet altitude. The proposed route crosses the flood plain of the Little Missouri River at an altitude of about 1,900 feet, passes through the saddle, and descends to roughly 2,300 feet, the altitude of the general upland surface some 5 miles farther southeast.

The first prominent escarpment encountered is the east-facing Coteau du Missouri. It lies about 90 miles southeast from the Missouri River Valley across nearly level, undulatory terrain, and trends north. The second escarpment is essentially parallel to the first, and some 55 miles southeast. It marks the west facing escarpment of the Coteau des Prairies, which is also characterized by an undulatory surface. Both escarpments are readily visible for many miles as they rise 350 and 400 feet respectively above the adjacent country in horizontal distances of 14 and 4 miles.

In terms of pipeline construction, however, perhaps the most significant characteristic of the topography is the least impressive. This characteristic is the surprisingly level nature of the upland from the Canadian border to the western boundary of the Appalachian Plateau, a quality indicated by the preceding description of the relief. The level character is largely attributable to the fact that the region was glaciated.

Geographic Names and Average Elevations

The entire alignment will lie at altitudes that range from a minimum of about 460 feet to a maximum of about 3,050 feet. Approximately 80 percent of the route is at altitudes of from 500 to 2,000 feet and roughly 45 percent is at altitudes ranging from 1,000 to 1,500 feet.

The proposed route enters the United States on an upland surface at an average altitude of about 2,650 feet. In the next 40 miles, the surface gradually increases in altitude, reaching a maximum for the route of about 3,000 feet at Wendell Ranch Post Office. From that locality, the route descends very gradually for a distance of about 60 miles, then drops more rapidly for the next 90 miles to the valley floor of the Missouri River which is at about 1,900 feet altitude.

After this crossing of the Missouri River, the proposed alignment returns to the upland surface, here at a maximum altitude of some 2,300 feet, and passes among the Tepee Buttes, reaching altitudes of about 2,400 feet. From these buttes it drops gradually to the margin of the Missouri River Valley (or Trench) and makes a second crossing of the river at an altitude of some 1,700 feet. The distance between the two crossings is roughly 185 miles.

From the second crossing of the Missouri River Trench, the alignment climbs rapidly to the rolling Coteau du Missouri surface at an average altitude of about 2,000 feet. About 90 miles from the Missouri River Trench along this surface, the route reaches the crest of an eastward-facing escarpment; it then drops about 350 feet in a lateral distance of roughly 14 miles. In the next 55 miles, approximately, it loses, then regains, about 200 feet of altitude and reaches the base of a west-facing escarpment. Here it climbs about 400 feet in a lateral distance of about 4 miles to a rolling plain, the Coteau des Prairies. The rolling plain, and thus the route, loses altitude gradually until the valley floor of the Mississippi River is reached, some 410 miles farther east at an altitude of a little less than 600 feet.

From the Mississippi River, the route ascends to a maximum altitude of about 750 feet and then descends to the valley floor of the Illinois River, a route distance of about 80 miles. This valley floor, the minimal topographic elevation along the entire route, is at an altitude of about 460 feet. From the Illinois River valley floor, the alignment again ascends to the adjacent regional surface which slopes gradually upward toward the east for roughly 440 miles to an altitude of approximately 1,000 feet. Along the final 120-odd miles of the alignment, the terrain is well dissected, but the crests of the ridges increase gradually in altitude to from 1,300 to 1,400 feet.

Steepness of Slopes Traversed

The steepness of slopes traversed by the proposed route ranges from level to vertical. Slopes of upland surfaces are consistently very gentle whereas the slopes of valley walls range from moderate to extremely steep. Steepness is perhaps best expressed quantitatively in terms of the number of feet increase, or decrease, in altitude in the horizontal distance of 1 mile; a change in altitude of about 93 feet in 1 mile distance represents an angle of 1 degree. Average figures given below disregard minor variations within the stated distance.

The upland surface traversed by the proposed pipeline between the Canadian border and Wendell Ranch Post Office increases in altitude 350 feet in 40 miles of distance. This is an average slope of nearly 9 feet per mile, or about 0.1 degree. Probably the upland slope for some 90 percent of the route does not exceed this figure.

The upland slope appears to exceed this figure only in two areas. One is the escarpments of the two coteaus in east-central South Dakota. The east-facing escarpment of the Coteau du Missouri has a slope of less than 25 feet per mile, or less than 0.3 degree. The west-facing escarpment of the Coteau des Prairies has a slope of less than 100 feet per mile, or slightly more than 1 degree. This is the steepest upland slope along the proposed route. Upland slopes of less than 50 feet per mile are present in the easternmost part of the route, but the terrain is so thoroughly dissected that an upland slope figure there is of little value.

The slope of valley walls varies. Those along the western part of the route are in general steeper than those in the eastern part. In the west, slopes of from 45 to 90 degrees along valley walls are not uncommon. One of the few exceptions for a major stream is Big Muddy Creek in eastern Montana with valley slopes of about 1 degree. In the middle part of the proposed route, valley walls with slopes of from 1 to 10 degrees are common. In the easternmost part, valley walls that slope at from 15 to 30 degrees are common and some that are steeper may be encountered. Very locally, where hard bedrock layers control the slope, angles as great as 45 degrees may be found and perhaps some that are even greater.

General Drainage Characteristics

A part of each of three major drainage basins is crossed by the proposed alignment. The basins are those drained by the upper Missouri River, the upper Mississippi River and the Ohio River. The Missouri River is crossed twice, and each of the other valleys once. The valley of the Missouri River is the broadest valley traversed by the route.

The first crossing of the Missouri River Valley is about 17 miles southwest of Williston, North Dakota, very near the head of Lake Sakakawea, a reservoir held by the Garrison Dam which is located in central North Dakota. At the crossing site, the valley is about 4 miles wide and the reservoir is roughly 1,600 feet in width. The altitude of the reservoir surface is mapped as 1,850 feet, and the altitude of the valley floor near the north valley wall is from 1,900 to 2,000 feet. The reservoir impinges against the south valley wall so that no valley floor is present. The valley walls are from 150 to 200 feet high and slope steeply at the crossing. The north wall of the valley is well dissected by gullies; the south wall is less so.

The eight principal tributaries of the Missouri River that are crossed by the proposed route prior to the second crossing of the Missouri River are similar in general character and are considered here as a group. The width of the valley floor generally is from 1/4 to 1/2 mile wide, although three of the valleys have floors of about 1, 2 and 3 miles, respectively. The six valleys in Montana have walls that range in height from 100 to 200 feet, and that are from gentle to steep in slope. Two of the valleys in North Dakota have moderately sloping to steep walls about 300 feet in height, and one has walls about 600 feet in height. All the valleys are alike in that each stream meanders about its valley floor, and both walls are well to thoroughly dissected for a distance of a few to several miles back from the stream.

Between the second crossing of the Missouri River and the Mississippi River, the Wapsipinicon River is the largest stream crossed by the proposed route. The Wapsipinicon River is crossed twice, the sites nearly 14 miles apart. The second crossing is about 8 miles from the site of the Mississippi River crossing. The two crossings of the Wapsipinicon are alike. The valley is 3 to 3.5 miles wide; the valley walls are less than 150 feet high and slope moderately to gently. The stream meanders moderately on the valley floor, and the valley walls are moderately to well dissected for several miles back from the stream.

Between the Missouri River and the Wapsipinicon, principal streams are few. The four largest are generally similar in character and are considered here as a group. Their valley floors are generally less than 1 mile wide, although one valley is about 3 miles wide because at the crossing site, it joins another, larger valley. Valley walls are from 50 to 100 feet high and are gently to moderately sloping. Each stream meanders moderately to strongly on the valley floor, and dissection of valley walls is moderate.

The Mississippi River is crossed about 14 miles east of the second crossing of the Wapsipinicon River. The Mississippi crossing lacks a typical valley profile; instead the pipeline route approaches the crossing along the valley floor of the Wapsipinicon River, a tributary of the Mississippi. The route thus reaches the Mississippi essentially at river level, crosses, and continues eastward along the floor of a now dry valley that was formerly occupied by an extension of the Wapsipinicon River. The crossing is made just upstream of an island, where the river's width is about 1/2 mile. The west side of the crossing area is somewhat marshy.

Fifteen miles east of the Mississippi River, the Rock River is crossed in a similar topographic manner. The Rock River is only a few hundred feet wide, but its valley floor is about 3 miles wide with gently sloping, indefinite valley walls less than 50 feet high. The river meanders strongly at the crossing site.

The prominent valley of the Illinois River is crossed about 75 miles east of the Mississippi River. The valley floor is about 2 miles wide although the river is only a few hundred feet wide. The valley walls are less than 150 feet high, steeply sloping, and only slightly dissected at the crossing site. This river does not meander.

About 163 miles east of the Illinois River, the Eel River and the Wabash River are crossed about 15 miles apart. The two are similar. The valley floors are 1.5 to 2 miles wide, and the river widths are only a few hundred feet. Valley walls are only steeply sloping and slightly dissected. Neither river is a meandering stream.

The last four major valley crossings are located in eastern Ohio and western Pennsylvania. The first of these is the valley of the Muskingum River. The valley is about a mile wide, with a river width of several hundred feet. The valley walls are less than 250 feet high, moderately to steeply sloping and thoroughly dissected. The river meanders moderately on the valley floor.

The valleys of the Ohio, Monongahela and Youghiogheny Rivers are similar to each other and are considered as a group. The valley floors are from 1/4 to 1/2 mile wide, and in each case the floor is nearly filled by the width of the river. Valley walls are approximately 300 feet high, moderately sloping and thoroughly dissected. The rivers do not meander within their respective valleys, but the valleys themselves meander strongly and are deeply incised into the upland surface.

2.1.3.3 Geology

The general geologic aspects of the proposed pipeline route are described below. The regional character of the physiography, bedrock formations and surficial deposits are treated, together with the significant geologic history of the area. Following the description of the geologic environment, attention is given to mineral resources and geologic hazards present along the corridor. Water resources are described in Section 2.1.3.5.

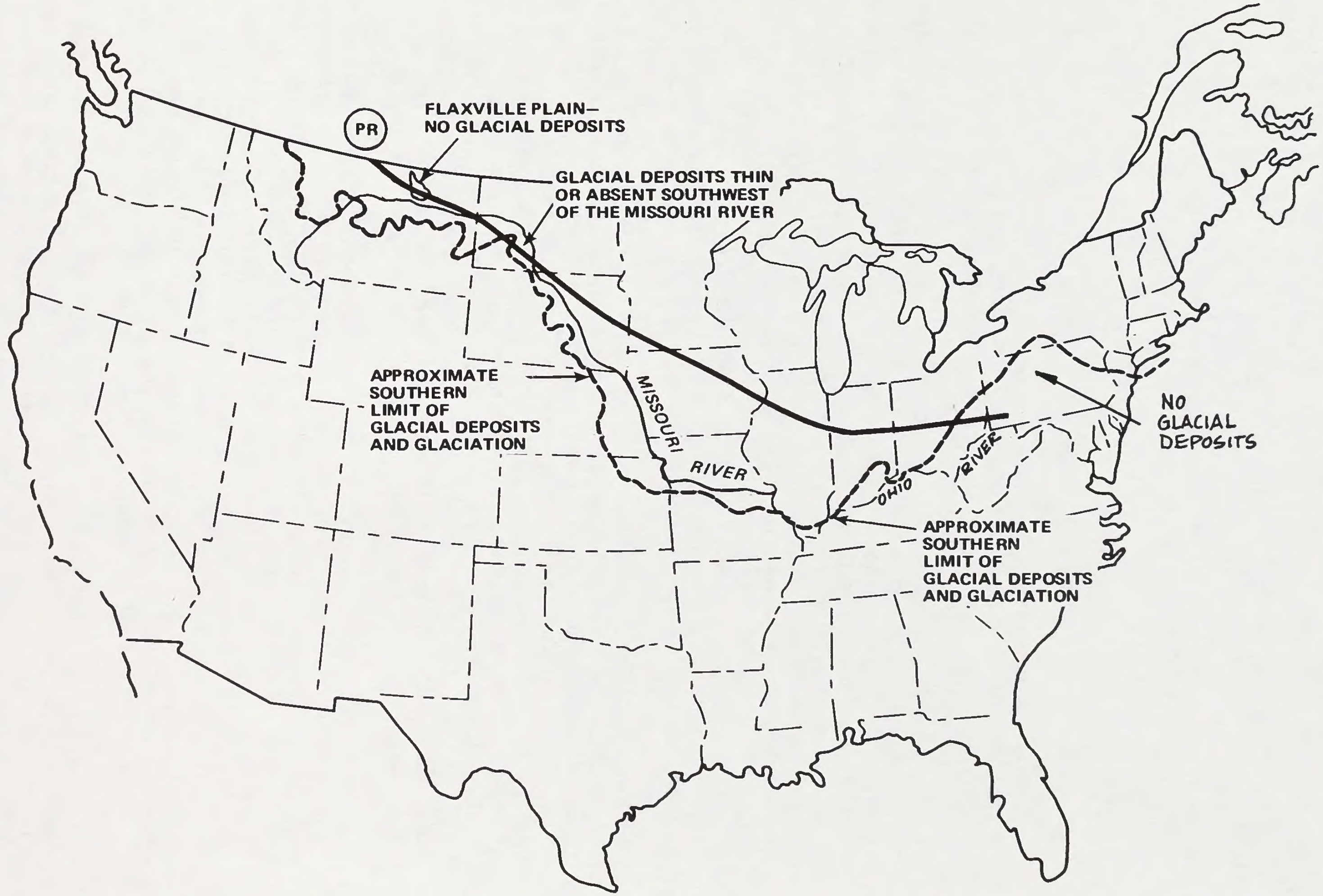
Physiography

Nearly the entire area traversed by the proposed route was covered by one or more continental glaciers (Figure 2.1.3.3-1) during the Great Ice Age, and surficial deposits left by the ice sheets generally form a thick cover over the underlying bedrock. In four areas deposits are thin or lacking. One of the areas is the Flaxville Plain in Montana; it was never covered by a glacier and so lacks glacial deposits. A second area never covered by a continental glacier, and of much larger extent than the first, is located west of the Missouri River in southwestern North Dakota. The third area was covered by ice, but in places deposits never were laid down, and in other places deposits were thin and have since been removed by erosion. This area constitutes a narrow belt of terrain between the Missouri River Trench and the nonglaciated region of southwestern North Dakota. The fourth area without glacial deposits is a nonglaciated region in eastern Ohio and southwestern Pennsylvania. Wherever glacial deposits are absent, the ground surface is underlain by bedrock typical of the area.

The broad physiographic framework of what is now the North American continent was established long before glaciers spread southward across the north-central part of the United States. All the major features of the land surface existed--the Rocky Mountains on the west and the Appalachian Mountains on the east, with a broad lowland between. The lowland was drained by two networks of rivers, one flowing south, the other north. North of the lowland lay a tremendously broad, slightly higher area of little relief--the Canadian Shield. Farther east between the lowland and the Appalachian Mountains lay an area that was neither lowland nor mountainous--the Appalachian Plateaus Province.

As each of a succession of continental glaciers advanced slowly southward across the land its general course was influenced strongly by the topography of the terrain. Here and there the glaciers followed existing river valleys, damming the streams and forming extensive glacial lakes. Fine-grained sediments deposited in those lakes now underlie the ground surface in large areas. Drainage, diverted by the ice from its customary course, overflowed interstream divides and cut spillways; moreover, meltwater from the ice cut additional channels across the upland. Many of these new drainage routes as well as older, now-modified valleys, are occupied today by rivers, creeks or intermittent streams.

Generally the ice scoured the land surface, smoothing irregularities and deepening low areas and deposited a mantle of glacial debris. In some places the ice, not thick enough to cross the highest parts of the terrain, was forced to flow around them leaving such places free of glacial deposits (drift). The terrain beyond the outermost extent of the glaciers is similarly free of drift except for some meltwater channels and river valleys



(PR) PROPOSED ROUTE

SOURCE: Modified from Division of Geography, N. R. C., Glacial Map of the United States east of the Rocky Mountains, 1959.

Figure 2.1.3.3-1 Approximate southern limit of continuous glaciation in the United States which contain debris washed beyond the glacial margin. Stream erosion and weathering of the unglaciated terrain at the eastern part of the proposed route has not been interrupted, and its physiographic maturity stands in sharp contrast with the relatively smooth, young glaciated land surface to the west.

The widespread veneer of glacial debris, which is distinguished by its highly irregular thickness and its seemingly homogeneous composition, is of critical importance to construction of the pipeline. At least 80 percent of the estimated 1,619 miles of pipe required for the proposed route would be placed in trenches excavated into the glacial deposits, which are, in a general sense, weak and somewhat heterogeneous. The remaining 20 percent of the pipeline would be placed in trenches excavated into layered rock and earth materials that are called bedrock by geologists, but which a construction engineer would describe as ranging from very hard rock to relatively weak earth material termed "soil". This engineering use of the term soil must not be confused with the agricultural use of the term.

Much of the description of the existing geologic environment along the proposed route thus concerns the deposits of the continental glaciers. Some basic knowledge of glaciers and the nature of their deposits is necessary if the reader is to understand the impacts of the proposed pipeline construction on those deposits, the impacts of the deposits on the pipeline, and indirectly, on the vegetation and wildlife that grows upon the deposits. In a general way the advance of the first great continental glacier across the region marked a turning point in time that determined a major change in geologic conditions. These conditions constitute a major influence on the planning, design and construction of the proposed pipeline.

The rock and earth materials that were scoured from the landsurface by the over-riding ice commonly were transported by the ice for distances ranging from perhaps a fraction of a mile to many miles. Eventually this material was deposited by a variety of processes, and a variety of deposits resulted. Together all these kinds of glacial deposits are indiscriminately grouped under the general term "drift". In some places the material was plastered smoothly by the advancing ice onto surface irregularities beneath; in other places it was let down upon the underlying surface as the ice stood motionless and melting. These materials are a nearly chaotic mixture of all the kinds of materials transported by the ice, and heterogeneous in geologic composition and in particle sizes and shapes. Commonly it consists of a clay- or silt-rich matrix that encloses coarse material ranging from sand-size material to large boulders. This is the material called "till" by geologists, but which farmers and ranchers, impressed by its stickiness when wet, commonly call "gumbo."

The glaciers deposited most of the till as a mantle with low relief and varying thickness that covers thousands of square miles; such a deposit is called "ground moraine" and the surface is sometimes called a "till plain". Elsewhere some till was deposited at or near the ice margin to form low, separate sub-parallel ridges, these commonly reflect changing positions of the margin with time. Such landforms are known as "end-" or "terminal moraines". In some places an ice sheet that was melting back (receding) became rejuvenated and so readvanced, over-riding and burying earlier glacial deposits. Because the character of the debris transported tended to differ with each of the successive ice sheets, the character of the till deposited commonly differs. The till deposits of the older glaciers are generally firmer and marked by a finer-grained, locally darker matrix, whereas the till deposited generally by the younger glaciers is somewhat less firm, has a somewhat siltier or sandier matrix and is a little lighter in color.

Although the margin of each successive glacier advanced to a maximum and eventually receded, the position of the ice front fluctuated considerably with time, and advanced or withdrew as its regimen altered. When the climate moderated the ice margin would recede, or perhaps simply waste away, slowly and stagnantly. Meltwater carried debris from the ice out onto the ground along the ice margin building wide plains and scouring broad channels extending in places many miles beyond the ice front, or following existing valleys. As the velocity of the meltwater diminished, its load of coarser glacial debris was deposited in these plains, channels and valleys; the debris is now seen as glacial deposits of sand and gravel and are known as outwash. In places these fill broad, sinuous channels of glacial age and elsewhere partly fill preglacial valleys. It is important to realize that the sand and gravel of glacial origin constitutes in many parts of the glaciated area the major, if not the only, source of good quality fill and aggregate. The quantities of these materials are exceeded greatly by the quantities of till available.

As the ice margin receded, meltwater was trapped in places between the ice front and outlying bedrock ridges or morainal deposits. Glacial sediments accumulated in these lakes, some of which were a few hundreds of miles long. The sediments of the larger lakes consist mainly of clay with some silt, and locally a little sand. In places ridges of beach sand with some gravel are prominent, and broad, thick delta-like deposits of sand and silt mark the mouths of entering streams.

Following the melting of each glacier the deposits left by the ice were attacked by the elements, and in time their surfaces were more or less modified. In several areas the wind picked up great quantities of clay, silt and sand from the flood plains of streams. This wind-blown material was deposited as dunes on river terraces and as a blanket on the upland terrain down-wind of the source area, forming a deposit geologists call "loess". Time has been sufficient in the case of till deposits left by the older glaciers for surface drainage to develop a fine network of watercourses on the uneven surface. These have eventually integrated the drainage leaving few or no undrained depressions. In the case of till deposits left by the last glaciation, time has not been sufficient to permit integration of drainage and undrained depressions by the thousands remain, some dotting the landscape with sloughs and small ponds.

The undrained depressions characteristic of unmodified ground moraine are present in great numbers, particularly throughout the glaciated parts of North and South Dakota. In this region the rolling, irregular topography typical of the till plain is marked by few integrated drainageways other than meltwater channels. The depressions, commonly called "potholes," vary in size from a few hundred feet to a few hundred yards across. The depth of these depressions below the lowest part of the surrounding uneven rim may be from perhaps 2 feet to as much as 25 feet. The highest point may be as much as 25 feet greater. The depressions drain to the center, and so are commonly flooded by runoff during the spring and summer. Water depth ranges from a few inches to a few feet. Many of the depressions are dry during the fall and winter, but some contain water all year. The floor of the depression is commonly blanketed by clay as much as 36 inches deep that has been washed from the surrounding slopes. It is hard and tough when dry, but extremely sticky and plastic when wet. In a few cases a depression may contain a sulfate salt, and when dry displays the white powdery coating of that material.

There is a record in the rocks, however, that portrays another, older, sequence in the course of geologic events. This sequence caused the differences in the character of the bedrock (Figure 2.1.3.3-2) as one progresses from the region west of the Missouri River, to the area between

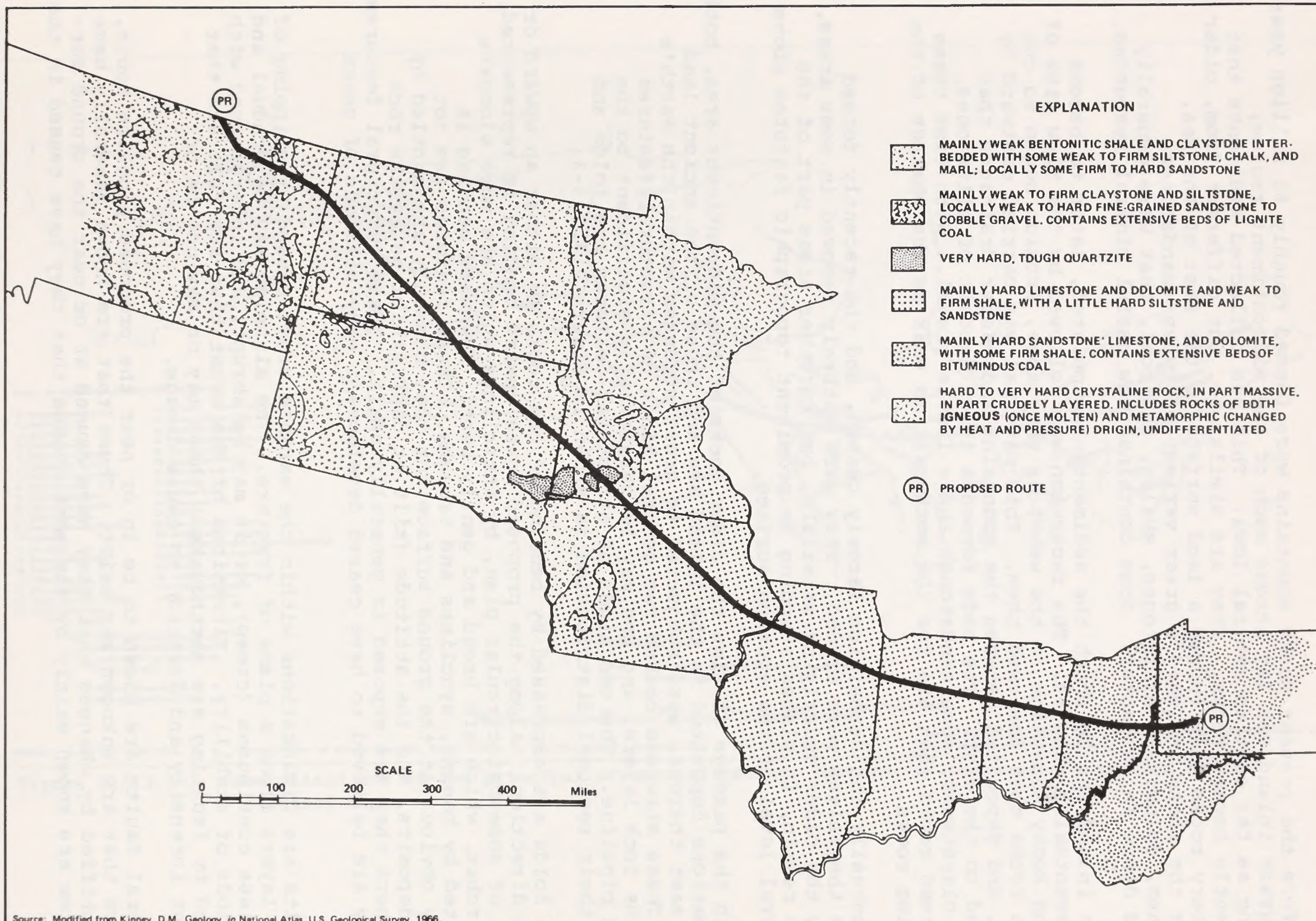


Figure 2.1.3.3-2 Generalized map showing the areal distribution of the broad categories of bedrock lithology in the 10-State Region

the Missouri and Mississippi Rivers, and to the area east of the Mississippi River.

Before the present Rocky Mountains were formed roughly 65 million years ago, a great inland sea lay across much of the midcontinent region, extending as far east as central Iowa. This sea collected sediments that subsequently became rocks. They are similar to, but different from, older sedimentary rocks that formed a land surface to the east of the sea. Together the rocks included a great variety of types--sandstones, limestones, dolomites, siltstones, shales, and coal, that were generally firm and dense in character. Some contained now useful mineral resources.

The inland sea in which the sediments accumulated, later to become rocks, eventually receded. The recession was followed by the slow rise of the young Rocky Mountains to the west; as they rose, erosion began to cut away the rocks that composed them. This material was carried eastward by streams, and deposited between the mountains and master drainages that developed to the east. The beds formed a thick deposit of siltstones, shales, claystones, some sandstones and a little gravel. With time these beds formed rocks that are for the most part as weak as the weakest of the underlying rocks.

Eventually the deposition largely ceased, and the recently formed deposits themselves were eroded. They were entirely removed in some areas, exposing the older underlying materials, but in other areas part of the deposits remain, in places standing as prominent topographic features above the general level of the erosion surface.

With the passage of time the older rocks of the midcontinent area, both the formations deposited in the inland sea and those of the ancient land surface east thereof, were subjected to great stresses within the earth's crust. These stresses caused two general kinds of structural features within the rock layers, and one may be particularly significant to the proposed pipeline. The two kinds of structural features are folds and faults; their regional distribution is shown in Figure 2.1.3.3-3.

The folds are expressed by bending of the rocks in either an upward or downward direction. Along the proposed route upward bending is represented by domes of somewhat circular plan, by anticlines which are more elongate and by arches, which are broad and gently bent. Downward bending is represented by basins, synclines and troughs. These features are not generally obvious at the ground surface for they commonly are mantled by younger deposits, and the attitude (tilt or dip) exhibited by the rock layers where they are exposed is generally small. These structural features generally are believed to have ceased development many millions of years ago.

Faults are dislocations within the earth's crust caused by slipping of the rock layers along a plane of fracture. The slipping may be gradual and more or less continuous (creep), or it may be abrupt, and interspersed with long periods of stability. Vibrations of the crust that are felt and that are caused by faulting are earthquakes; these may or may not be of sufficient intensity and duration to cause damage.

Several faults are known to be in or near the proposed pipeline route, and others that are unknown may exist. Those that are known generally have been identified by changes that they have caused at or near the ground surface; a few are known mainly by the earthquakes that they have caused in the past.

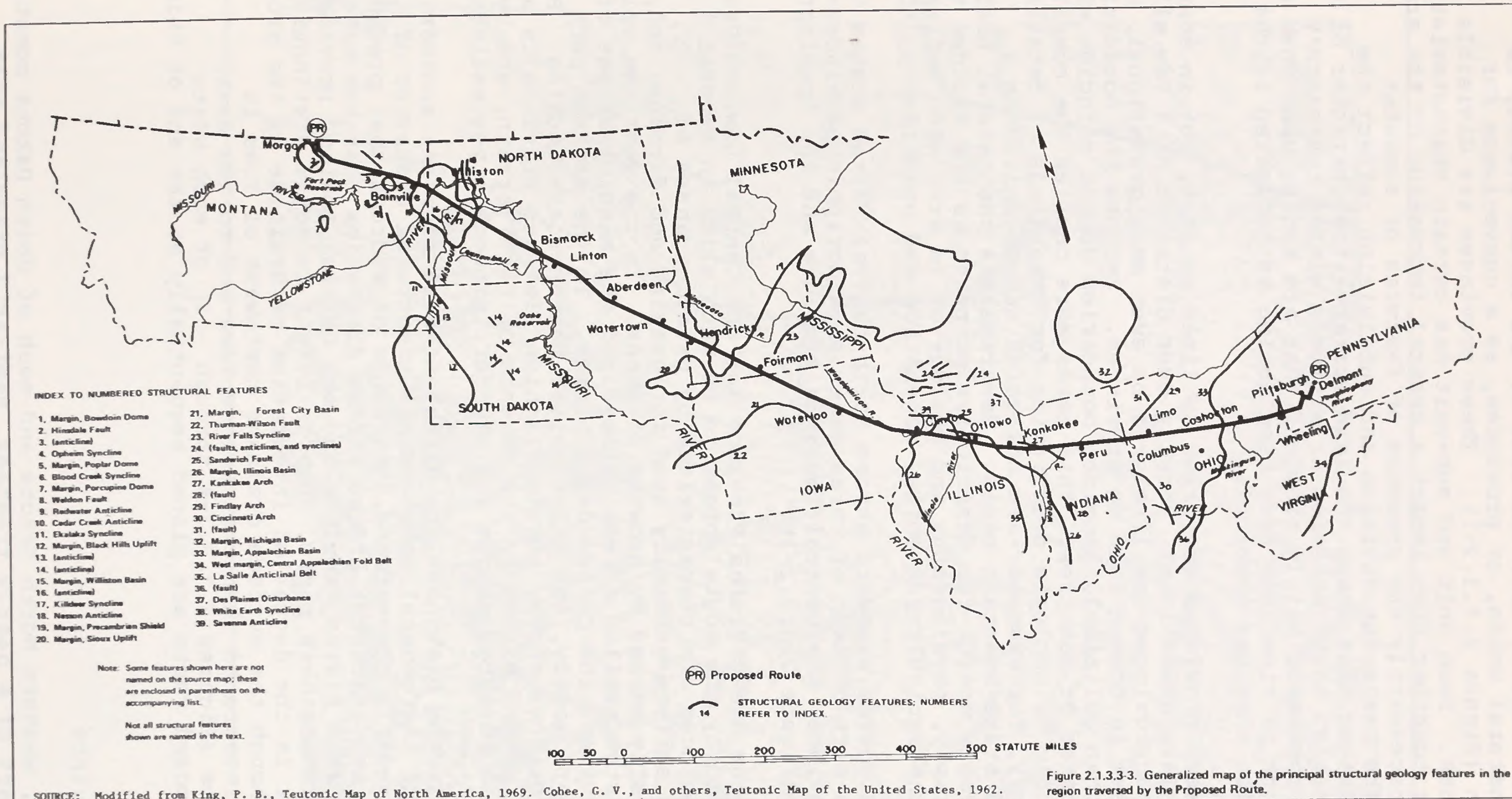


Figure 2.1.3.3-3. Generalized map of the principal structural geology features in the region traversed by the Proposed Route.

Figure 2.1.3.3-3 Generalized map of the principal structural geology features in the region traversed by the proposed route

The mid-continent region, like the rest of the United States, is divided into large natural units, or provinces, as a convenience for physical description (Figure 2.1.3.2-1). These provinces are divisible in turn into subprovinces. Each unit and sub-unit has certain characteristics common to the whole; together they impart a general impression of the area, but do not exclude necessarily the presence of features of somewhat different nature. The basis for division and subdivision reflect the complexity of the factors that shape the land surface--the character of the rock and earth materials, their position or attitude within the earth's crust, the natural processes, mainly erosion, that are acting upon them and in a sense, the length of time they have been acting as reflected in the degree of modification that has occurred.

Boundaries between provinces are drawn as lines on maps, but in some cases the boundaries are gradational, locally over distances of a few miles. Boundaries between subprovinces are likely to be even more gradational, as subprovinces have less in common than do provinces. Because the boundaries are natural rather than political, province boundaries do not coincide with the boundaries of states or counties. This makes more complex the compilation of a physiographic or geologic description for some kinds of detailed information--hydrology, for example--are collected and organized on a county-by-county and state-by-state basis. Nevertheless the natural basis of division is extremely useful for descriptive purposes as the factors that influence the topography, physiography and geology of an area also influence the development of the agricultural soils, vegetation and wildlife.

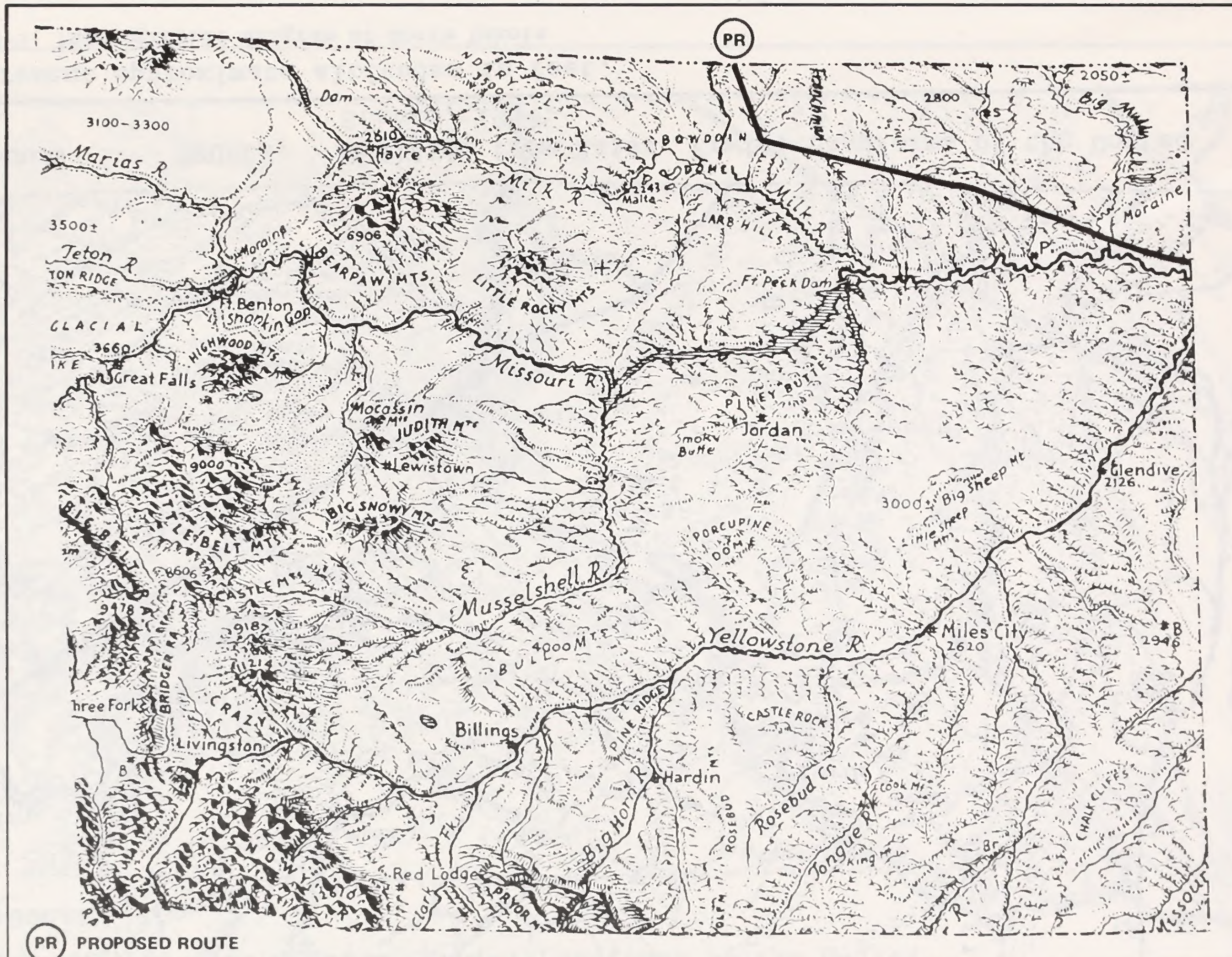
In its proposed course eastward across north-central United States the pipeline would cross part of each of three great physiographic provinces--the Great Plains Province, the Central Lowlands Province and the Appalachian Plateaus Province. (Figure 2.1.3.2-1).

Those parts of the Great Plains Province and the Central Lowland Province that are crossed by the route appear to be much alike in general character. Both provinces are characterized by great expanses of monotonously rolling surface generally used for grazing and farming, and, in the eastern part locally marked by growths of trees. In the west the upland is broken mainly by steep-walled stream valleys and the massive slopes of the Coteau du Missouri and the Coteau des Prairies. In the eastern part valley walls slope more gently, and major relief features are lacking. By contrast with the provinces above, the Appalachian Plateaus Province is a thoroughly dissected upland marked by the absence of flat terrain, and by the presence of narrow forested ridges and slender, sinuous river valleys.

Physiographically the provinces are differentiated from one another mainly on the basis of the general attitude and structural character of the bedrock layers that underly the surface, the kinds of bedrock that predominate, and the extent and character of the stream dissection that has taken place. As both the Great Plains Province and the Central Lowland Province are glaciated in their northern parts, this in itself is not a distinguishing feature. Neither is the degree of integration of drainage on the ground moraine surface, although the surface drainage northwest of Iowa is generally less well integrated than that across Iowa and to the east. Physiographic diagrams (Figures 2.1.3.3-4 through -12) of each state traversed by the proposed route are placed sequentially at the end of this section (2.1.3.3).

The Great Plains Province

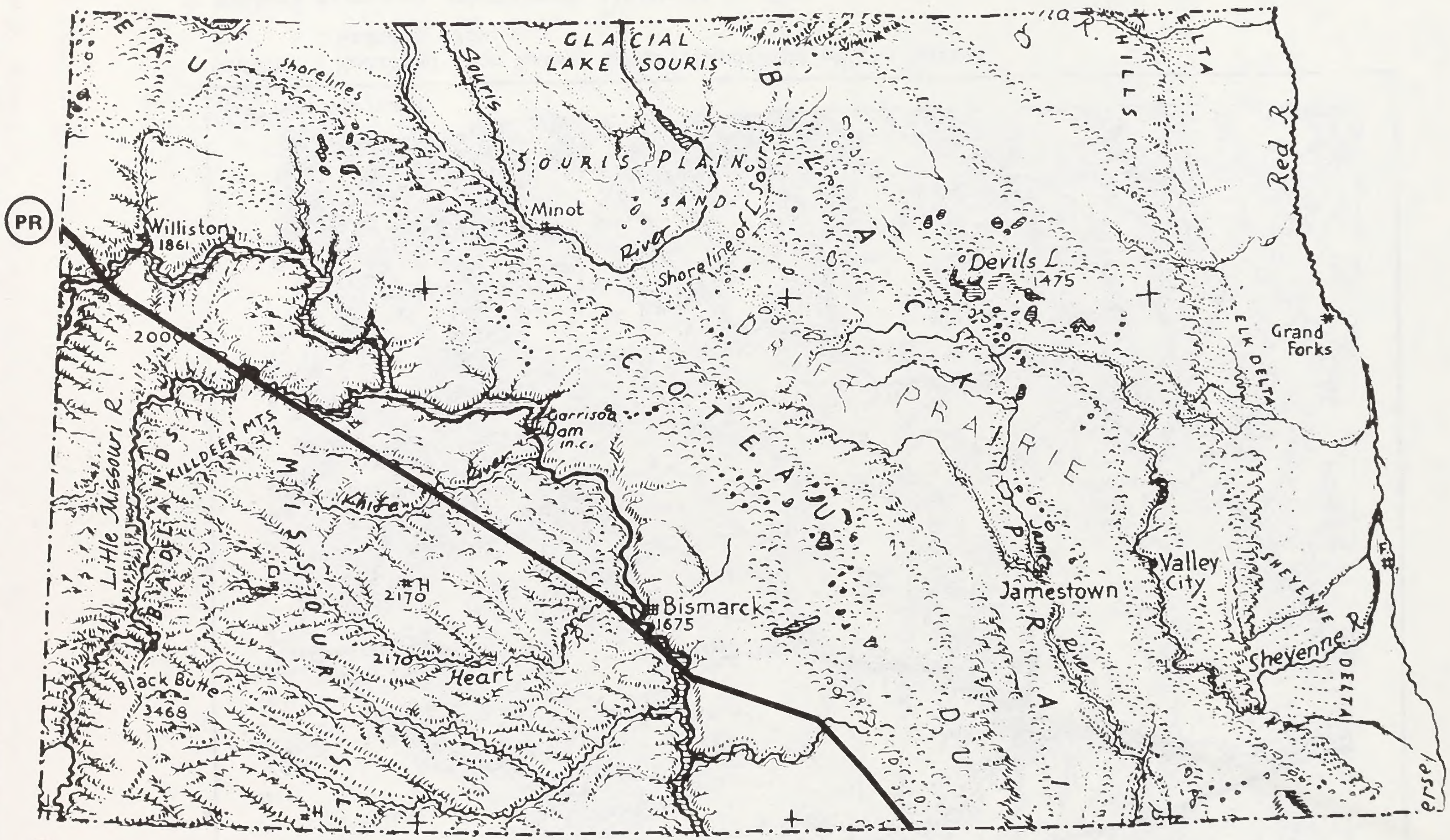
Eastern Montana, western North Dakota and much of South Dakota constitutes the northern part of a nearly treeless, semi-arid grassland that



SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

Numbers represent approximate altitudes in feet.

Figure 2.1.3.3-4 Physiographic diagram of eastern Montana

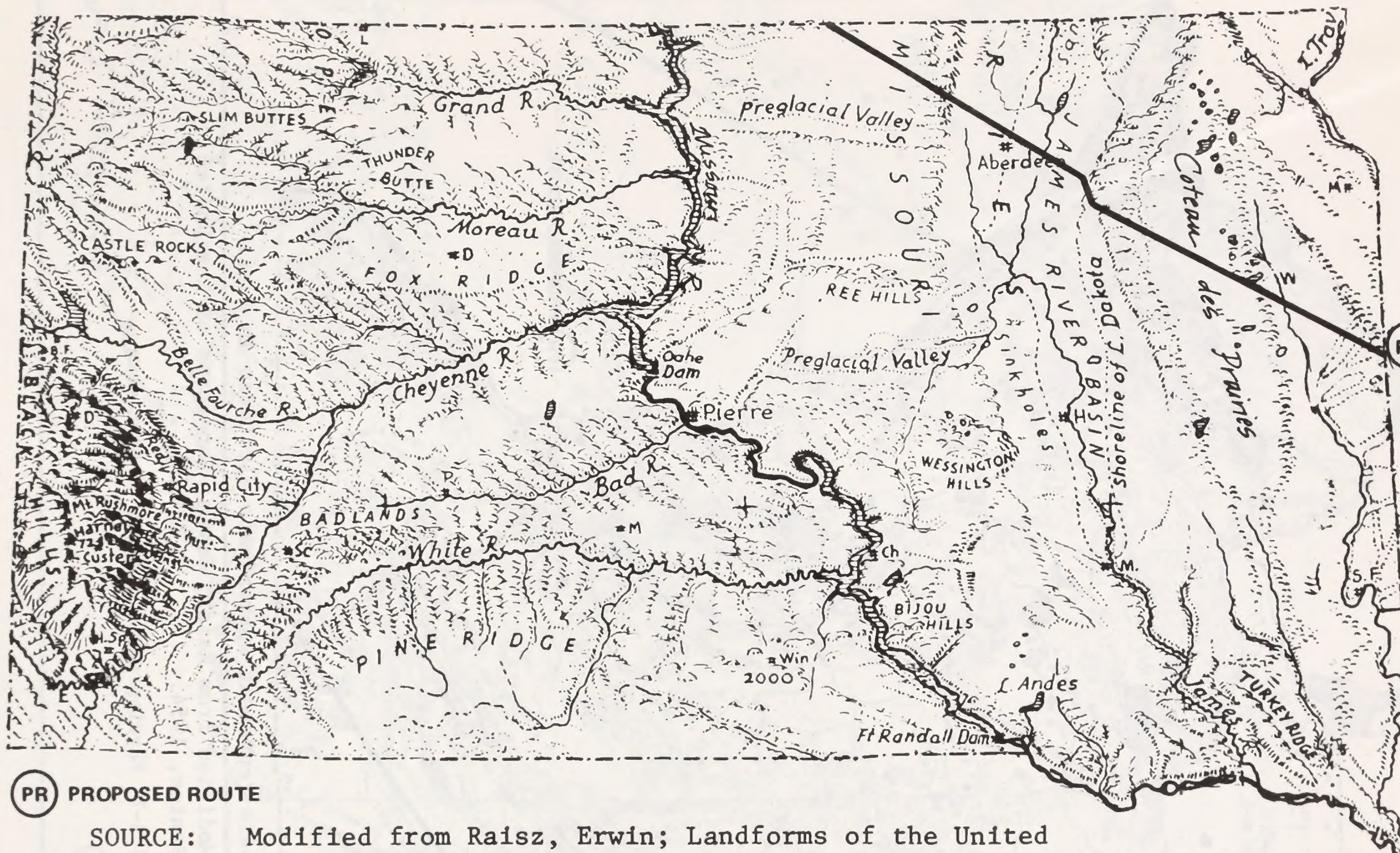


PR PROPOSED ROUTE

SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

Numbers represent approximate altitudes in feet.

Figure 2.1.3.3-5 Physiographic diagram of North Dakota



PR PROPOSED ROUTE

SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

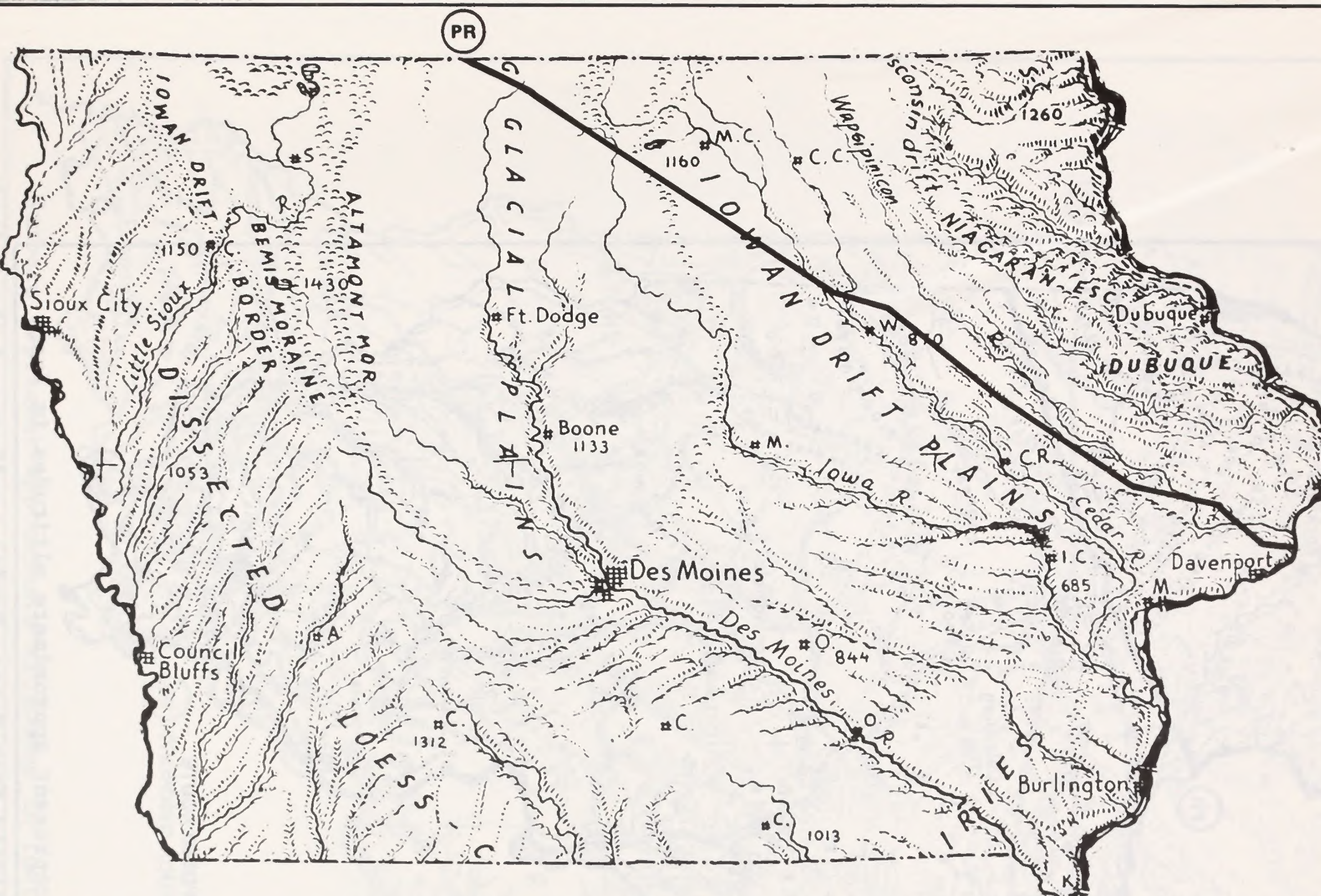
Numbers represent approximate altitudes in feet.

Figure 2.1.3.3-6 Physiographic diagram of South Dakota

Numbers represent approximate altitudes in feet.

SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

Figure 2.1.3.3-7 Physiographic diagram of Minnesota



(PR) PROPOSED ROUTE SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

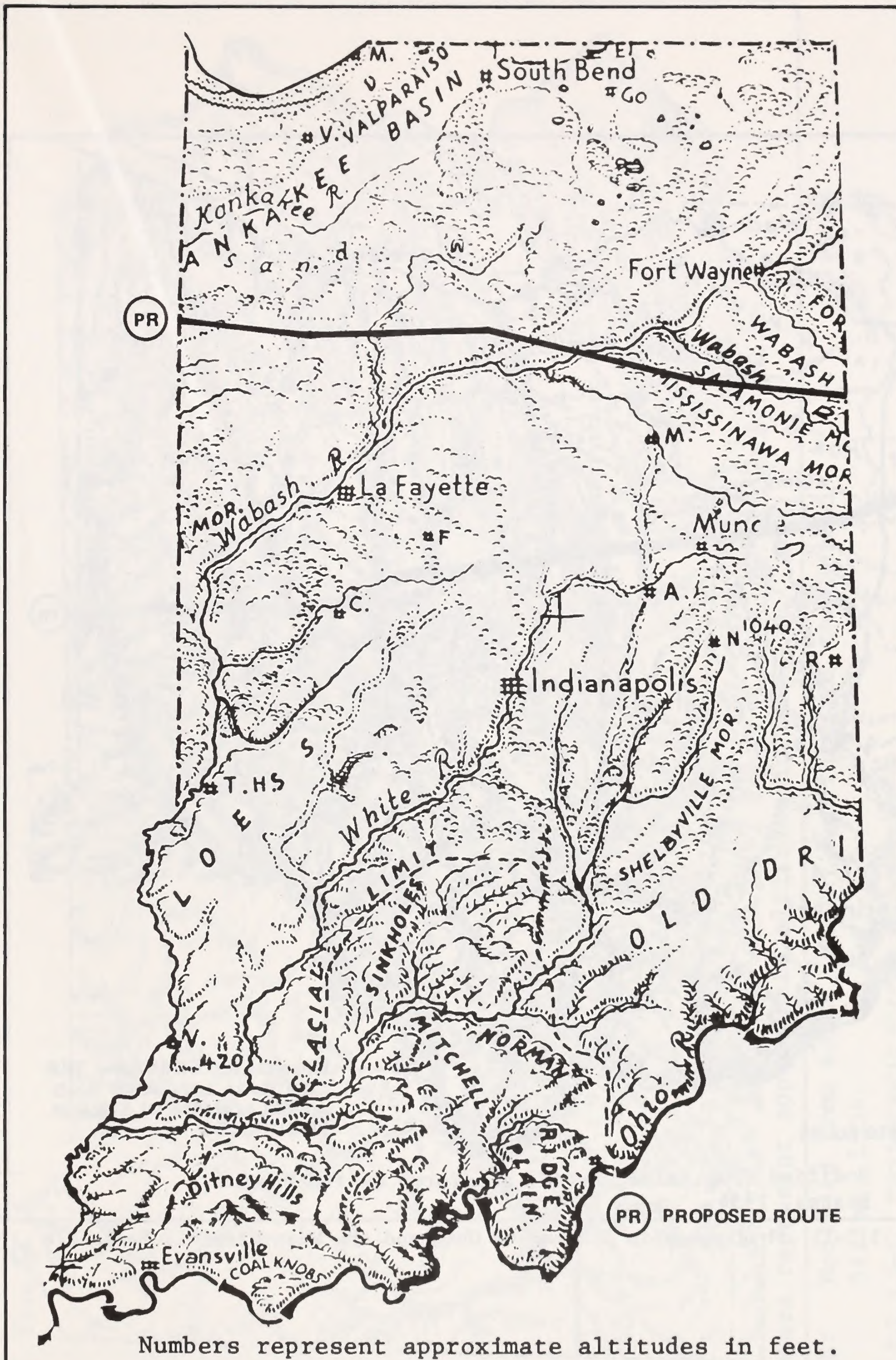
Numbers represent approximate altitudes in feet.

Figure 2.1.3.3-8 Physiographic diagram of Iowa

Numbers represent approximate altitudes in feet.

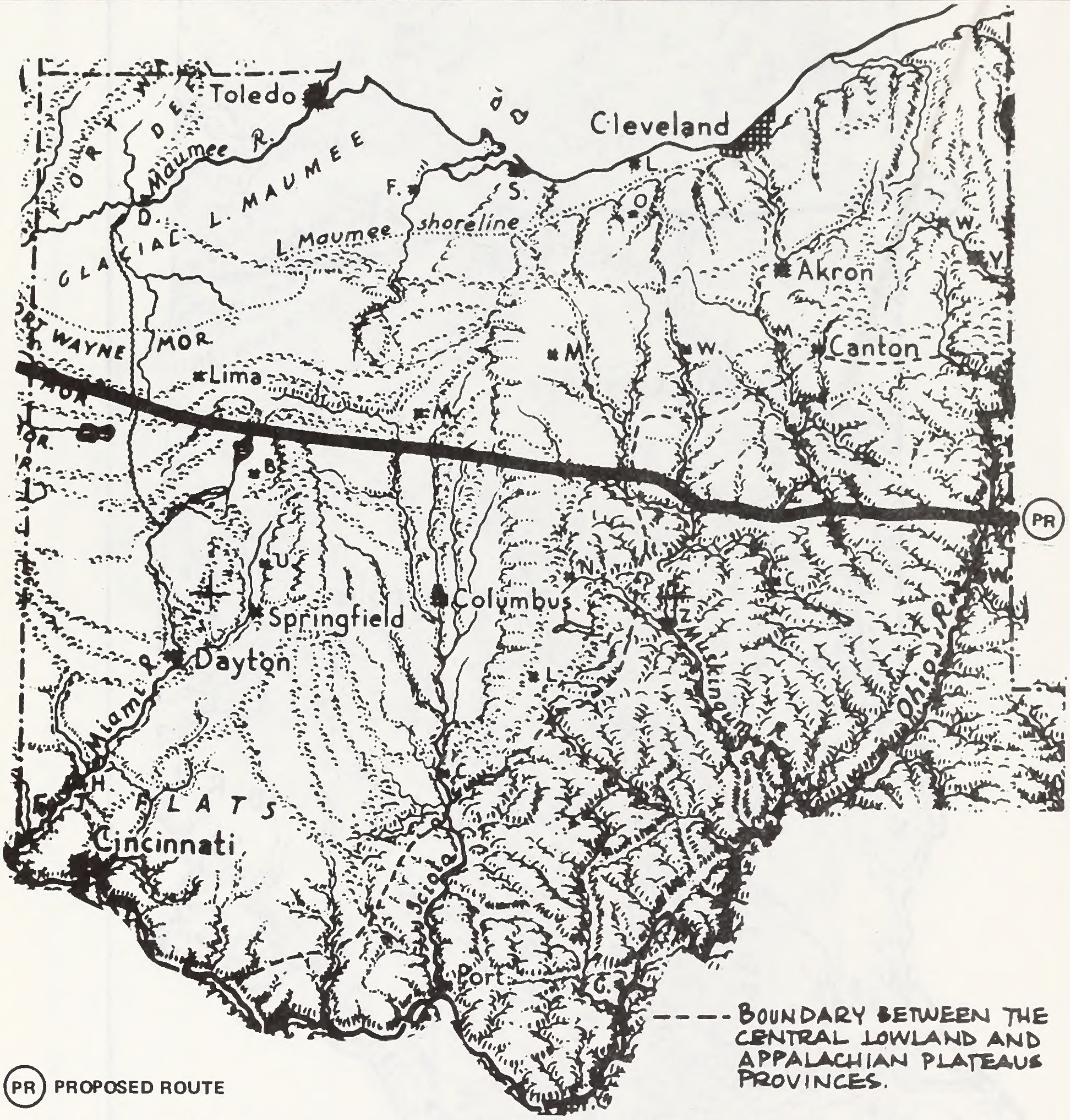
SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

Figure 2.1.3.3-9 Physiographic diagram of Illinois



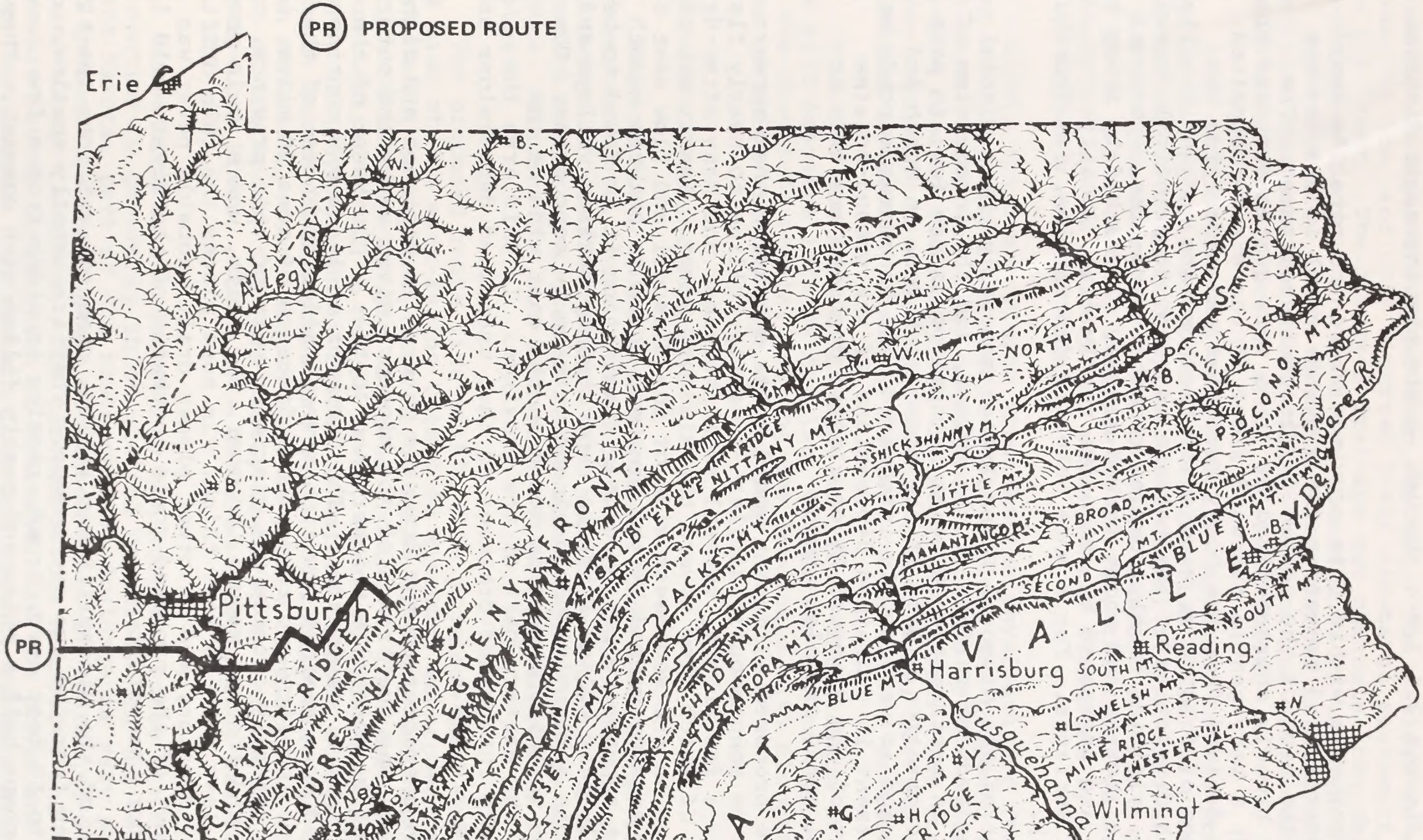
SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

Figure 2.1.3.3-10 Physiographic diagram of Indiana



SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

Figure 2.1.3.3-11 Physiographic diagram of Ohio and the West Virginia Panhandle



Numbers represent approximate altitudes in feet.

SOURCE: Modified from Raisz, Erwin; Landforms of the United States, 1954.

Figure 2.1.3.3-12 Physiographic diagram of Pennsylvania flanks the eastern margin of the Rocky Mountains and is known as the Great Plains Province. Figures 2.1.3.3-4 through -6 are physiographic diagrams of these states.

The proposed route is within this province where the pipeline would enter the United States, and traverses the province until it reaches the eastern margin at the base of the Coteau du Missouri escarpment. The terrain crossed is broadly characterized by (1) a very gentle eastward slope of the surface, (2) a very gentle eastward slope of the stream-deposited sedimentary strata derived from the Rocky Mountains and underlying the surface, (3) absence of folding or warping of these strata and (4) locally extensive, thorough dissection of the terrain adjacent to principal streams by its tributaries, yielding highly complex somewhat maze-like, erosional patterns of gullies, buttes and short forked ridges, all marked by steep to very steep slopes, and separated by extensive nearly flat, locally undissected upland surfaces. For a more detailed description, see Thornbury (1965, pp. 287-296).

North and east of the Missouri River Trench generally thick glacial deposits mantle the bedrock surface of the upland, and the integration of drainage is poor. In northeastern Montana natural ponds are few, in part because of low precipitation. East of the Missouri River, in North and South Dakota, drainage is very poorly integrated, and innumerable ponds and small lakes are present in undrained depressions of the ground-moraine surface. Southwest of the Missouri River glacial deposits are thin or absent, and natural ponds are also absent.

In general the proposed alignment would cross a terrain that appears from a distance to be monotonously similar--a gently rolling to nearly flat upland dissected by a few rivers, several small streams, and many often-dry drainage ways, all of which flow toward the Missouri River. Nearly all of the large rivers are on the southwest side of the Missouri and flow east to it. Certainly the area traversed by the proposed route is not the smooth unbroken surface it appears to be; on closer examination it is found to be a succession of nearly flat upland surfaces separated by shallow valleys and draws that constitute a tightly-knit drainage pattern in some areas. The principal exception to this pattern is found on the east side of the Missouri River, in the eastern part of the province. In this area the rolling surface lacks integrated drainage so that undrained depressions are common, and streams are few.

This change in character of the drainage pattern is distinct and significant. In a general way the trench of the Missouri River marks the outer margin of drift that is generally thicker than 10 feet. Southwest of the river the picture is more complicated. The front of at least one continental glacier advanced to a maximal position several miles southwest of the valley. Only at one locality and there for a distance of some 20 miles, is the proposed route actually outside the glaciated part of this province. Between the valley and the ice margin, however, the drift, where it is present, is generally less than 10 feet thick. In some places the thin drift has been removed by erosion, and in other places drift probably never was deposited. Thus most of the proposed route southwest of the river would lie across bedrock rather than drift.

North and east of the Missouri River Valley, channels cut into the till surface by meltwater from the ice are common. They are usually shallow, generally from 20 to 50 feet deep, broad, ranging in width from a few hundred feet to perhaps half a mile, and partly filled with outwash. They may be from several hundred feet to a few miles in length. A few may reflect deep pre-glacial valleys.

The valleys west of the present Missouri River formerly extended east thereof. No Missouri River then existed. The valleys were dammed by the advancing ice, and this diverted their discharge southward, commonly along the ice front. The diverted drainage cut channels into the underlying weak, fine-grained bedrock and in a few places into or through the thin drift. The present valley of the Missouri River formed in this way. Most of the diversion channels are partly filled by sand and gravel outwash; these deposits are from a few to about 300 feet thick.

Less distinctive but geologically important to the proposed construction is an unglaciated upland, the Flaxville Plain, in northeastern Montana. This upland is underlain by sand and gravel of pre-glacial age, now cemented to a rock-like character. The original deposit covered a much larger area, and as it was eroded to its present extent, the reworked sand and gravel was redeposited on the bedrock and subsequently blanketed by till, beneath which it is commonly exposed today.

Within the Great Plains Province the physiographic feature that rises most abruptly above the eroded surface along the proposed route is the Killdeer Mountains. They constitute a remnant of the sediments deposited by streams flowing eastward from the Rocky Mountains. The greater part of those sediments have now been partly eroded away, leaving scattered erosional landforms, commonly buttes, on the upland surface.

Time has not been sufficient to permit integration of the drainage on the till deposits left by the last glaciation and so undrained depressions by the thousands remain, dotting the landscape with sloughs and small ponds, some of which are dry part of the year.

The Central Lowland Province

Eastern South Dakota, southwestern Minnesota, Iowa, Illinois, Indiana and western Ohio, where crossed by the proposed pipeline route, are part of the Central Lowland Province. The region is a gently to moderately rolling cropland with many groves of trees about farm buildings and along drainage routes. Figures 2.1.3.3-6 through -11 are physiographic diagrams of these states.

The proposed route lies within this province from its western margin at the base of the east-facing Coteau du Missouri escarpment to the base of a west-facing escarpment, some 1,000 miles distant, that marks the eastern margin of the Appalachian Plateaus Province. The terrain crossed is broadly characterized by (1) a nearly level, somewhat dissected upland surface, (2) nearly flat-lying, gently folded or warped bedrock strata, (3) numerous bedrock layers of limestone and (4) a moderately textured drainage pattern with moderately steep slopes that is poorly developed in the western-most part of the route, and more finely textured in the region adjacent to the Mississippi River. For a more detailed description, see Thornbury (1965, pp. 212-249).

The entire area traversed by the proposed route was glaciated and now is mantled by generally thick glacial deposits. In the western-most, or South Dakota, part of the route surface drainage is very poorly integrated, and innumerable small ponds and lakes exist in undrained depressions of the ground-moraine surface. The terrain across Minnesota and Iowa is marked by somewhat better integration of drainage, and the ponds and lakes present are fewer but larger. In eastern Iowa and beyond, surface drainage is well integrated and ponds and lakes are few.

The proposed alignment across the Central Lowland would traverse terrain that is perhaps less diversified than that of either the Great Plains Province or the Appalachian Plateaus Province. Although the terrain of the Central Lowland does not display the monotony characteristic of the Great Plains, the Lowland landscape is similar from west to east. Its variation is mainly in the degree of drainage integration and stream dissection, together with a reduced field of vision caused by increasing numbers of trees as one progresses eastward. Only one feature, the great Coteau des Prairies, some 55 miles southeast along the proposed route from the western margin of the Lowland, rises above the general level of the Lowland surface. Much of the terrain traversed is nearly level, somewhat dissected, and marked mainly by festooned end moraines several miles across and several tens of feet high. These are locally interspersed with broad, gently sloping glacial deposits of sand and gravel outwash.

One reason for the lesser diversification of the terrain along the proposed route in this province is that the alignment follows drainage divides wherever possible. In southwestern Minnesota and across Iowa, these are commonly interstream divides between sub-parallel drainages; across Illinois, Indiana and Ohio the divides are commonly of regional character, separating drainage flowing southward from that flowing northward.

In the western-most part of this province, between the escarpments of the two Coteaux, is a broad, gently rolling till plain. The middle part of this plain was formerly occupied by a glacial lake in which silt and some clay and fine sand were deposited. These poorly drained sediments are as much as 40 feet thick, and underlie the proposed route for some 25 miles southeastward from a point just southward of Aberdeen, South Dakota. Locally the continuity of lake sediments is interrupted by shallow sand or gravelfloored meltwater channels.

The great Coteau des Prairies, traversed by the proposed route southeast of Aberdeen, South Dakota, rises prominently above the general surface of the Central Lowland. The Coteau is flanked by escarpments which are visible for many miles across the Lowland surface, and which decrease in height toward the south. In plan view the Coteau suggests a 60 degree isosceles (two equal sides) triangle pointed north, with the upper surface sloping southward. Because of the slope of the Coteau surface the Coteau no longer stands above the Lowland surface southward from the vicinity of Windom, Minnesota.

Although the northern point of the triangle is some 750 feet above the lowland surface, the western escarpment where it is crossed by the route rises only about 350 feet high, and that in a distance of some 4 miles. Because of the southeastern trend of the route and the triangular form of the feature, the generally higher eastern escarpment is not traversed.

The entire Coteau des Prairies has been glaciated, but the flanks and escarpments have been covered by ice more recently than the central part. The more recently glaciated parts are characterized by poorly integrated drainage, and innumerable ponds and lakes occupy irregularities in the till plain surface. As the central part has been exposed to erosion longer, drainage there is better integrated so that ponds and lakes are fewer. Locally small areas about the headwaters of streams are well dissected to a depth as great as some 150 feet.

From about the South Dakota-Minnesota boundary southeastward the proposed route follows the approximate crest of a great, broad end moraine to northern Iowa. Here the trend of this and other large end moraines becomes transverse to the route, and the alignment crosses a succession of end moraines from 100 to 150 feet high and 10 to 15 miles wide, separated by areas of mainly outwash sand and gravel only a few miles wide.

In northeastern Iowa the route crosses for some 140 miles an area of eroded ground moraine characterized by a more gently rolling topography than any previously traversed. The till that underlies the surface here is deeply weathered, so that the upper 7 to 8 feet is now about 50 percent clay.

About 150 miles northwest of the Mississippi River crossing in the vicinity of Waterloo, Iowa, the proposed route enters an area somewhat dissected by tributaries of the Mississippi. Here the general surface is gently rolling, with gentle to moderate slopes along the valley walls of streams.

East of the Mississippi River the character of the Central Lowland changes somewhat. Although the glacial deposits are young there has been enough erosion to integrate the drainage. Thus potholes are absent and the surface of the till plain is smoother and more nearly flat or undulatory than rolling. The diversified glacial terrain is marked by a variety of glacial features; among these are numerous large sand- and gravel-filled meltwater channels, glacial lake plains, and outwash plains.

In north-central Illinois the alignment traverses a surface consisting of very broad, low end moraines alternating with nearly featureless till plains containing scattered glacial-lake deposits.

From eastern Illinois to central Indiana the proposed route crosses a broad plain consisting mainly of outwash and glacial-lake sediments, with many poorly drained areas. Low end morainal ridges project through the till surface, and sand dunes locally overlie it.

From central Indiana to the Appalachian Plateaus the till plain consists of nearly flat to gently rolling ground moraine interrupted by broad, inconspicuous, festooned end moraines, and scattered ridges and knolls of sand and gravel.

The Appalachian Plateaus Province

Eastern Ohio, the prong of West Virginia and western-most Pennsylvania constitute part of the Appalachian Plateaus Province. The western-most part of the province is moderately to strongly rolling terrain with scattered groves of trees, but as one progresses east the surface becomes higher, more rugged, and tree growth more prevalent. Figures 2.1.3.3-11 and -12 are physiographic diagrams of all or part of these states.

The proposed alignment enters this province at the crossing of Big Walnut Creek in northeast Delaware County, Ohio, and extends eastward about 180 pipeline miles to the terminus located two and one half miles southeast of Delmont, Pennsylvania, some 23 miles east of Pittsburg. The western boundary of the province is commonly described as an escarpment, but at the pipeline locality the change is marked by a distinct increase in surface altitude and a change in the character of the topography. These differences are readily apparent but lack the relative abruptness of the escarpment which does mark this boundary elsewhere in Ohio.

In general the Appalachian Plateaus Province is distinguished by its (1) somewhat tilted and warped bedrock strata, (2) higher altitudes of the upland surface, (3) more strata of sandstone, siltstone, coal and shale, fewer strata of limestone and little dolomite and (4) a finely-patterned drainage system characterized by deep dissection, from the Central Lowland Province to the west. For a more detailed description of the Appalachian Plateaus Province, see Thornburg (1965, pp. 130-131, and 138-141).

The western-most part of the province, represented by some 40 miles of the proposed route east of Big Walnut Creek, was glaciated. The western part of this glaciated area is thickly mantled by glacial drift and characterized by discontinuous end moraines and a hummocky surface. In the eastern part of the glaciated area rounded bedrock hills carry a thin veneer of till. Near the margin of glaciation only scattered stones remain to represent the former drift mantle, and exposures of bedrock are common.

In the glaciated part of the plateau, flat valley floors are distinct in many stream valleys, and terraces composed of sand and gravel are common. Drainage is well integrated, and natural ponds are lacking. Because of the drainage pattern available, there has been little post-glacial dissection.

The final 145 miles of the proposed route lies across unglaciated land. This terrain is characterized by narrow ridges with rounded crests and steep flanks, separated by narrow sinuous valleys. The upland surface represented by the ridge crests is gently rolling. The valley walls are underlain by soil and other loose earth materials that are generally less than 15 feet thick; these materials overlie bedrock, which commonly crops out on the steeper slopes. Glacial lake sediments and thick glacial outwash form isolated remnants of terraces along the valleys of the principal rivers and some of their major tributaries that formerly served as meltwater channels.

Lithology

Rock and earth materials present along the proposed pipeline route can be classified into two principal groups (1) bedrock and (2) surficial deposits. Geologic maps that show the generalized distribution of the various kinds of bedrock and surficial materials for the 10 states traversed by the proposed route together with selected maps of various other aspects of the geology follow the text of this subsection on Lithology (Figures 2.1.3.3-13 through -39). The term bedrock refers to those materials which are generally relatively hard, compact or consolidated when compared with overlying surficial deposits which are commonly weak, noncompact or loose.

The term bedrock is not to be interpreted as meaning that the difficulty of its excavation will be such that it will warrant the premium price commonly paid for "rock excavation" during construction. Some of the bedrock that will be encountered may require that designation; most will not. Surficial deposits can in turn be divided into two general subgroups, (a) those of glacial origin, mainly till, outwash, and lake sediments, and (b) those of nonglacial origin.

One unit present along the proposed alignment may cause confusion in classification: the sand and gravel which underlies the surface of the Flaxville Plain. This deposit is composed of preglacial stream deposits (alluvium) rather than post-glacial alluvium as is all other alluvium along the proposed route. The Flaxville gravel, together with somewhat younger gravel derived from it by erosion and redeposition, is so firmly cemented by calcium carbonate that it is probably hard enough to cause some difficulty in excavation. For this reason the Flaxville gravel, together with its derivative gravel, is considered to be bedrock for the purpose of this discussion.

Probably the most significant fact about bedrock along the proposed pipeline is that the bedrock generally does not lie at or very close to the ground surface. Along approximately 80 percent of the route the bedrock is mantled by surficial deposits that range in thickness from a few tens of feet to some 650 feet. Bedrock generally will be encountered within 10 feet of the ground surface (1) in the walls of many valleys and in the floors of some valleys, (2) along most of the proposed alignment that extends from the first crossing of the Missouri River to the second crossing, in the vicinity of Westbrook and Windom, Minnesota, and (3) along the nonglaciated parts of the route: a length of about 20 miles southwest of the Missouri River and some 145 miles of proposed route in the Appalachian Plateaus Province from the margin of glaciation to the terminus.

The bedrock that the proposed pipeline will cross is moderately varied in character. It includes hard, tough, quartzite that will probably require blasting to excavate, beds of hard, tough conglomerate, sandstone, limestone and dolomite that can require blasting and beds of sandstone, siltstone, claystone, shale, coal and various mixtures thereof that are generally firm to weak and will not be difficult to excavate. Some wellcemented sand and gravel will also be encountered.

Bedrock

Five broad categories of bedrock strata are recognizable along the proposed route. The five categories are based, in part, on the kinds of bedrock present and, in part, on the relative quantities of those different kinds.

The differences between these categories are not necessarily great but the distinction is not difficult and is, in part, related to the geologic origin of each unit. In the following discussion, the geologic age of each unit is omitted as the simple factor of geologic time does not play a significant role in categorization or in the excavatability, trafficability of other physical qualities of the units. Similarly, the formal geologic names of formations are omitted wherever possible; the names generally are not needed to understand the character of the rock materials present, how they may be affected by the proposed pipeline, or how it affects them.

One bedrock category consists of the non-consolidated stream-deposited sediments that forms most of the surface along the proposed alignment from the vicinity of Big Muddy Creek, Montana, to several miles northwest of the second crossing of the Missouri River Valley. These sediments were eroded from the Rocky Mountains to the west and spread eastward to yield a great expanse of plains that sloped gently eastward, as did the layers of sediments themselves. Erosion now has removed all or part of these strata leaving remnants such as the Killdeer Mountains and the smaller Haystack Buttes.

The strata are all very similar in appearance and the geologic units they constitute can be distinguished only with difficulty. The layers consist mainly of claystone, shale, siltstone, shaly sandstone, sandstone, lignite, and conglomerate. Some of the beds contain disseminated bentonitic clay ("bentonite") which expands on wetting and shrinks on drying. It is extremely sticky and plastic when wet. Strata that contain bentonitic clay are particularly susceptible to landsliding, in part because of the swelling pressure developed by that clay on wetting. Because of such pressure, the strata also may cause problems for structures built on them without properly designed foundations.

Most of these strata are weak and weather rapidly, but some of the sandstone beds are hard to very hard. With the possible exception of these hard beds, the strata are excavatable without difficulty. The strata are all tilted very gently southeastward. In the vicinity of Williston, North Dakota, these strata conceal a shallow structural basin named for that community and composed of older bedrock formations far below the ground surface.

A second category of bedrock consists mainly of now-consolidated sedimentary strata of marine origin, and partly of somewhat similar strata deposited by streams. Beds of this category underlie most of the ground surface from the Canadian border to Big Muddy Creek, and from a locality several miles northwest of the second crossing of the Missouri River Trench to approximately the Minnesota-Iowa border. Much of Cottonwood County, Minnesota, must be excluded, however, as a third category of bedrock may be encountered in this area.

Strata of the second category consist mainly of materials that accumulated in a shallow sea which extended from about central Iowa far to the west. The sea eventually receded and the strata were mantled by sandstone beds of continental (stream-deposited) origin, and subsequently by strata of the first category.

The marine strata consist mainly of thick layers of claystone, shale and silty claystone, interbedded with thinner layers of clayey chalk. The overlying continental beds are mainly siltstone and sandstone. The marine layers contain considerable quantities of disseminated bentonitic clay as well as scattered beds of that material as much as 2 feet thick locally.

The strata are weak and weather rapidly and permeability is very low. Any significant amount of water that is contained is present in fractures. The overlying continental strata are moderately thick to thick beds of hard to very hard sandstone that present no strength or stability problems. Their permeability is greater and ground water can be present in both the rock and its fractures. Some difficulty may be encountered in excavation of these beds.

Structurally the strata are little deformed. They are nearly level in attitude along most of the pipeline route, but various structural features, such as minor folds and faults, are locally apparent. The folds probably do not exceed a mile or two in length, a few hundred yards in width, and several tens of feet in height. Displacement on most observed faults is not determinable; they are not known to be active. Landsliding is widespread in the sedimentary rocks of marine origin and this has led some investigators to assume the presence of larger structural forms.

The third category of bedrock consists of quartzite that is extremely hard and tough and which may be interbedded with some thin sandy or clayey layers. Along the proposed route, the quartzite is restricted in its area of occurrence to Lyon, Cottonwood and Martin Counties in southwestern Minnesota. The area of outcrop is nearly surrounded by marine sediments of the second bedrock category and in addition is generally mantled by till. Along the route the till is sufficiently thick so that exposures of the quartzite are unlikely, and the likelihood of the pipeline trench encountering the rock is small to negligible. The rock is nearly impermeable except through fractures, or perhaps through the sandy or clayey beds where present. Excavation probably will require blasting. The rock crops out below the mantle of glacial deposits on the crest of a broad, structurally stable arch, and the beds are very nearly flat-lying.

The fourth and fifth categories of bedrock are mutually similar but differ in the amount of limestone and coal present. At the time that marine sediments were accumulating in the inland sea that lay west of central Iowa, a broad lowland lay to the east. The rocks of that land mass had been deposited in a succession of ancient seas and so differed somewhat in character. The strata of that land mass that are now exposed between central Iowa and central Ohio contained more limestone and less coal than do the strata exposed east of central Ohio. The former strata constitute the fourth category of bedrock, the latter the fifth category.

The fourth category of bedrock strata consists of large amounts of limestone with considerable amounts of dolomite, some shale, sandstone and siltstone and a little coal. Bedrock of this category underlies the proposed route from north-central Iowa to central Ohio. Most of the limestone, dolomite and sandstone beds are hard to very hard, tough, massive in character and permeable. Some difficulty may be encountered in excavating. The siltstone and shale are somewhat weaker, less permeable, and may or may not be thicker bedded. The coal is somewhat thinner bedded, permeable and weak.

The strata are nearly level in attitude along the proposed alignment for structurally they are a little deformed. Several regional structural features are crossed by the route or are adjacent to it and so are reflected in the attitudes of the various strata. Faults known to be present along the pipeline are not known to be active, although there has been some known, possibly significant earthquake activity in Montana, Illinois, Indiana and Ohio.

Strata of the fifth category are exposed along the proposed pipeline route eastward from central Ohio and so underlie the Appalachian Plateaus Province. These rocks consist of relatively larger amounts of sandstone, siltstone shale and coal, lesser amounts of limestone, and much more dolomite, than do the strata exposed west from central Ohio. The physical characteristics of the rocks in this fifth category are essentially the same as those of the fourth category.

The principal structural feature of this province is a broad trough, but the features actually apparent along roadcuts and in valley walls are a series of parallel anticlines and synclines that trend north-northeast from 5 to 8 miles apart. In the western part of the Province these folds are broad and moderately gentle, with amplitudes of roughly 300 to 400 feet. Farther east the folds are narrower, more intense and amplitudes are greater. Beds are essentially horizontal along the axes of the folds and are tilted to angles as great as 400 feet per mile on the flanks.

Differential erosion of the hard and soft bedrock layers has resulted in the harder layers forming prominent ledges on valley walls. In many areas these can be traced for miles.

Surficial Deposits

The surficial deposits that the proposed pipeline will traverse are varied in character. They include till, meltwater deposits of sand and gravel and glacial lake deposits of clay, silt and sand; all are of glacial origin. They also include some (1) wind-blown silt and sand; (2) alluvium generally consisting of stream-deposited silt, sand and gravel; and (3) colluvium, a mixture of commonly clay, silt and sand that accumulates on or at the foot of slopes through the action of slopewash and gravity. These deposits are nonglacial in genesis, although the materials of which they are composed may be derived from glacial deposits.

Till has been described previously as a nonstratified, nonsorted mixture of rock and earth materials that range from clay-size particles to boulders, deposited by a glacier. Commonly till is described as homogenous, and locally it is, but it differs in composition more than that term implies. The material of which till is composed is rock and earth material eroded from the ground surface by overriding ice. Most of the material is deposited within several miles of its point of origin, but some is carried for long distances. Thus the composition of till reflects the kinds of rock over which the glacier passed. Overridden shale yields a clay-rich till; sandstone, a sandy till; and limestone, a highly calcareous till. The maximum size of boulders expectable in a till is difficult to predict from available data. The possibility exists that a boulder of great size may be encountered, but this is unlikely. Most boulders probably are less than 3 feet in diameter, and the size that may be encountered during excavation generally will be represented by the size of boulders observed on the ground surface along the proposed route. Locally surface boulders may be concealed by a mantle of wind-blown silt or sand.

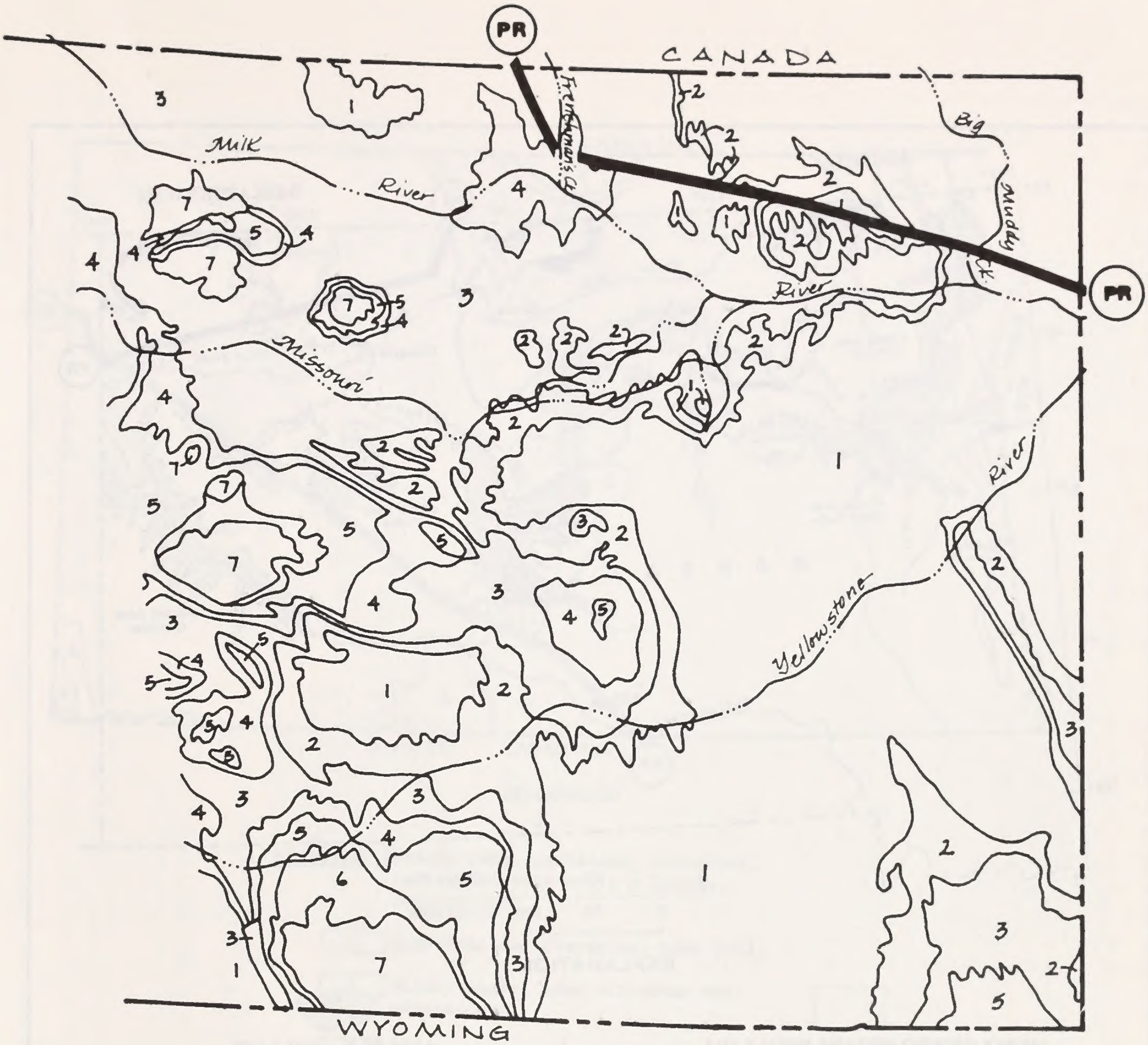
Local variations in the process of till deposition generally are matched by internal variation in composition and particle size. Commonly till deposits contain lenses and irregular bodies of sandy material and in some places clean, well washed sand and gravel. These permeable lenses may be from a few inches to several feet thick and may extend laterally for a few yards or perhaps for distances of a few miles. Such lenses seem to make "permeable" a clayey till that is otherwise impermeable. Generally the permeability of till itself increases as the finer components become coarser--a sandy till is more permeable than a clayey till.

From the Canadian Border to north-central Iowa the till generally is characterized by a calcareous clay-rich matrix that is locally somewhat silty. Excavation is not a problem, although when wet the till may become sticky and plastic causing movement problems for wheeled vehicles. In eastern Iowa the till is thoroughly weathered to a clayey soil to a depth of 7 to 8 feet; unweathered till is very firm and compact, somewhat blocky and may cause some difficulty in excavation. From eastern Iowa to central Ohio the till is highly calcareous and the matrix is generally clayey, somewhat like the till along the western part of the proposed route. In central Ohio the till becomes a little sandier, and sulfur-rich compounds in the overridden shale and coal locally yield a sulfate-rich till.

The other major component of the drift mantle along the proposed route is outwash, composed of the coarser, harder components of the rock and earth debris carried by the glacier which have been deposited by meltwater and from which the finer, softer components have been washed. The stones in outwash are generally well rounded. The material is not naturally cemented and permeability is high. Outwash may be encountered as hills or ridges on the till surface; as lenses enclosed by till; as larger, more extensive deposits in meltwater-cut channels and stream valleys; or as broad aprons mantling an area that may be as much as a few miles across. Deposits as much as 300 feet thick are reported in drainage channels southwest of the Missouri River in North Dakota and in valleys in Illinois and Indiana. Thicknesses of from 5 to 50 feet are probably common.

Wind-blown deposits of sand or silt are widespread along the proposed alignment but they are generally less than 5 feet thick. Wind-blown sand is loose, highly permeable and easily eroded where exposed on slopes. Sand dunes are traversed by the route just east of Big Muddy Creek in eastern Montana, in Illinois between the Mississippi and Illinois Rivers and very locally in Indiana. These areas locally are mantled by wind-blown sand too thin to possess dune topography.

Wind-blown silt (loess) is widespread along the proposed route and ranges in thickness from a few inches to several feet. It is characterized by a distinctive columnar structure which permits thick deposits of the

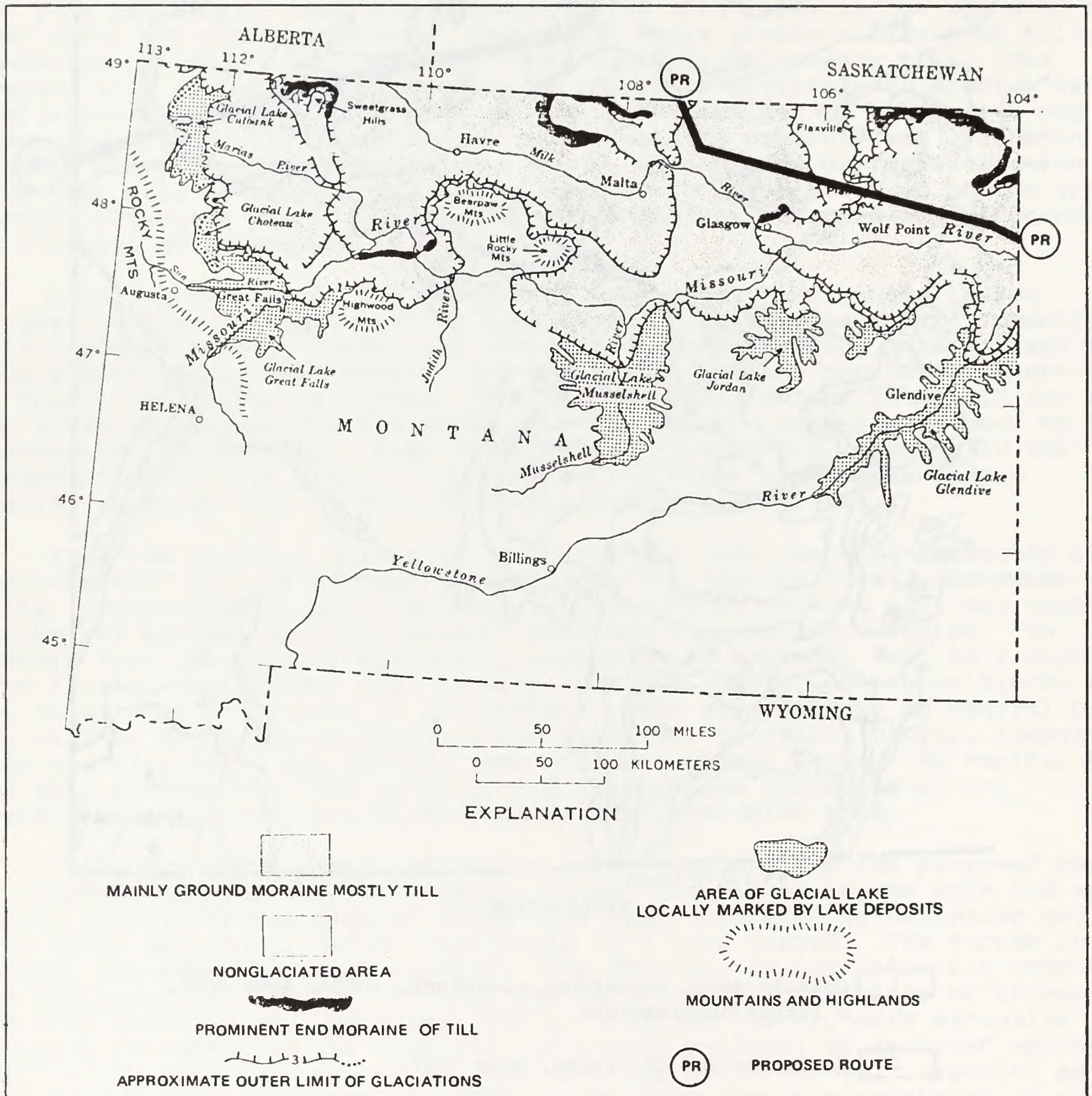


EXPLANATION

1	Chiefly sand, sandstone, claystone, shale; some coal, a little conglomerate
2	Sandstone and claystone, some coal
3	Mainly shale, some siltstone and sandstone
4	Mainly sandstone, some shale
5	Mainly shale, some sandstone, a little limestone
6	Mainly sandstone, some siltstone and conglomerate
7	Mainly limestone, sandstone, and dolomite; some gneiss

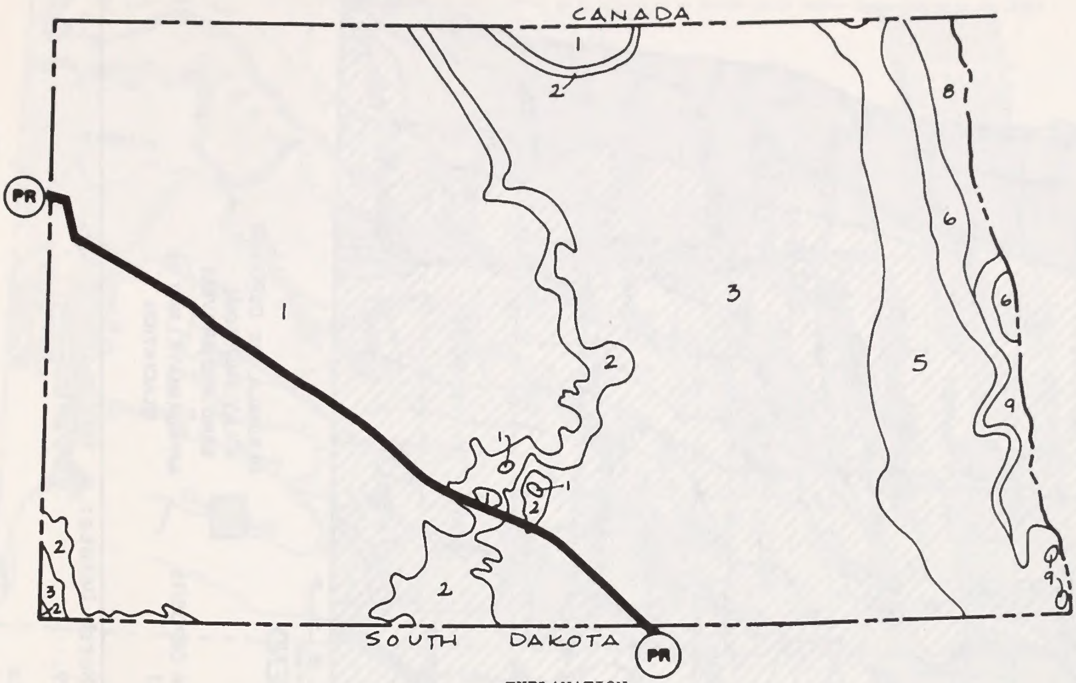
SOURCE: Modified from King, P. B., and Beikman, H. M., Geologic Map of the United States, 1974.

Figure 2.1.3.3-13 Generalized geologic map showing the known and inferred distribution of bedrock lithologies in eastern Montana



SOURCE: Modified from Lemke, R. W., and others, Quaternary Geology of Northern Great Plains, 1965.

Figure 2.1.3.3-14 Distribution of glacial deposits of eastern Montana

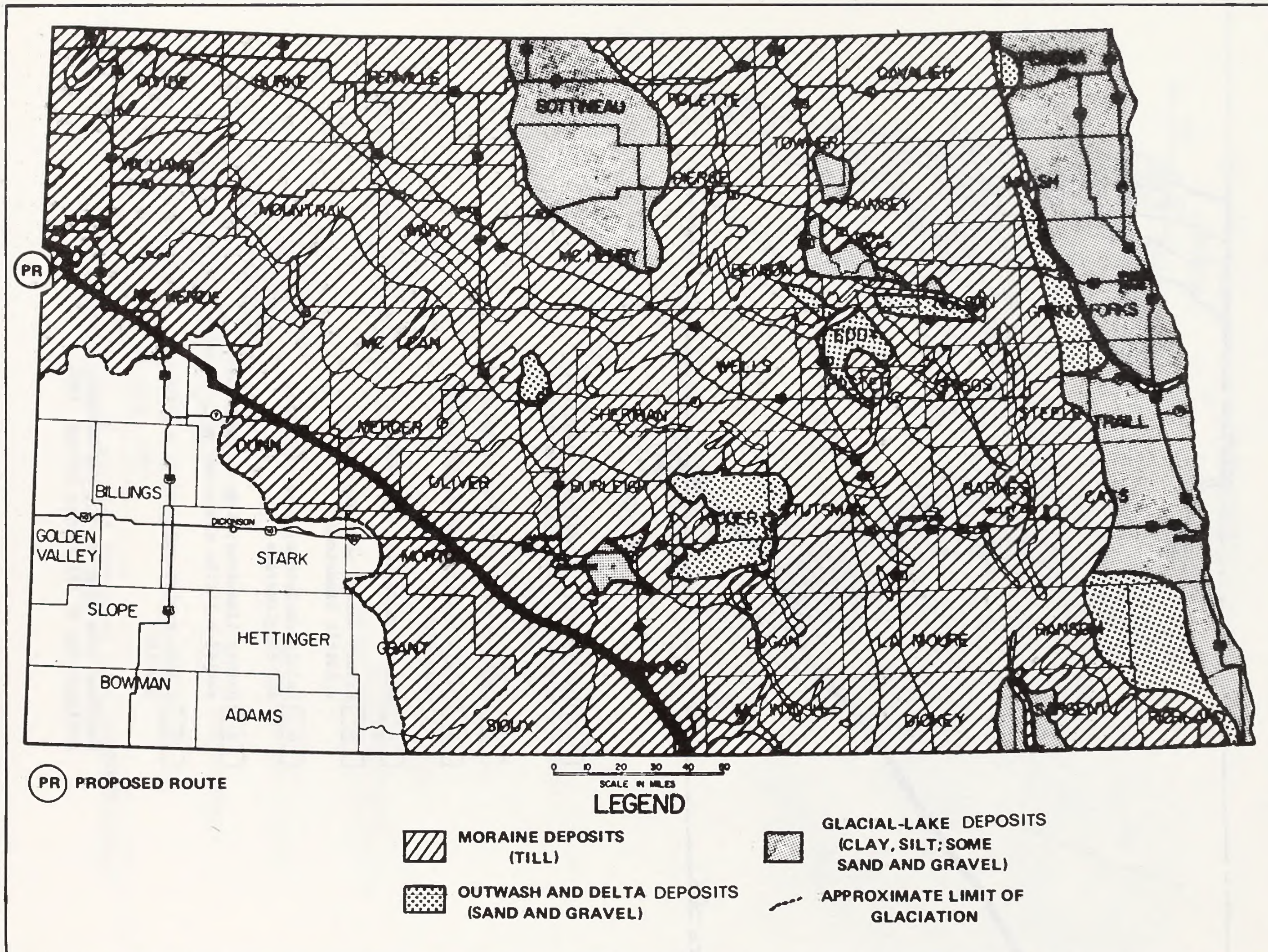


EXPLANATION

1	Mainly sand, sandstone, claystone, and shale; some coal; a little conglomerate
2	Sandstone and claystone, some coal
3	Mainly shale; some siltstone and sandstone
4	Mainly sandstone; some shale
5	Mainly shale; some sandstone; a little limestone
6	Mainly sandstone; some siltstone and conglomerate
8	Mainly limestone; some dolomite and shale; a little claystone and siltstone
9	Mainly gneiss and schist; a little granite

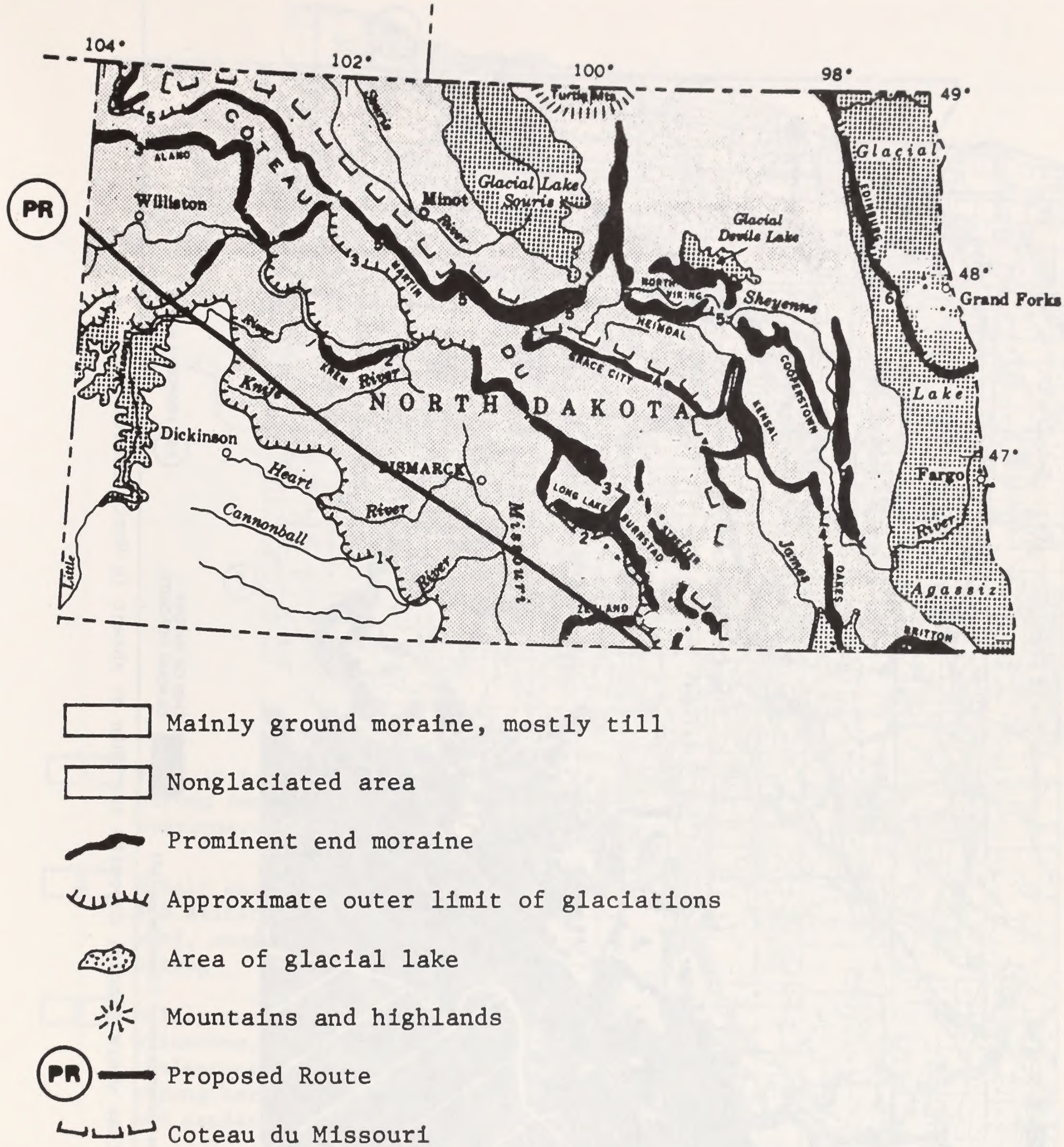
Source:
Modified from King, P. B., and Beikman, H. M., Geologic map of the United States, 1974.

Figure 2.1.3.3-15 Generalized geologic map showing the known and inferred distribution of the principal kinds of bedrock lithologies in North Dakota



SOURCE: Modified from Generalized Glacial Map of North Dakota: North Dakota Geological Survey Misc. Map 9.

Figure 2.1.3.3-16 Glacial deposits of North Dakota



SOURCE: Modified from Lemke, R. W. and others, Quaternary Geology of Northern Great Plains, 1965.

Figure 2.1.3.3-17 Morainal features of North Dakota

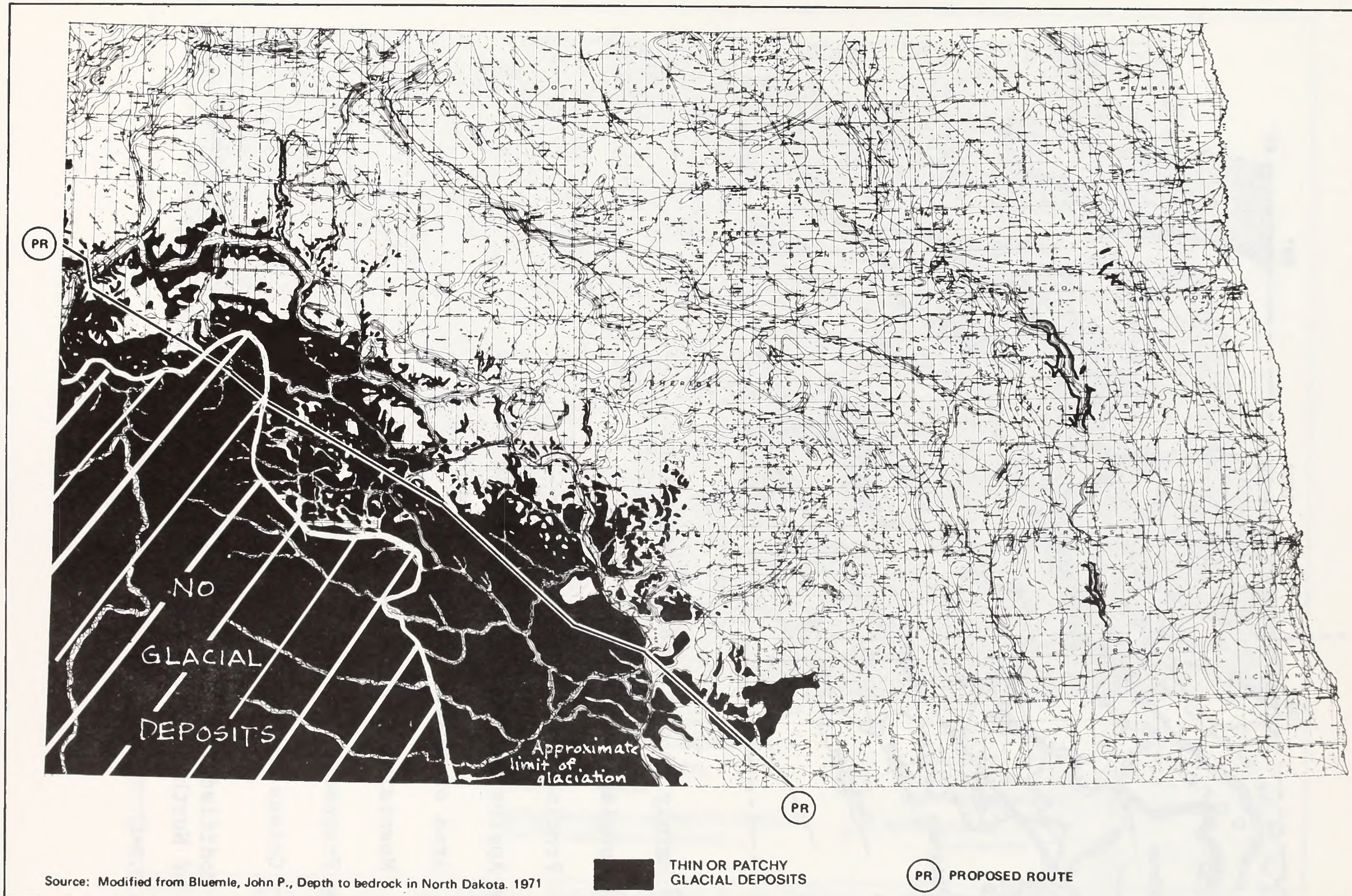
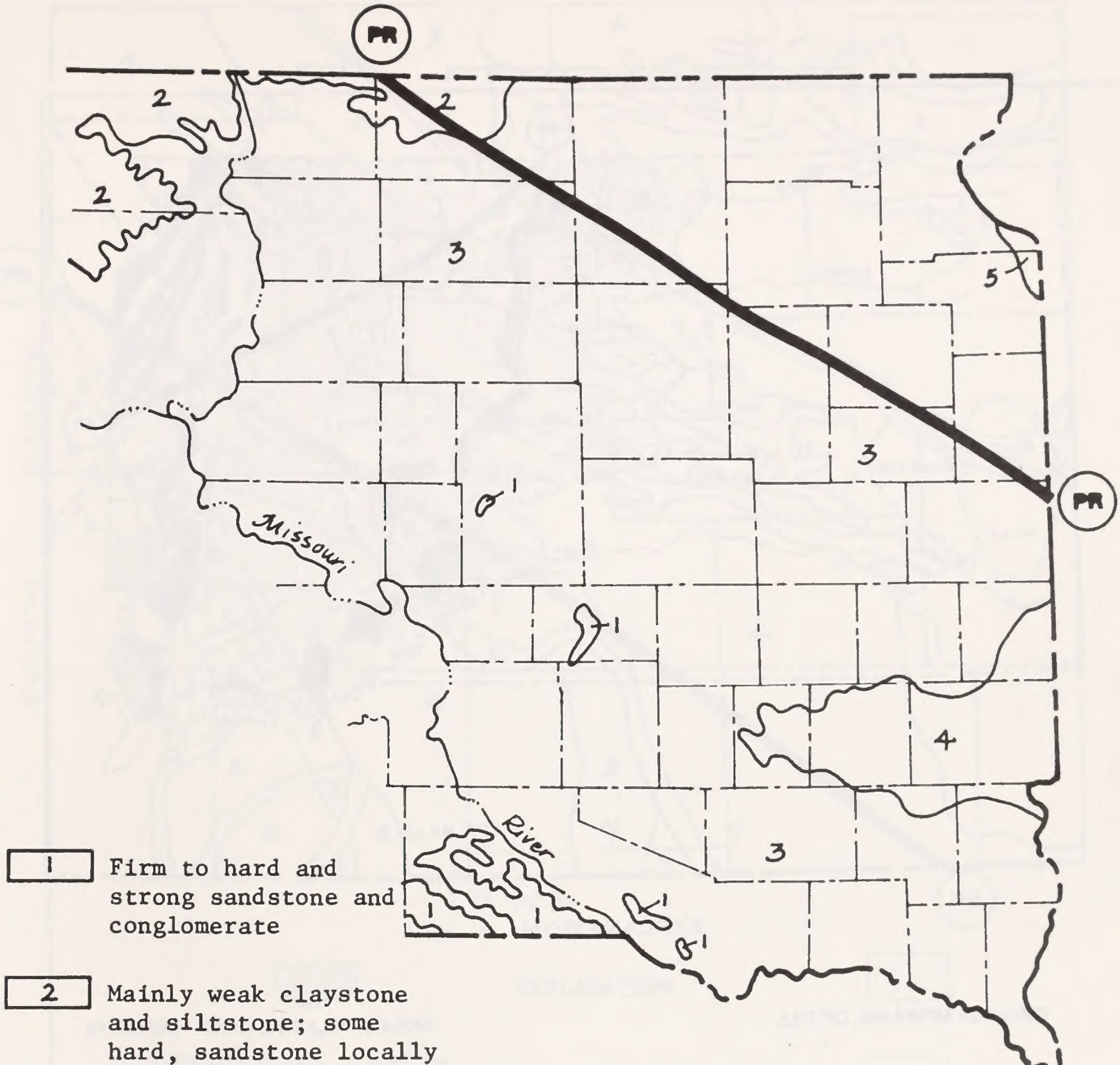


Figure 2.1.3.3-18 Areas where glacial deposits are thin or absent in North Dakota



| 1 | Firm to hard and strong sandstone and conglomerate

| 2 | Mainly weak claystone and siltstone; some hard, sandstone locally strong

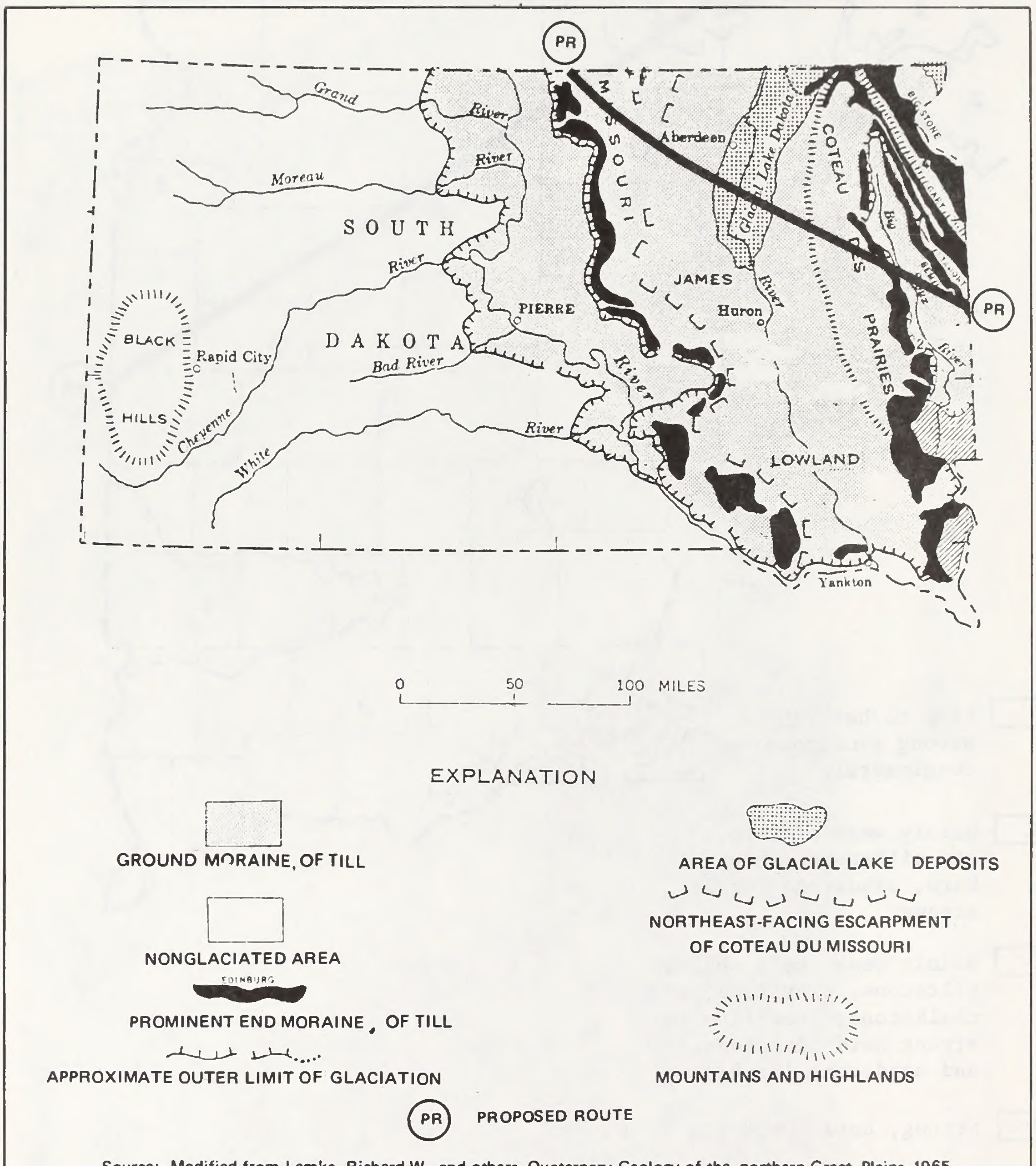
| 3 | Mainly weak, soft shale, siltstone, claystone, and chalkstone; some firm to strong hard limestone and sandstone locally

| 4 | Strong, hard quartzite

| 5 | Strong, hard granite

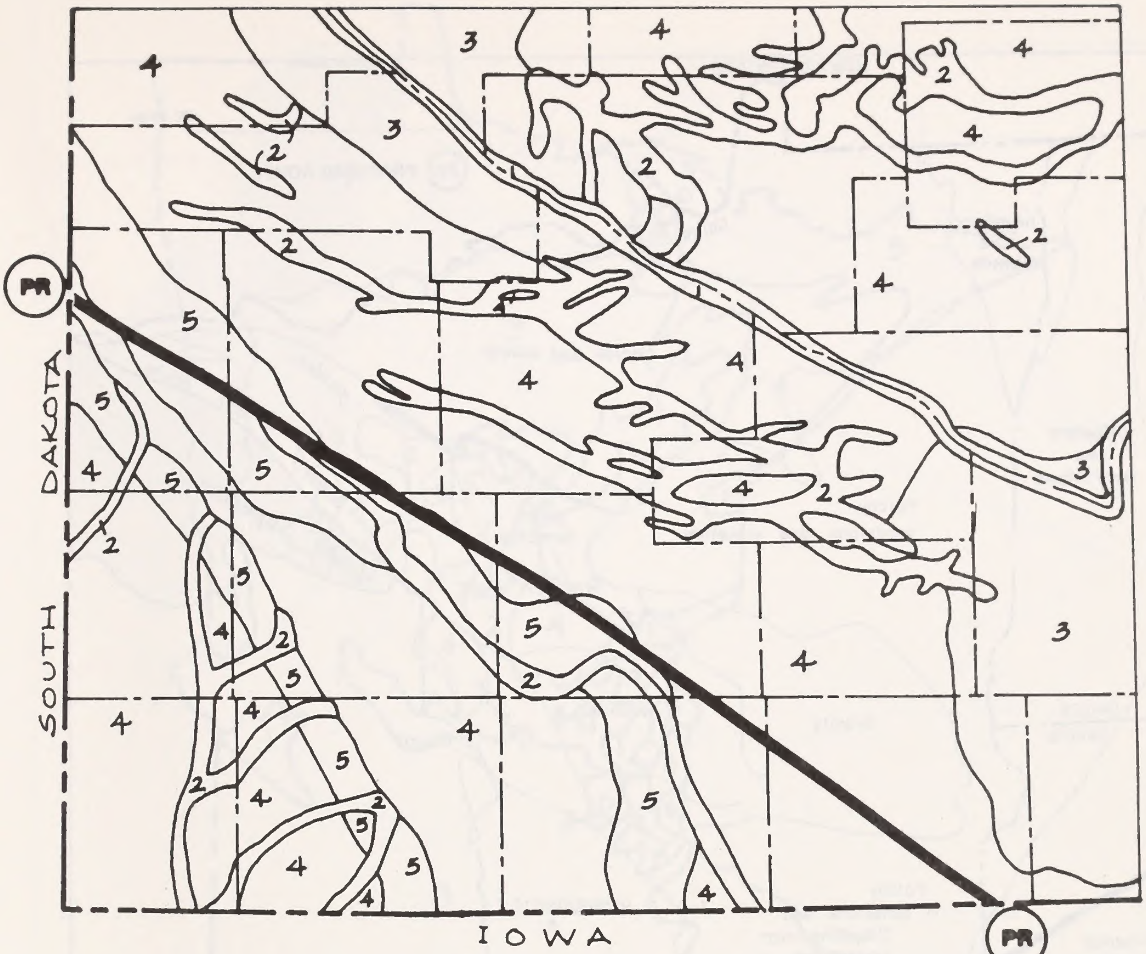
SOURCE: Modified from Flint, R. F., Pleistocene Geology of Eastern South Dakota, 1965.

Figure 2.1.3.3-19 Generalized geologic map showing the known and inferred distribution of bedrock lithologies in eastern South Dakota



Source: Modified from Lemke, Richard W., and others, Quaternary Geology of the northern Great Plains. 1965

Figure 2.1.3.3-20 Distribution of glacial deposits in South Dakota

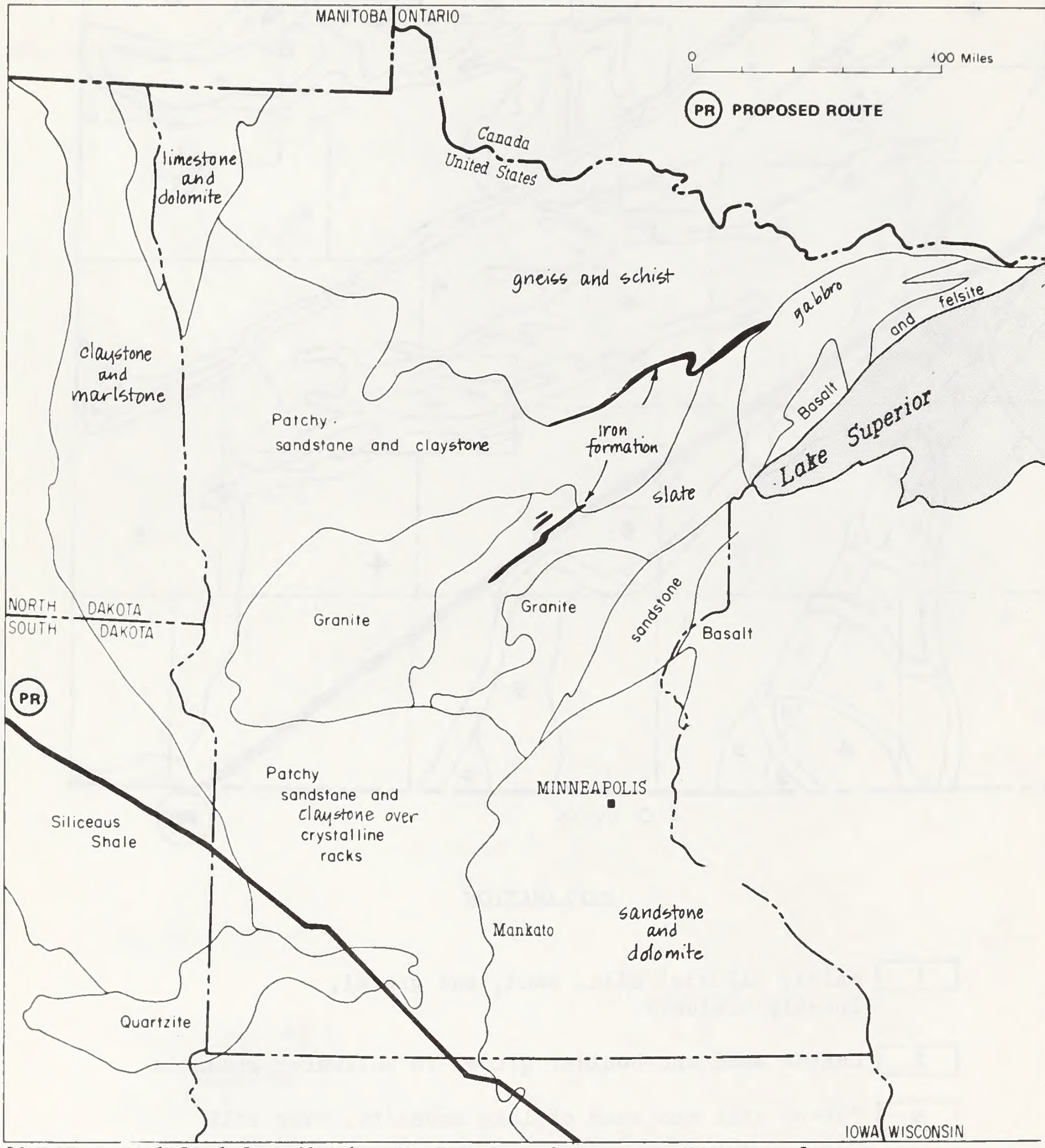


EXPLANATION

1	Mainly alluvial silt, sand, and gravel; locally bouldery
2	Coarse sand and boulder gravel in meltwater channels
3	Patchy silt and sand of lake deposits, over till
4	Mainly till, forming ground moraine; some sand and gravel locally; mantled with windblown silt southwest of the end moraines
5	Mainly till, forming end moraines

SOURCE: Modified from Matsch, C. L., Quaternary Geology of Southwestern Minnesota, 1972.

Figure 2.1.3.3-21 Glacial deposits in southwestern Minnesota



SOURCE: Modified from Wright, H. E., Jr., Quaternary History of Minnesota, in Geology of Minnesota: A Centennial Volume, Minnesota Geological Survey, 1972.

Figure 2.1.3.3-22 Generalized geologic map showing the known and inferred distribution of bedrock lithologies in Minnesota

EXPLANATION

[1] Glacial lake deposits

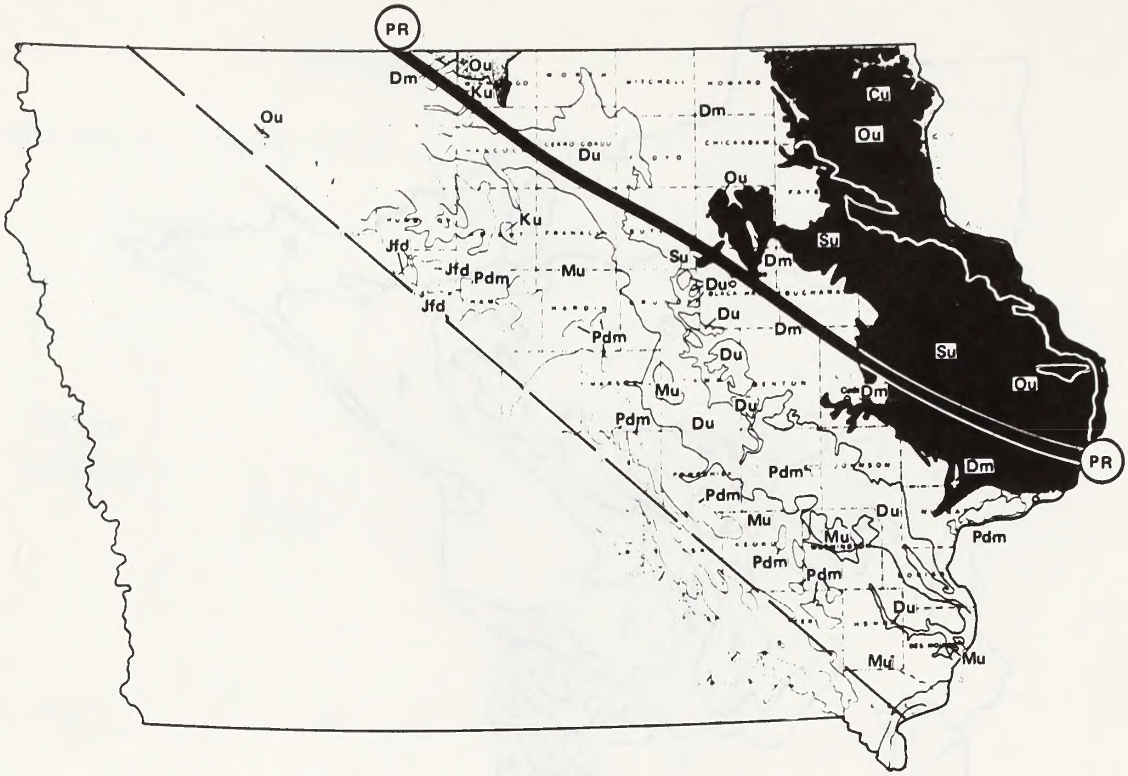
[2] Outwash, mainly sand and gravel

[3] [4] Morainal deposits, mainly till; relatively thick

[5] [6] Morainal deposits, mainly till; relatively thin

SOURCE: Modified from Hogberg, R. K., Ground Water Resources in Minnesota, in Geology of Minnesota: A Centennial Volume, Minnesota Geological Survey, 1972.

Figure 2.1.3.3-23 Principal glacial deposits of Minnesota



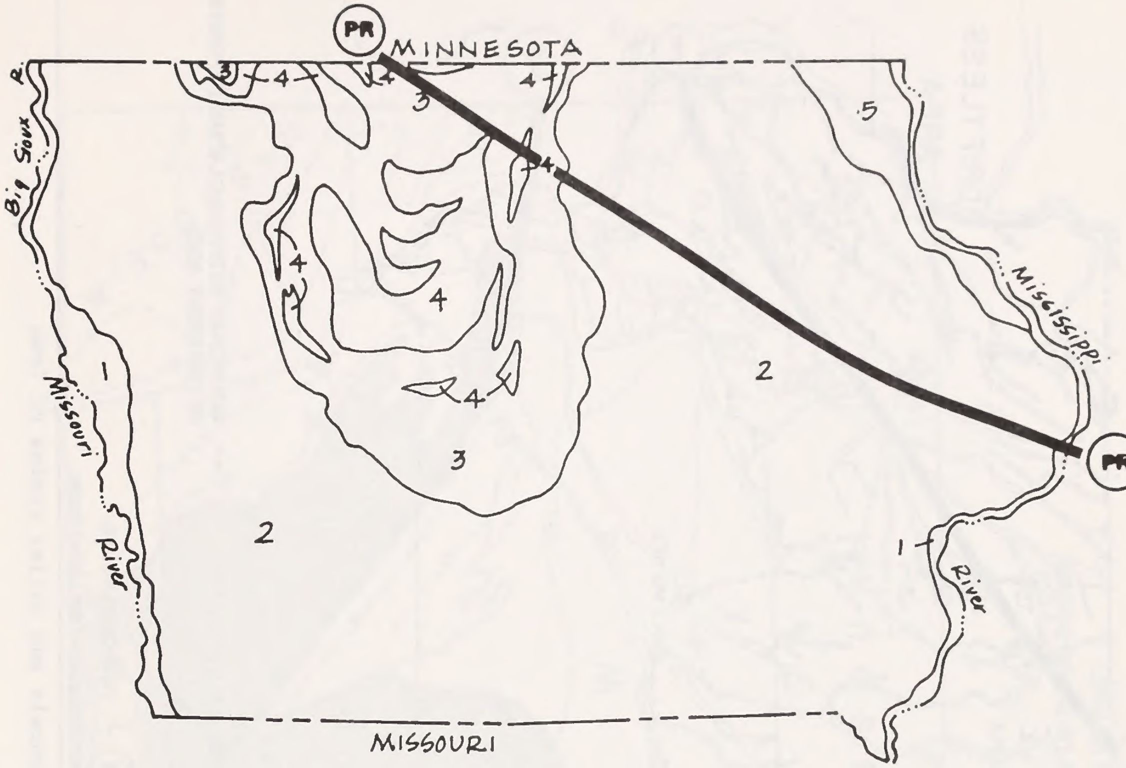
EXPLANATION

Ku / Jfd	Sandstone, shale, and limestone
Pdm	Limestone, shale, claystone, and coal
Mu / Du	Limestone, dolomite, and shale
Dm / Su	Limestone and dolomite
Ou / Cu	Sandstone, limestone, dolomite, and shale

Source: Modified from Horick, P. J., The Minerals of Iowa, 1974.

(PR) PROPOSED ROUTE

Figure 2.1.3.3-24 Distribution and lithologies of bedrock units in northeast Iowa

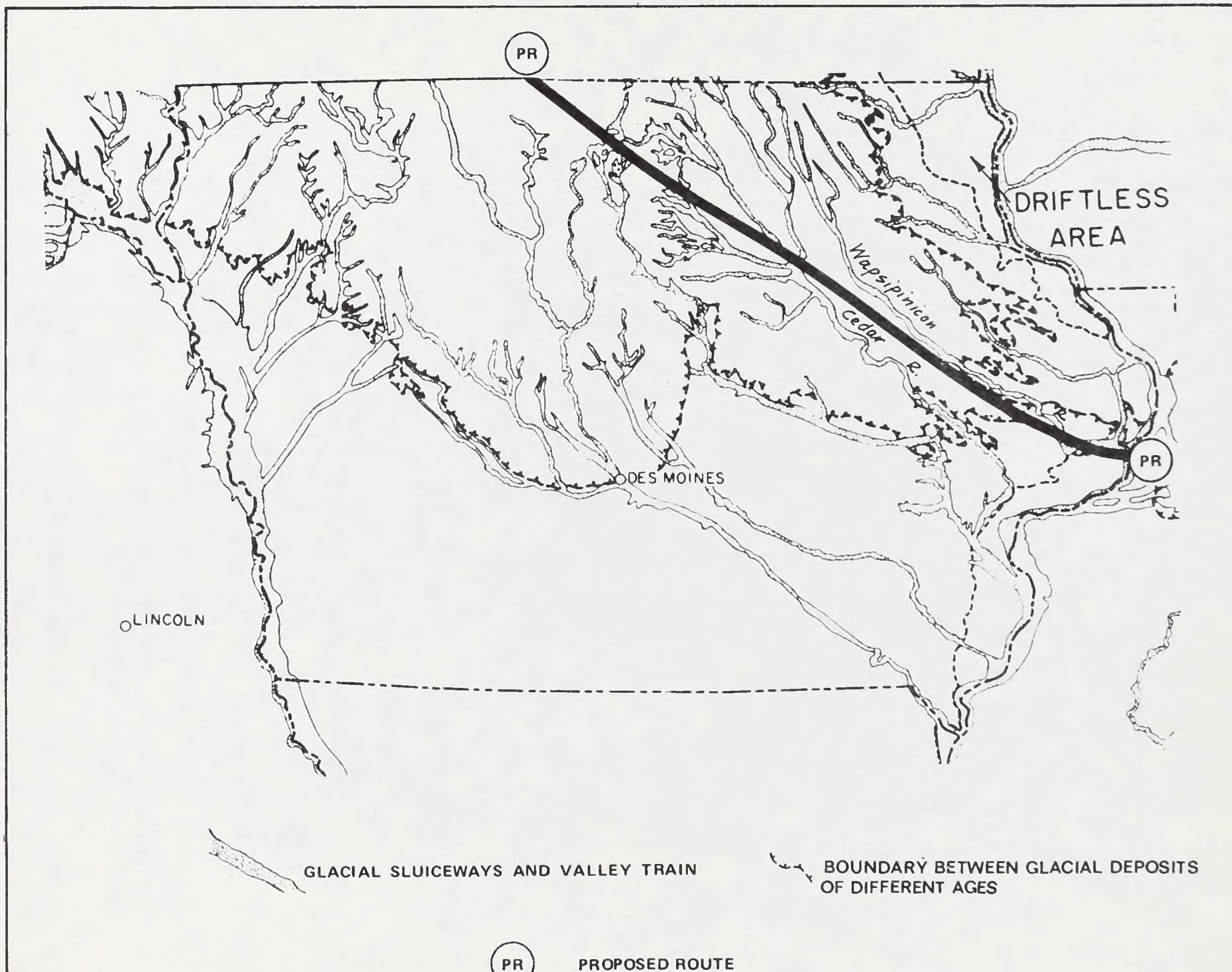


EXPLANATION

1	Alluvium
2	Ground moraine, mostly till. Generally mantled by wind-blown silt except in the northeast quarter of the state
3	End moraines, mainly till
4	Outwash, mainly sand and gravel
5	No glacial deposits except wind-blown silt

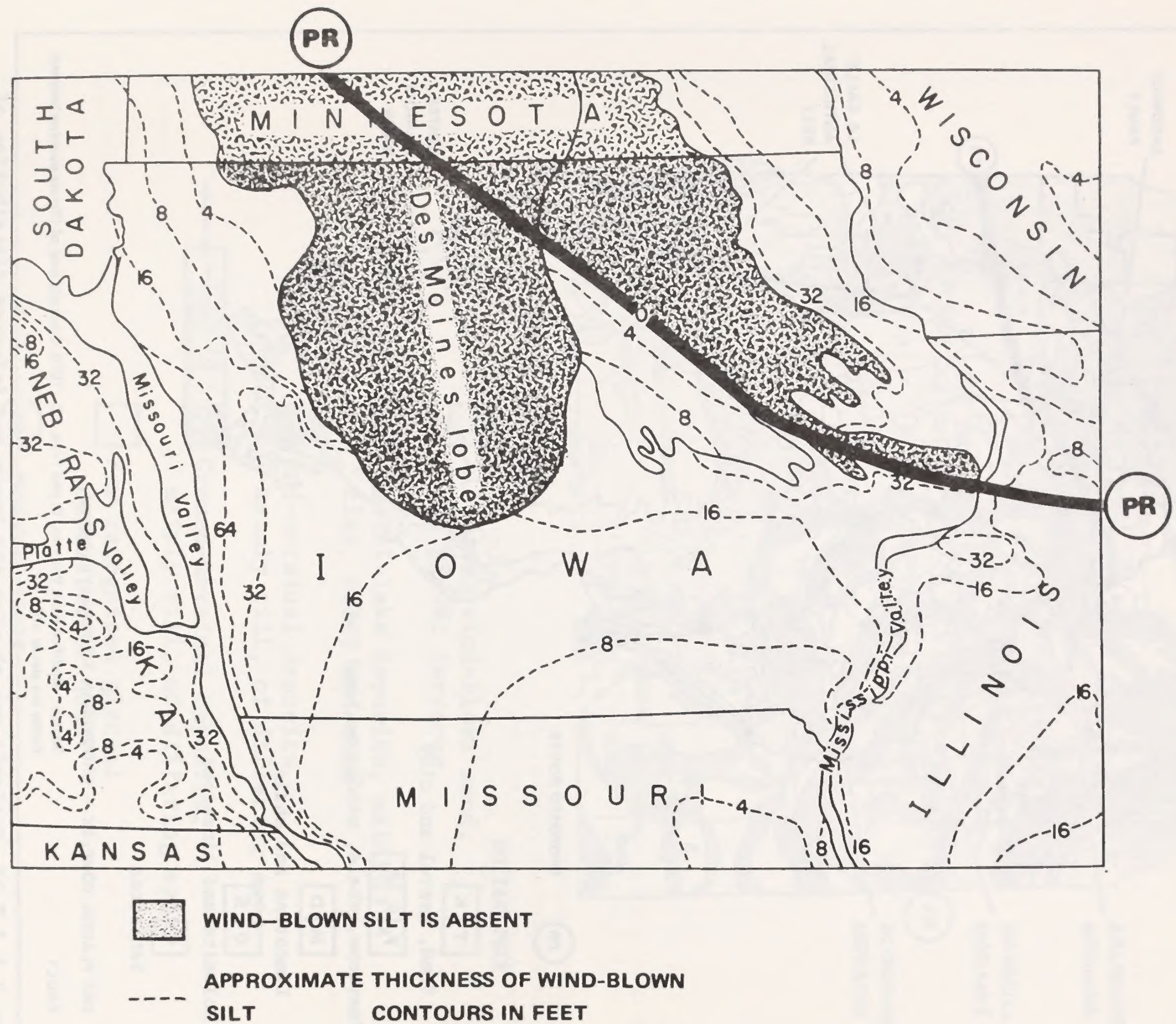
SOURCE: Modified from Wright, H. E., Jr., and Ruhe, R. V., Glaciation of Minnesota and Iowa, 1965.

Figure 2.1.3.3-25 Principal glacial deposits of Iowa



Source: Modified from Thornbury, William D., 1965, Regional Geomorphology of the United States.

Figure 2.1.3.3-26 Glacial-meltwater channels and valley trains of Iowa



Source: Modified from Ruhe, Robert V., 1969, *Quaternary landscapes in Iowa.*

Figure 2.1.3.3-27 Thickness of windblown silt in and near Iowa

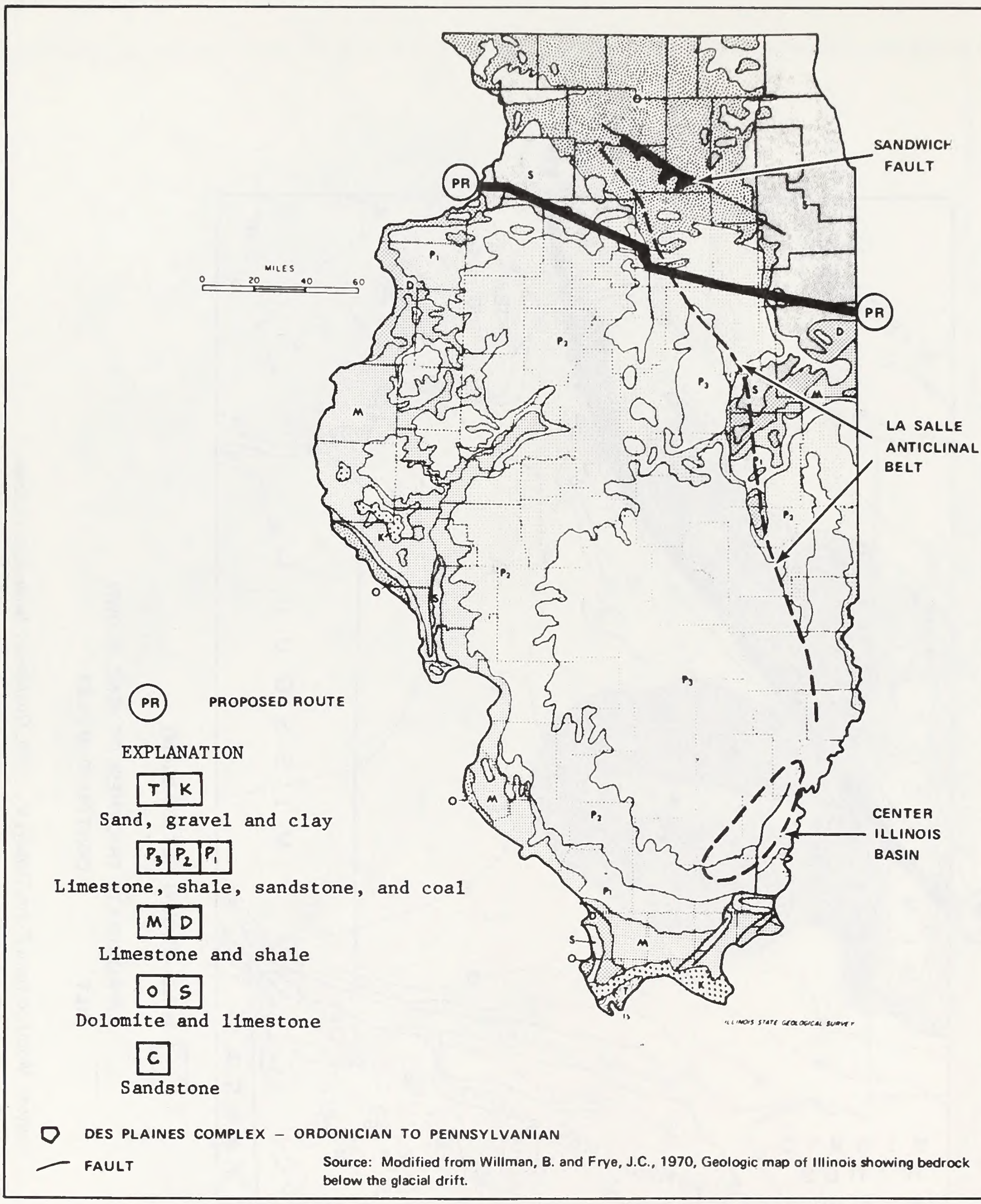
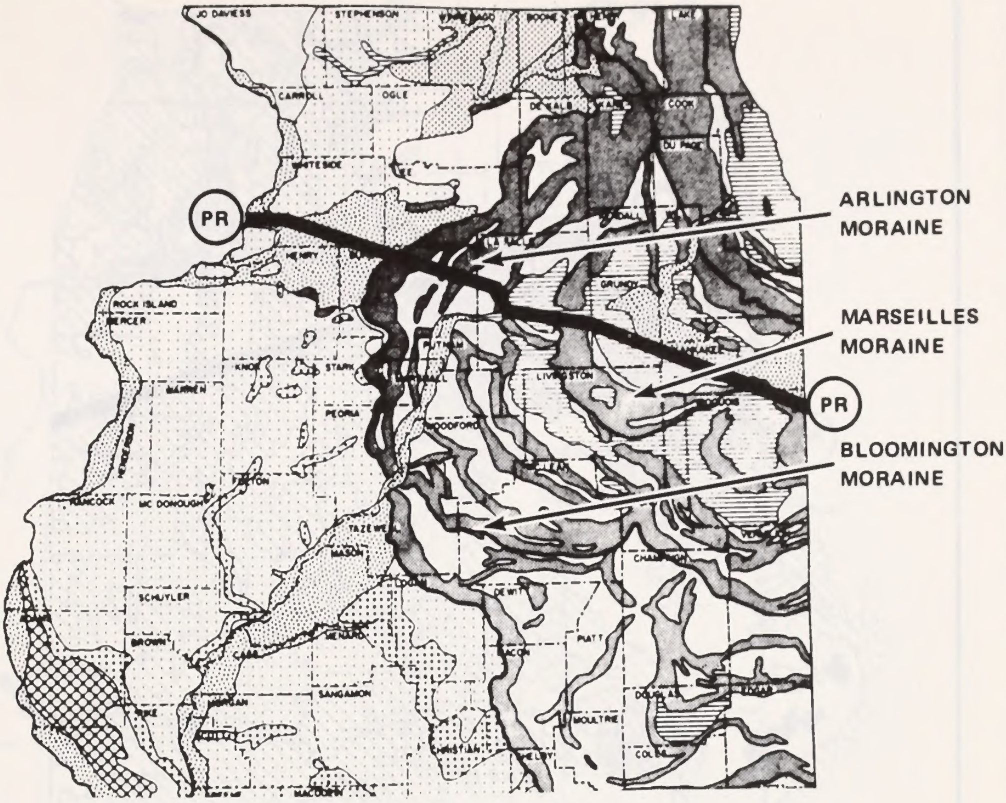


Figure 2.1.3.3-28 Geologic map showing the known and inferred distribution of bedrock lithologies in Illinois



EXPLANATION

Alluvium, wind-blown sand, and gravel terraces

Glacial-lake deposits, mainly clay, silt, and sand

End-morainal deposits, mainly till, of differing ages

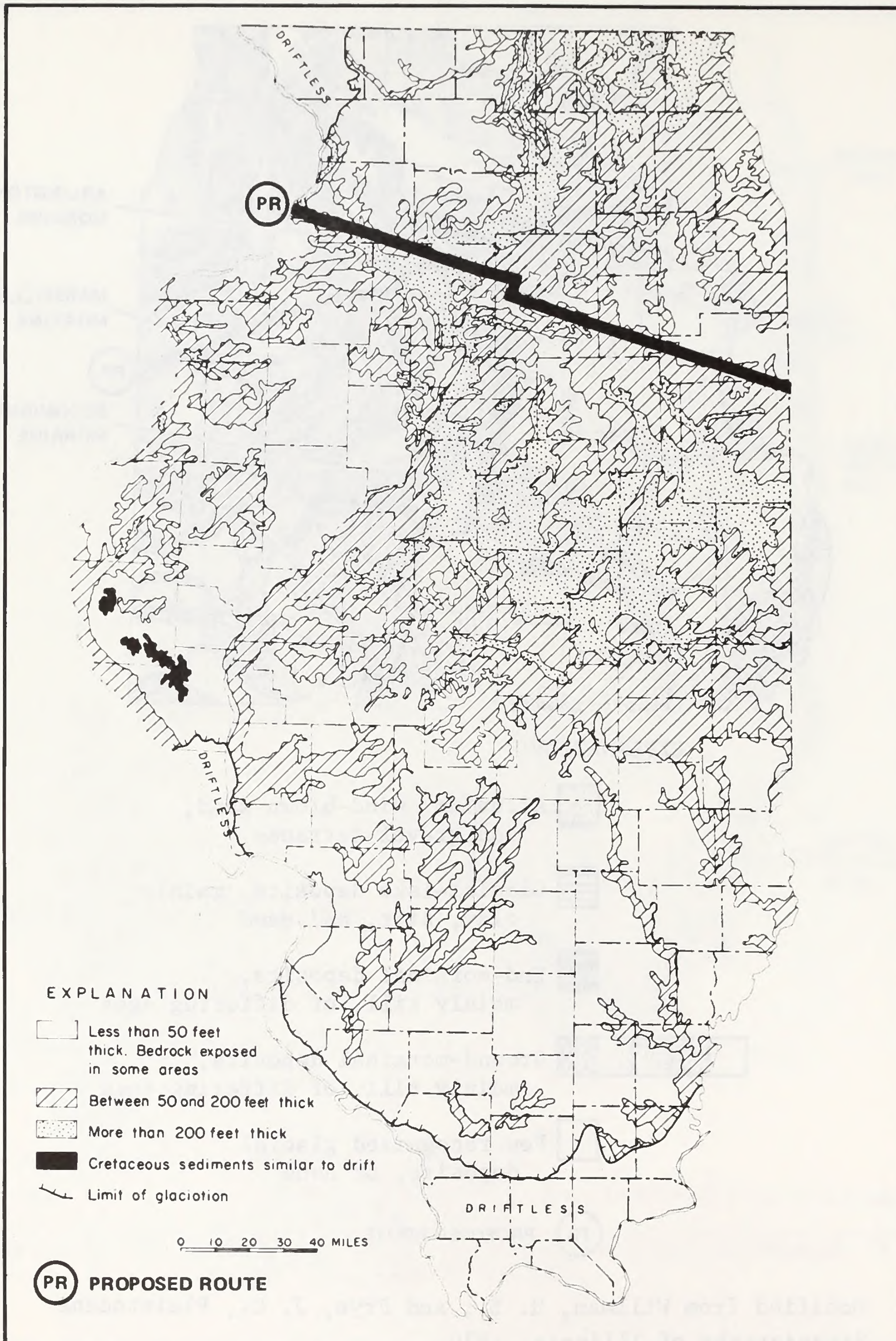
Ground-morainal deposits, mainly till, of differing ages

Few recognized glacial deposits, or none

(PR) PROPOSED ROUTE

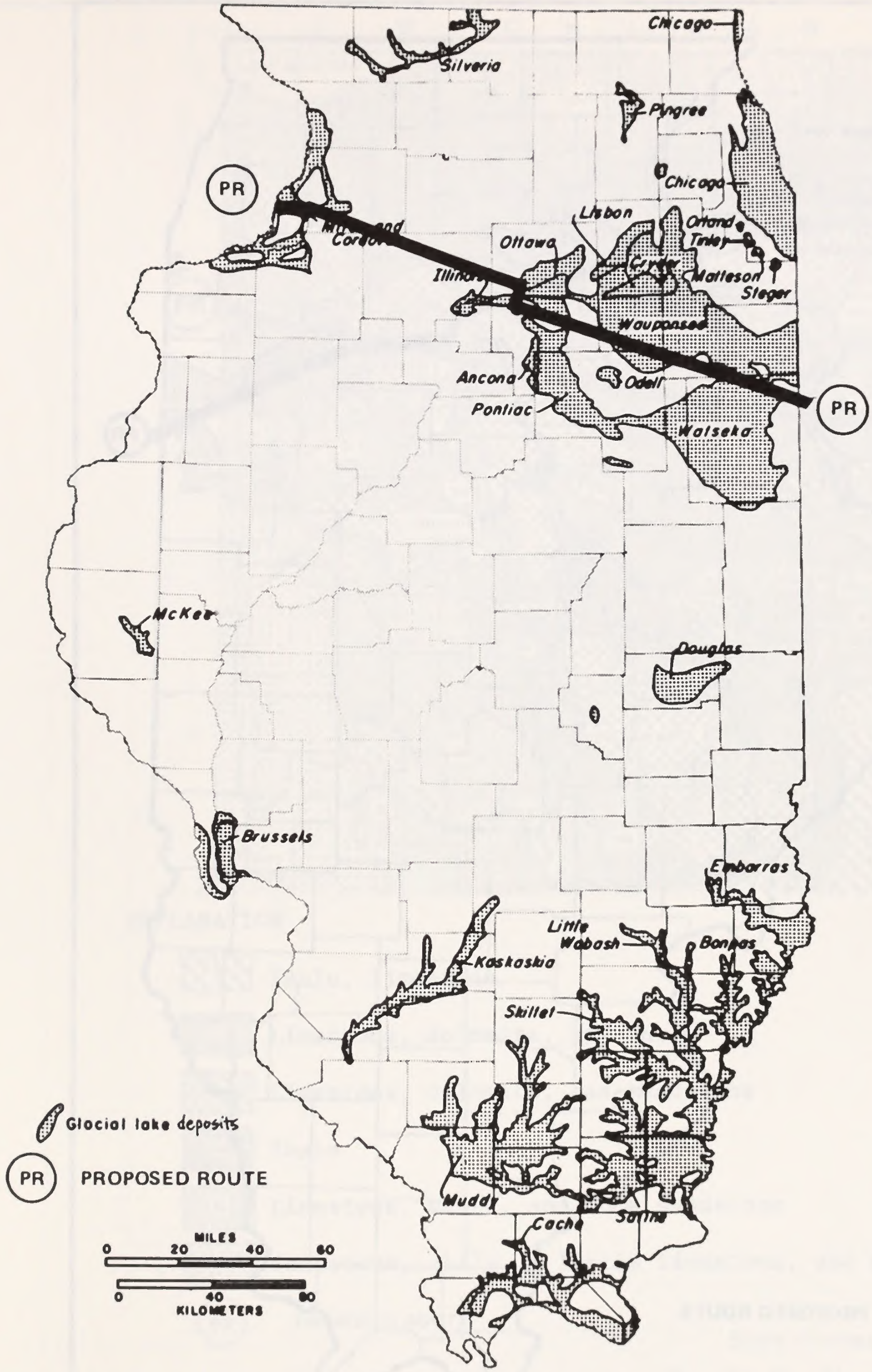
Source: Modified from Willman, H. B., and Frye, J. C., Pleistocene Stratigraphy of Illinois, 1970.

Figure 2.1.3.3-29 Distribution of glacial deposits in Illinois



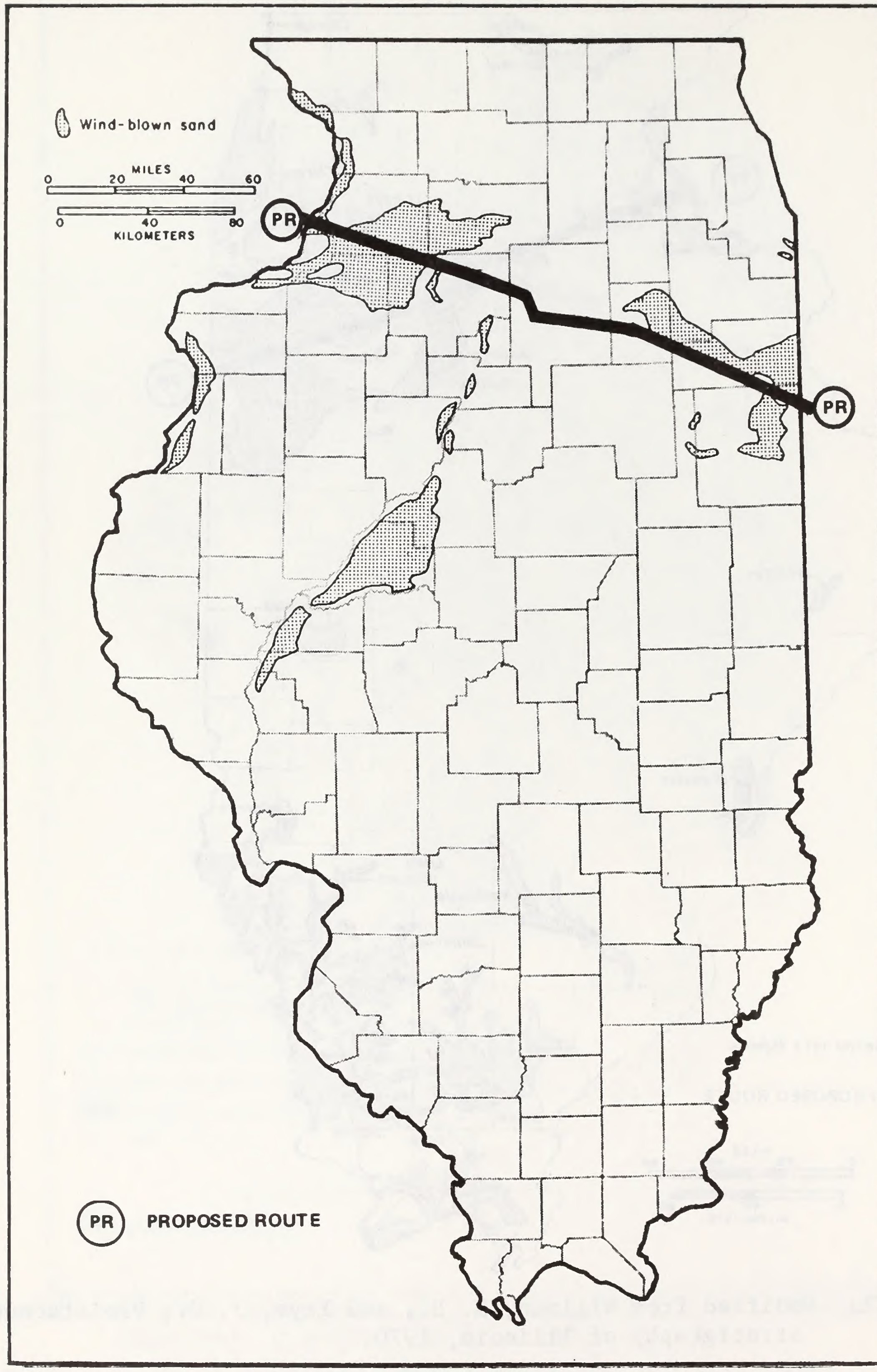
SOURCE: Modified from Piskin, K., and Bergstrom, R. E., Thickness and character of glacial drift in Illinois, 1967.

Figure 2.1.3.3-30 Generalized thickness of glacial deposits in Illinois



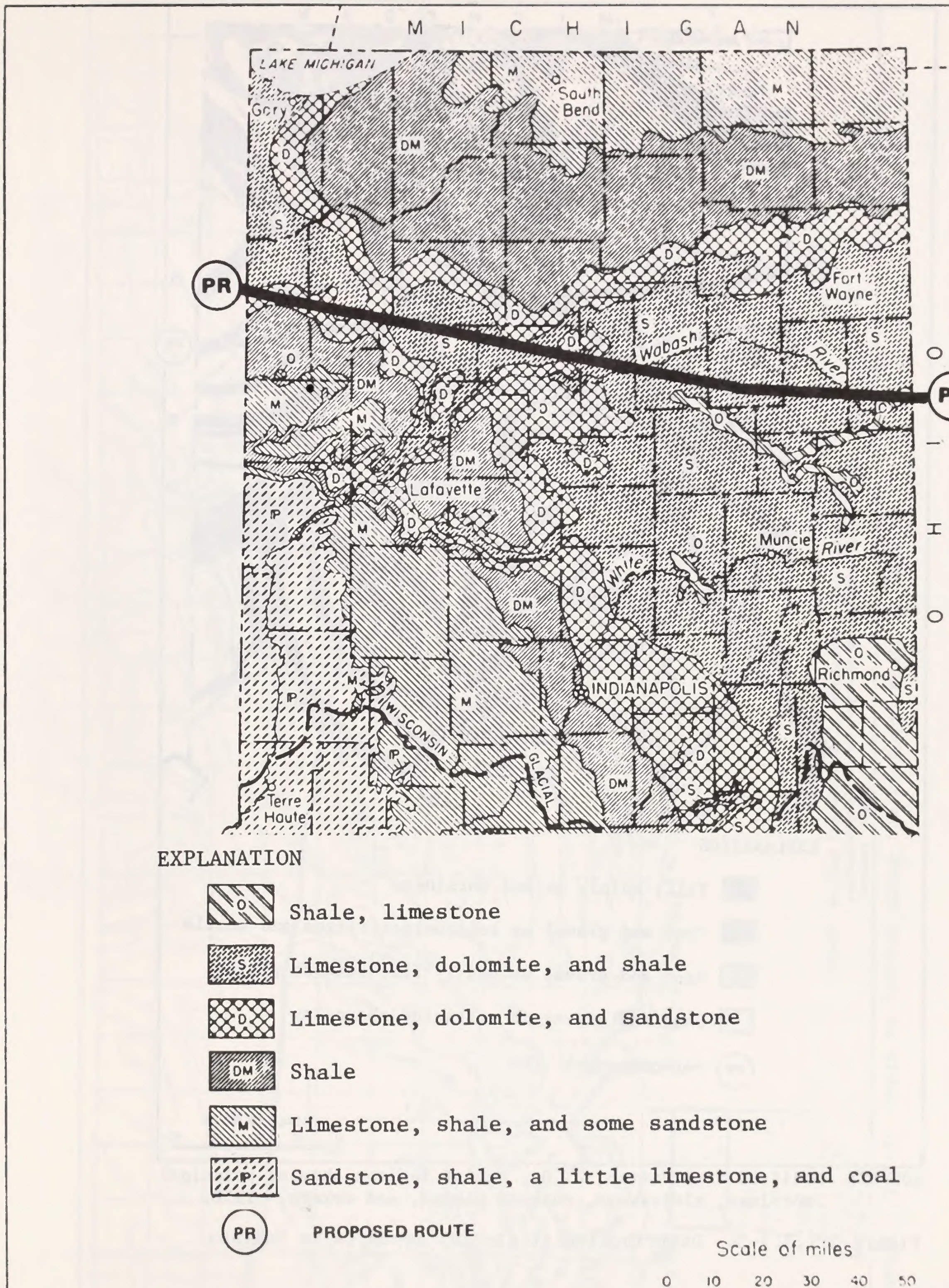
SOURCE: Modified from Willman, H. B., and Frye, J. C., Pleistocene stratigraphy of Illinois, 1970.

Figure 2.1.3.3-31 Areas of glacial-lake deposits in Illinois



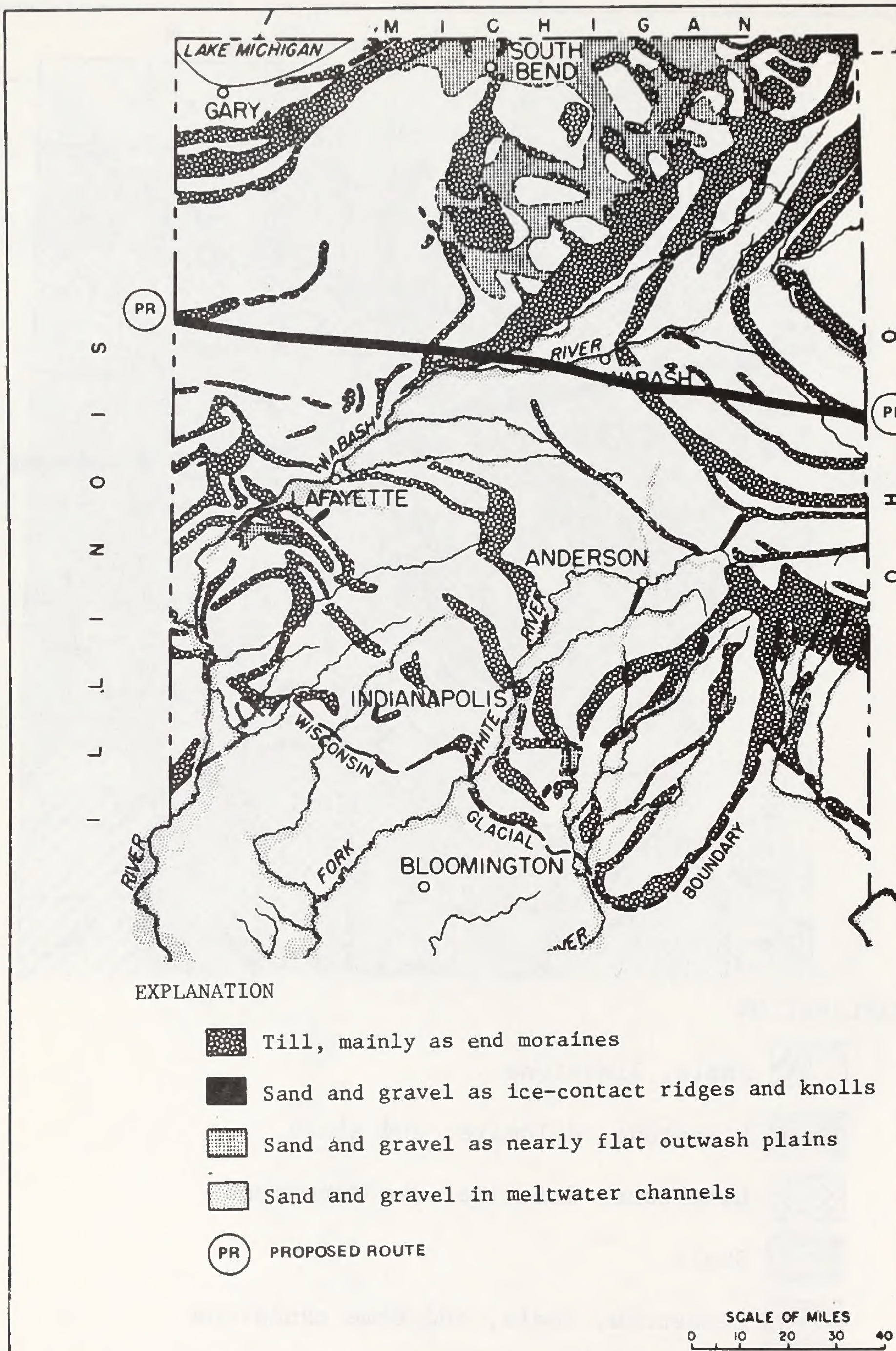
SOURCE: Modified from Willman, H. B., and Frye, J. C., Pleistocene stratigraphy of Illinois, 1970.

Figure 2.1.3.3-32 Principal areas of windblown sand in Illinois



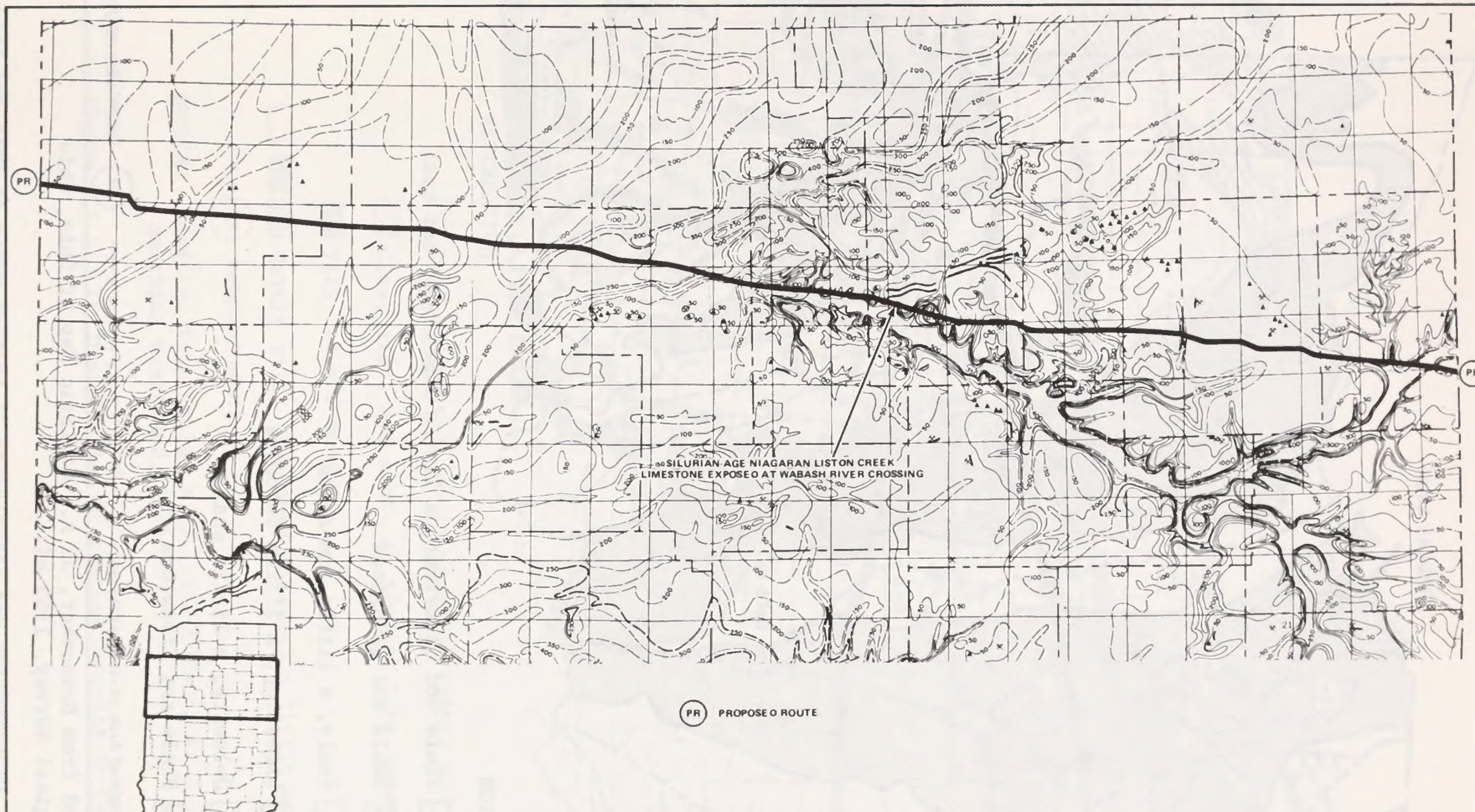
SOURCE: Modified from Patton, J. B., Underground storage of liquid hydrocarbons in Indiana, 1955.

Figure 2.1.3.3-33 Distribution and lithologies of bedrock units in Indiana



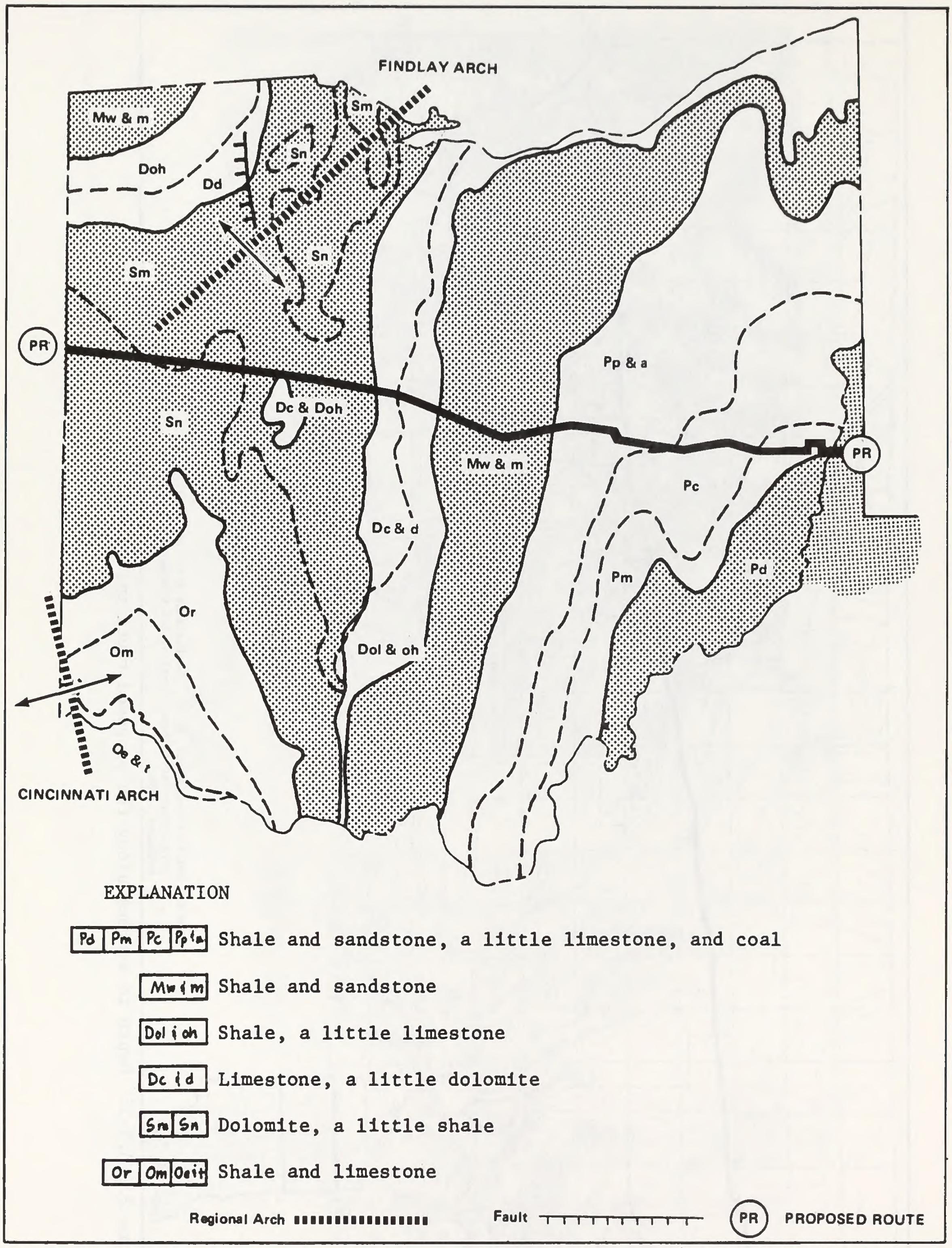
SOURCE: Modified from Patton, J. B., Map of Indiana showing principal moraines, sluiceways, outwash plains, and eskers, 1952.

Figure 2.1.3.3-34 Distribution of glacial deposits in Indiana



SOURCE: Modified from Wayne, W. J., Thickness of drift and bedrock physiography of Indiana, north of the Wisconsin glacial boundary, 1956.

Figure 2.1.3.3-35 Depth to bedrock along the proposed route in Indiana



SOURCE: Modified from Bownocker, J. A., Geologic Map of Ohio, Ohio Geological Survey, 1965 ed.

Figure 2.1.3.3-36 Distribution and lithologies of bedrock units in Ohio and the West Virginia Panhandle

EXPLANATION

- Sand and gravel, as ice-contact ridges and knolls
- Clay, silt, and sand, as glacial lake deposits
- Till, as end moraine
- Mainly till, as ground moraine; a little sand and gravel
- (PR) PROPOSED ROUTE

SOURCE: Modified from Noble, A. G., and Korsok, A. J., Ohio - An American Heartland, 1975.

Figure 2.1.3.3-37 Distribution of glacial deposits in Ohio

EXPLANATION

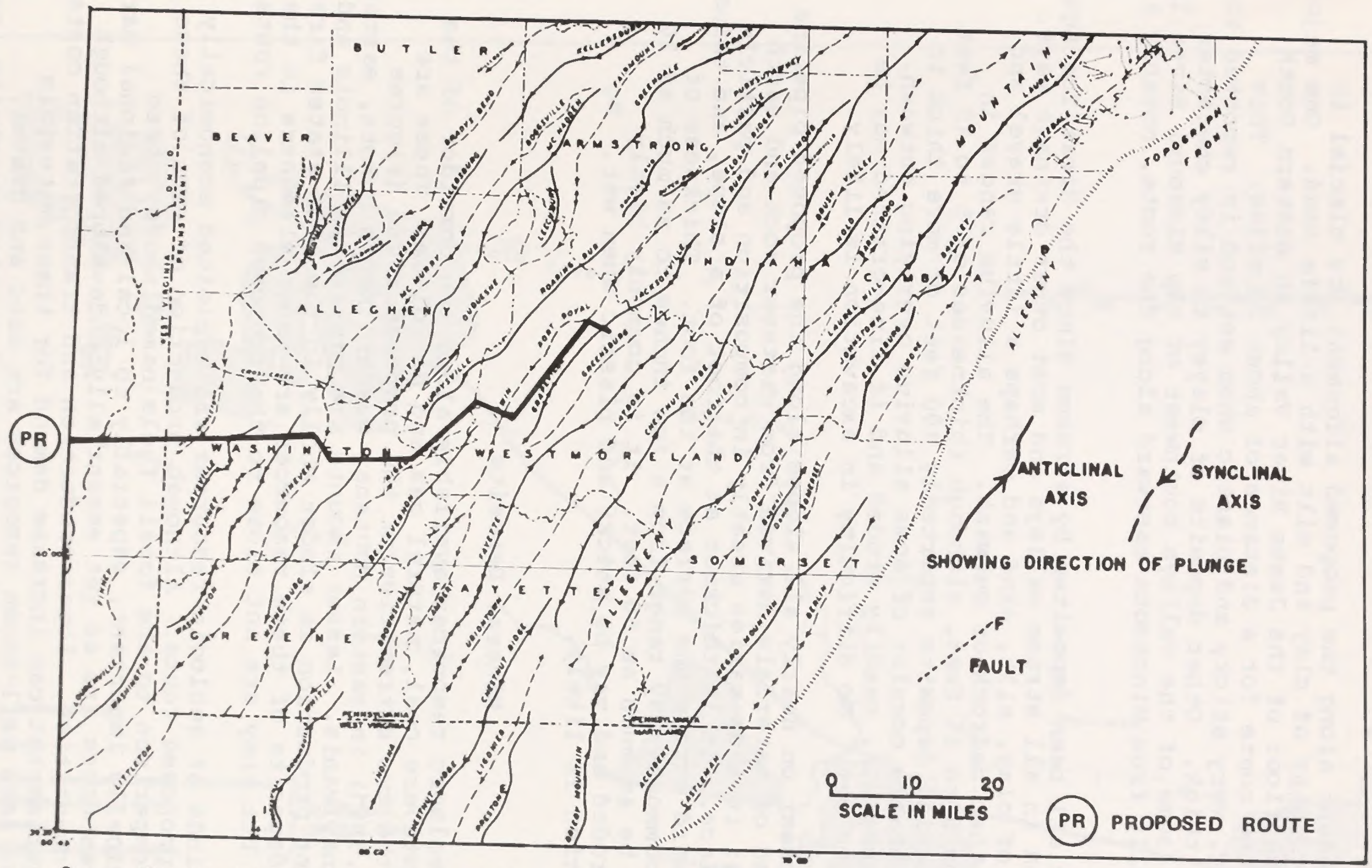
Pd Mainly sandstone; some shale, siltstone, and limestone; a little coal

Pm Mainly limestone; some sandstone, siltstone, and shale; a little coal

Pc Mainly sandstone; some shale and limestone; a little coal

SOURCE: Modified from Sisler, J. D., Map of Coal fields of Pennsylvania, 1929.

Figure 2.1.3.3-38 Distribution and lithologies of bedrock units in southwestern Pennsylvania



Source: Guidebook for Field Trips, Pittsburgh Meeting, The Geological Society of America, 1959.

Figure 2.1.3.3-39 Folds of southwestern Pennsylvania material to stand well in vertical faces with only minor sloughing. The silt is highly permeable and erodes readily. Saturation of the silt while supporting a load may cause some subsidence of the surface. It is easily excavated but some of the finer-grained deposits may cause trafficability problems when wet.

Lake deposits present along the proposed alignment are glacial in origin and generally consist of clay and silt with a little sand. One major deposit which forms the floor of the James River Valley in eastern South Dakota is crossed by the route for a distance of about 22 miles. This deposit is clayey silt, very sticky and plastic when wet and is reported to be as much as 40 feet thick. Other deposits of clayey to silty character may be encountered in some of the valleys southwest of the Missouri River in North Dakota and locally from Minnesota eastward along the route, notably in Illinois.

The alluvium has all been deposited by streams since the Great Ice Age. It will be encountered in all stream valleys and most other drainage ways. It commonly consists of clay, silt, sand and perhaps a little gravel and generally overlies either bedrock or outwash. The alluvium ranges in thickness from perhaps 2 to 25 feet, although thicknesses of 5 to 15 feet are more common. Alluvial deposits reportedly 100 feet or more thick in meltwater channels probably consist of some alluvium overlying outwash. Alluvium is highly permeable, readily eroded and if fine-grained may be sticky and plastic when wet. No difficulty in excavation is likely.

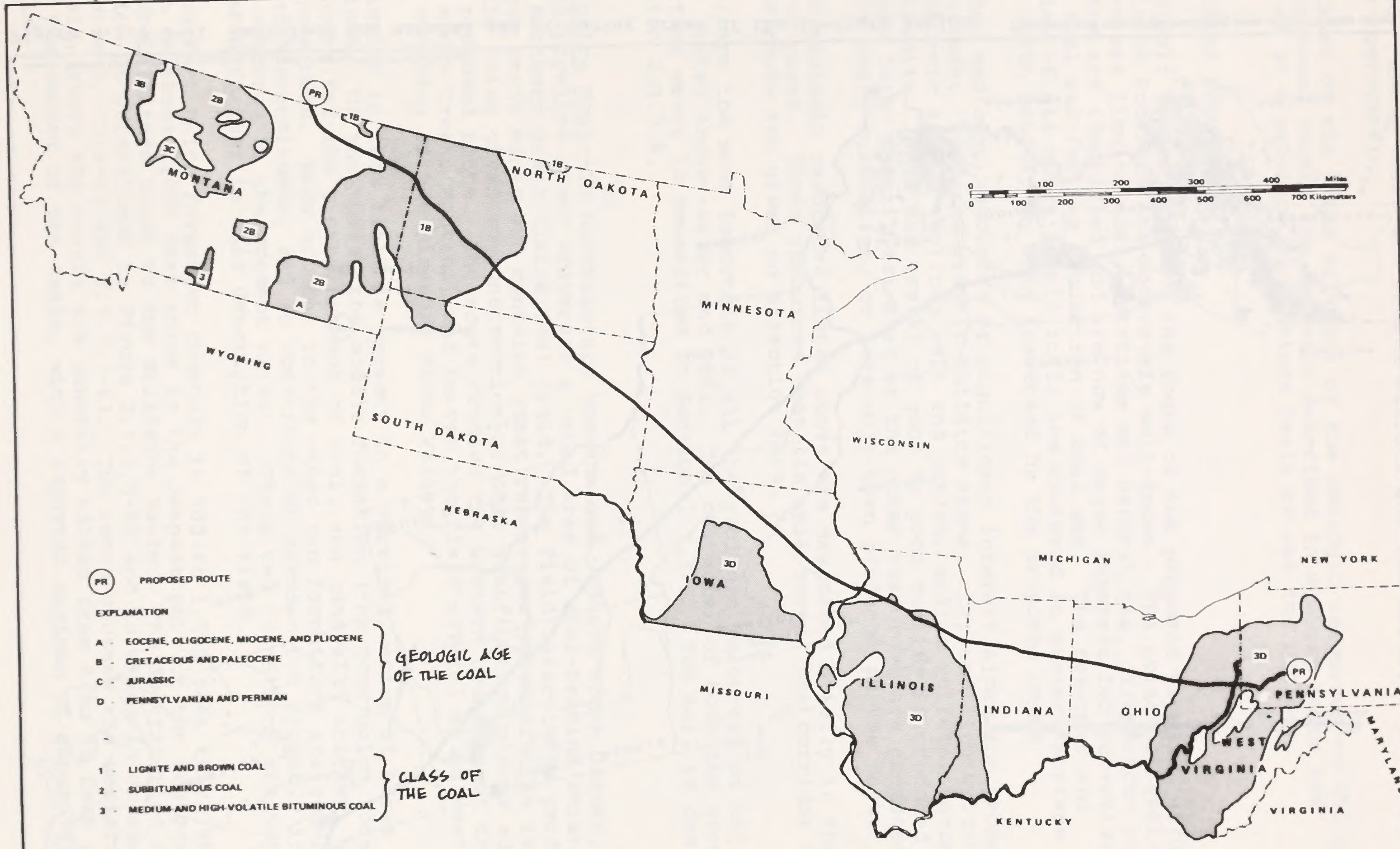
Colluvium is present on nearly all slopes along the proposed pipeline route. It is composed of materials derived from whatever rock and earth materials are upslope; it thus varies greatly in composition and particle size from place to place. It is thickest at the foot of a slope, and thins both upslope and outward across the surface at the foot. Thickness of individual deposits commonly may range from a few inches to as much as 20 feet but locally may be as much as 50 feet. It is commonly highly permeable, readily eroded and may be sticky and plastic when wet. No difficulty in excavation is likely.

Mineral Deposits

The principal geologic resources available along the corridor of the proposed pipeline route are coal, natural gas and petroleum. These are present mainly near the two extremities of the proposed route (Figures 2.1.3.3-40 and 2.1.3.3-41) in eastern Montana, western North Dakota, eastern Ohio and western Pennsylvania. Lesser amounts are present in Illinois and western Ohio. Present production is almost wholly in the four states first named. Significant deposits of these resources are known elsewhere in the several states also, but they are not close to the proposed pipeline route.

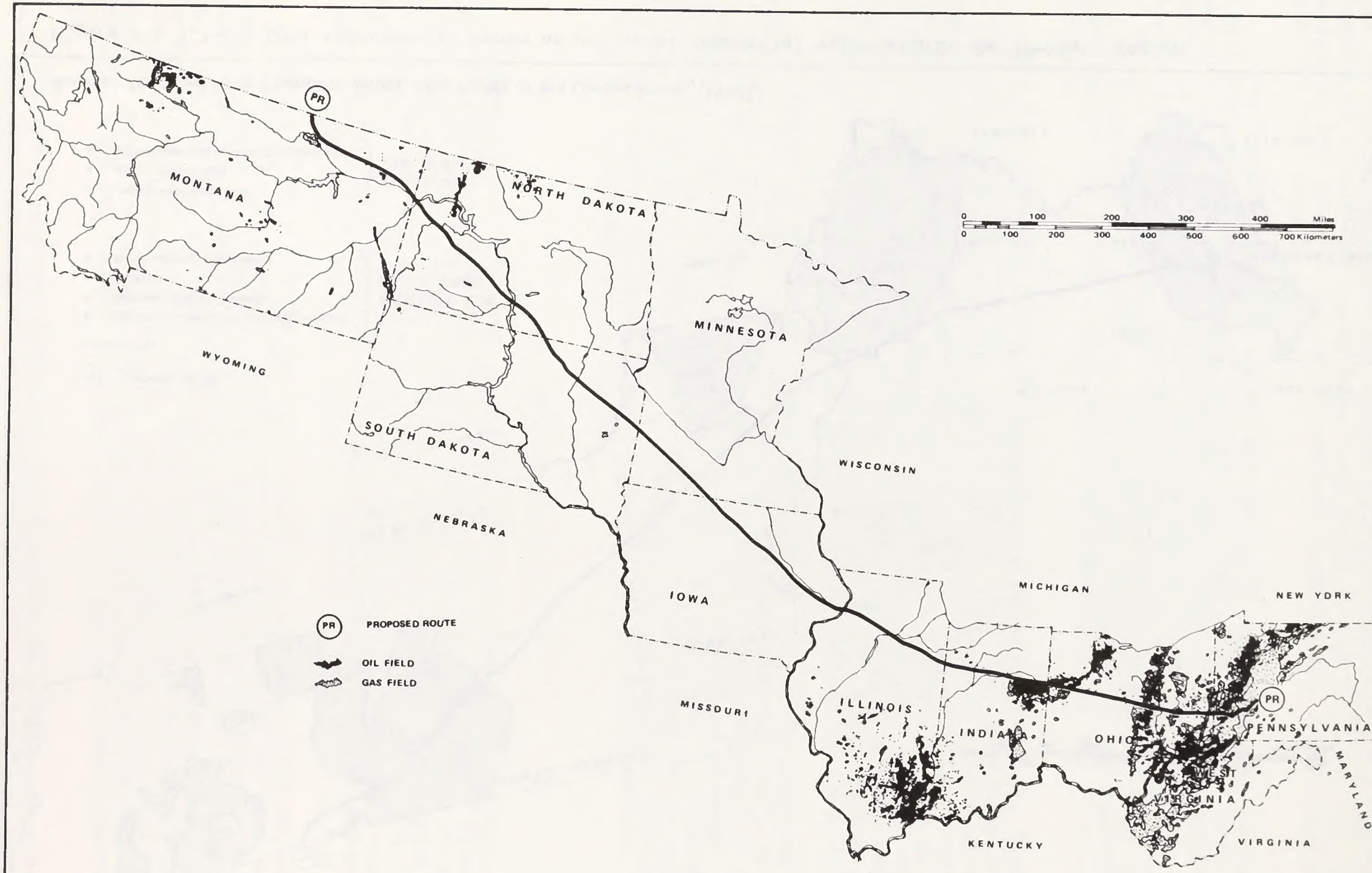
Several other kinds of geologic resources are exploited economically in the vicinity of the proposed route. Although production of each of these is presently small in comparison to the fossil fuels named above, these resources are economically important, especially to local and regional markets. Some of the resources are as yet essentially undeveloped although they occur in great quantities. Lower production and transportation costs together with a larger market can increase demand for these materials sharply. Among these less well-known resources are sand and gravel, limestone, both as crushed rock and dimension stone, crushed quartzite, and salt.

Still other geologic resources are known to be present in places, but either are not being exploited at the present time or have not yet been



Source: Modified from Trumbull, James, Coal Fields of the United States, 1959.

Figure 2.1.3.3-40 Coal resources of known or potential commercial value within the 10-State Region



Source: Modified from Vissides, S.D., and Quirin, B.A., 1963, Oil and Gas Fields of the United States.

Figure 2.1.3.3-41 Petroleum and natural gas producing areas of the 10-State Region

Petroleum and natural gas producing areas of the 10-state region.

exploited. Among these are sodium sulfate and raw material for lightweight concrete aggregate.

Because of the close relation of the geologic resources to the geology of the proposed route, the deposits described in summary below are considered on a province by province basis as was the geology.

Great Plains Province

Geologic resources along the route of the proposed pipeline within the Great Plains Province are moderately well-known. The principal geologic resources are lignite coal, petroleum and natural gas. Tremendous reserves of lignite are identified and are now of major interest for potential use both as fuel and for the production of coal gas. The reserves and production of all three fossil fuels are centered in eastern Montana and western North Dakota, an area traversed by the proposed route.

Other geologic resources of significant interest along the proposed route include: sand and gravel, building stone, clay and lightweight aggregate, volcanic ash, a zeolite, salt and potash, sodium sulfate, porcellanite and leonardite. Sand and gravel of good to poor quality is produced in moderately large quantities; most of the other resources are produced presently in small quantities, or have only been produced in the past.

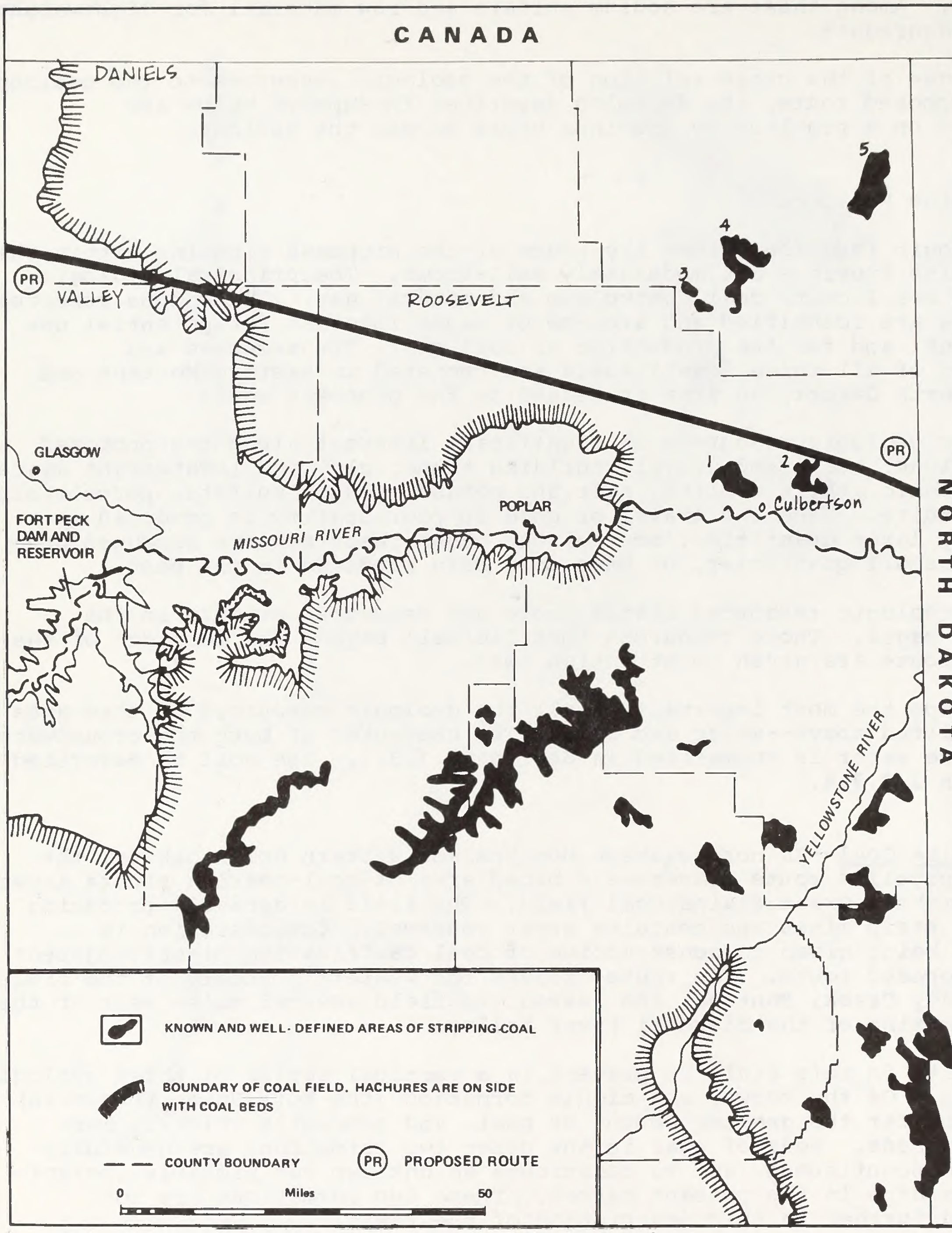
The geologic resources listed above are described briefly in the following pages. Those resources that lie well beyond the corridor of the proposed route are given no attention here.

Perhaps the most important of all the geologic resources of this area are not listed above--water and soil. The character of both the groundwater and surface water is summarized in Section 2.1.3.5. The soil is described in Section 2.1.3.4.

Lignite Coal--In northeastern Montana and western North Dakota, the proposed pipeline route traverses a broad area of coal-bearing strata known as the Northern Great Plains Coal Field. The field is actively producing coal from strip mines and contains great reserves. Consideration is presently being given to construction of coal gasification plants adjacent to the proposed route. The route crosses the western boundary of the field at Big Muddy Creek, Montana, and leaves the field several miles west of the second crossing of the Missouri River Valley.

Lignite in this field is present in a vertical series of three geologic formations. Of the three, the middle formation (the Fort Union Formation) contains by far the greater amount of coal, and generally thicker, more continuous beds. Beds of coal in the other two formations are generally thin and discontinuous, and so constitute an unknown but probably insignificant resource in the present market. These two formations are not considered further in this description of the field.

The Fort Union Formation commonly is 500 to 1,000 feet thick and may be as much as about 2,000 feet thick in the deepest part of the regional structural feature known as the Williston Basin. The distribution of the formation is generalized in Figure 2.1.3.3-40 and is shown in greater detail in Figures 2.1.3.3-42 and 2.1.3.3-43. The route crosses the western part of the basin, where the strata are generally tilted from 5 to 50 feet per mile toward the center of the basin, with a reported maximum of about 180 feet per mile.



SOURCE: Modified from Stripping Coal Deposits of the Northern Great Plains, U.S. Geological Survey, 1974.

Figure 2.1.3.3-42 Identified areas in northeastern Montana in the Northern Great Plains Coal Field

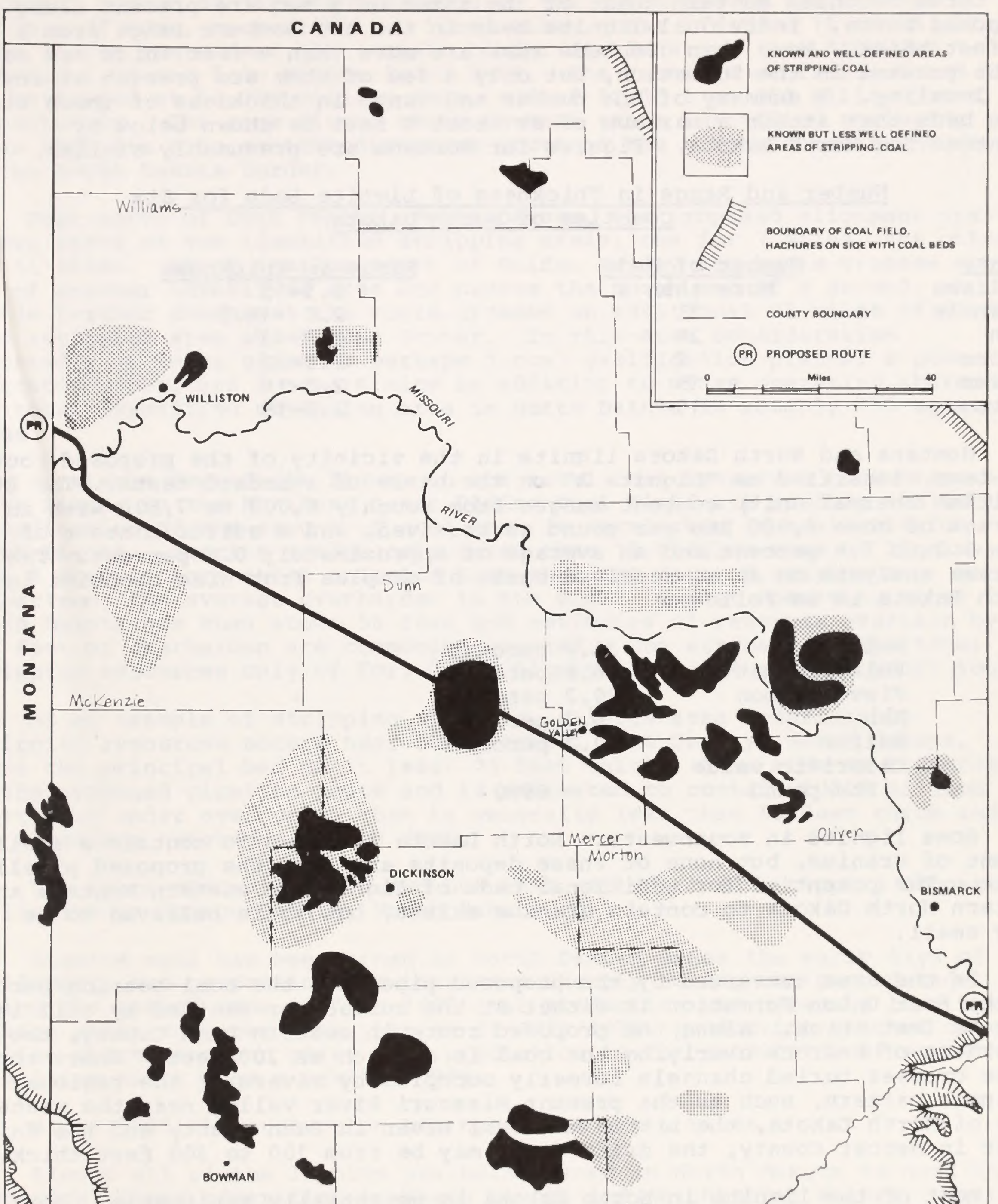


Figure 2.1.3.3-43 Identified areas in western North Dakota of stripping-coal in the Northern Great Plains Coal Field

The Fort Union Formation has been divided into four units (or members) and three of these contain coal; of the three only two are present along the proposed route. Individual lignite beds in the two members range from 1 to 44 feet thick. More than 100 beds that are more than 4 feet thick are said to be present in the formation, but only a few of them are present at any one locality. A summary of the number and range in thickness of those lignite beds that attain a maximum of at least 4 feet is shown below by counties for North Dakota. Figures for Montana are presumably similar.

Number and Range in Thickness of Lignite Beds for Six Counties of North Dakota

County	Number of Beds	Range in Thickness
Williams	More than 6	2.5-15
McKenzie	21	2.0 -14.5
Dunn	24	2.5-13
Mercer	7	2.5-22
Oliver	15	2.5-14
Morton	15	2.5-15

Montana and North Dakota lignite in the vicinity of the proposed route has been classified as "Lignite A" on the basis of standard tests. The Btu (British Thermal Unit) content ranges from roughly 6,000 to 7,500 with an average of some 6,800 Btu per pound as received, and a sulfur content of from 0.2 to 1.4 percent and an average of approximately 0.6 percent. The average analysis on an as-received basis of samples from nine counties in North Dakota is as follows:

Moisture	36.4 percent
Volatile matter	26.6 percent
Fixed carbon	30.2 percent
Ash	6.7 percent
Sulfur	0.7 percent
Calorific value Btu/pound	6990

Some lignite in southwestern North Dakota is known to contain a small amount of uranium, but none of these deposits are near the proposed pipeline route. The potential for additional beds of lignite in eastern Montana and western North Dakota to contain uranium exists, but it is believed to be very small.

In the area traversed by the proposed pipeline, the coal-bearing part of the Fort Union Formation is either at the surface or mantled by till less than 10 feet thick. Along the proposed route in eastern Dunn County, the thickness of bedrock overlying the coal is as much as 200 feet. Where the route crosses buried channels formerly occupied by rivers of the regional drainage pattern, such as the present Missouri River valley near the western edge of North Dakota, the Little Missouri River in Dunn County and the Knife River in Mercer County, the drift cover may be from 100 to 300 feet thick.

Most of the lignite in North Dakota is potentially strippable. Some 70 percent of the deposits are estimated to underlie less than 500 feet of overburden, 28 percent to underlie from 500 to 1,000 feet of overburden, and 2 percent to underlie from 1,000 to 2,000 feet of overburden.

Production and Reserves--In northeastern Montana, the proposed route passes some 2 miles north of an identified stripping area located just west of Culbertson, Montana, and about 8 miles northeast of that community the route traverses about 2 miles of a second identified stripping lignite resource (see "fields" numbered 1 and 2 on Figure 2.1.3.3-42). The estimated amount of lignite available in the two areas is 331 and 100 millions of tons, respectively. Three other areas lie from 15 to 45 miles north of the route near the eastern border of the state (see "fields" numbered 3, 4 and 5 in Figure 2.1.3.3-42. The reserves of fields 3 and 4 are estimated at 58,246 million tons, and of field 5 at 150 million tons, respectively. The same figure shows several other identified stripping areas that lie even greater distances south of the proposed route and west of the North Dakota border.

Just north of Dunn Center, North Dakota, the proposed alignment traverses parts of two identified stripping areas, one for 7 miles, the other for 11 miles. About 6 miles south of Golden Valley the route crosses the tip of another identified area and passes the north end of a second. A little farther southeast the route crosses an additional 22 miles of identified stripping area about Dunn Center. In this area consideration reportedly is being given to perhaps 5 coal gasification plants, 2 power generator sites, and 1 export mine in addition to mines operating there now. The total identified stripping area in North Dakota is roughly 750 square miles.

No single dependable figure on the total coal resources of Montana and North Dakota in the Northern Great Plains Coal Field are readily available. An indication of the amount of coal that is obtainable is available for North Dakota. Averitt (1970) calculated that 15 billion tons of lignite in beds 5 feet or more thick underlie less than 100 feet of overburden. For comparison, the average overburden in the eight largest operating mines in North Dakota was then about 56 feet and estimates of reserves overlain by 200 feet of overburden are commonly prepared. One estimate of the total stripping resources only of Fort Union lignite is 5,614 million short tons.

As an example of stripping reserves, a large area underlain by stripping resources occurs near Dunn Center, Dunn County, North Dakota, where the principal bed is at least 13 feet thick. This area is traversed by the proposed pipeline route and is estimated to contain 1,500 million short tons under overburden that is generally less than 50 feet thick and has a maximum thickness of 100 feet.

The route also crosses known but less well-defined stripping deposits of lignite in Morton County, North Dakota.

Lignite coal has been mined in North Dakota since the early days of settlement, and production has increased sharply during the past decade. During the period from 1960 to 1965 coal production was commonly less than 3 million short tons per year, but as of July 1974, production reached over 7 million short tons per year. One prediction is for production of more than 10 million short tons a year by 1976.

Since 1965 all production has been from strip mines.

Almost all of the lignite now being mined in North Dakota is used in electrical power generation in North Dakota and neighboring states. Unit trains hauling coal only have been in operation since the middle 1930's.

Petroleum and Natural Gas--The proposed pipeline route avoids nearly all localities of petroleum and natural gas production in the Great Plains Province, but the route does cross the end or flank of some producing geologic structures. The principal structure of the region is the Williston Basin; the center of which is a short distance southeast of that city. The bedrock strata are tilted downward toward the center of the basin, but their attitude is locally interrupted by small structures; only two of these are major. One is the Nesson Anticline, situated on the northeast flank of the Williston Basin; another is the Cedar Creek Anticline on the southwestern flank, and a third is the Poplar Dome on the northwestern flank (Figure 2.1.3.3-3). Some of the local structures are known or believed to be associated with faulting, now apparently inactive.

The northern flank of the Poplar Dome is crossed about 18 miles north of Poplar, Montana. The proposed route also crosses the south flank of a small oil field near the town of Dwyer, Roosevelt County, Montana, where at least one successful large well was completed in 1974. Both structures produce petroleum of paraffinic base from strata several thousands of feet beneath the ground surface.

The southeasterly course of the proposed pipeline after the first crossing of the Missouri River lies about 8 miles southwest of the most southerly oil wells presently on the Nesson Anticline and about 20 miles northeast of the nearest wells in Billings County, North Dakota. These wells all produce from several thousand feet depth also.

<u>Potential for Discovery</u>--New wells may serve to extend the areas of production on known structures and may discover new minor structures. Within the last decade the number of wildcat wells has decreased by nearly 25 percent although the number of dry wells has remained nearly the same at about 5 out of 6 drilled.

<u>Sand and Gravel</u>--Deposits of sand and gravel are present at many localities along the proposed route. Most of those that are of economic significance were laid down by meltwater streams, some in preglacial valleys, some in channels cut by the meltwater. Other deposits of glacial origin accumulated in direct contact with the ice, and now constitute isolated knolls and ridges scattered about the ground moraine surface. In addition a few deposits were laid down by modern streams that reworked the older glacial material.

Sand and gravel deposits of meltwater streams are of two types. One type consists mainly of thin accumulations, generally from 1 to 20 feet thick, laid down in broad, shallow channels cut into the upland surface at many localities by meltwater draining from the ice front. The deposits vary locally in thickness and may be discontinuous; the channels may be traced for as much as a few miles. Material in these deposits is fairly well sorted, may contain beds of well-sorted sand, and varies in quality from place to place. Undesirable constituents for aggregate use are varied. Lignitic and woody material may be intermixed in small amounts; some clay and silt may be present throughout or in thin beds, and fine-grained siliceous material, including chert, may be scattered through the sand and gravel fractions.

The other type of meltwater deposit consists of relatively thicker, more continuous accumulations of sand and gravel. These partly fill preglacial valleys or drainage ways that represent major meltwater routes or drainage diversion courses. The deposits range from about 25 to 300 feet or more thick, and the character of the material in them is similar to the deposits described above.

Isolated knolls and ridges of sand and gravel deposited in contact with the ice front constitute deposits of generally poorer quality than those described above. The size of these features can be as much as one-half mile across and 100 feet high, and for the ridges, less than a half mile long and

100 feet high. The material within these land forms is somewhat similar to the deposits described above, but these are likely to contain considerably larger quantities of clay and silt, and the stones contained may include large boulders. These deposits have very poor lateral and vertical continuity of material: changes commonly are abrupt and closely spaced.

Sand and gravel deposits in channels cut by meltwater are most likely to be encountered in the area prior to the first crossing of the Missouri River valley. Deposits that occupy preglacial channels, including those in the Missouri River valley itself, are most expectable in the area between the first and second crossing of that valley. Ice-contact deposits probably are most common along the proposed route from the second crossing to the foot of the Coteau du Missouri escarpment.

The gravel that underlies the Flaxville Plain in northeastern Montana probably averages about 40 feet thick. It contains beds of sand, silt, some clay and stones of very hard quartzite as large as small boulders. The deposit was laid down by streams and has since been firmly cemented by calcium carbonate cement. Erosion of the material, and its redeposition before the ice age, left deposits of similar material widely spread about the area traversed by the route in Montana although they are commonly mantled by drift, colluvium, and alluvium.

The lack of crushed rock production in the vicinity of the proposed route makes the sand and gravel resources more significant.

Production and Use--Sand and gravel obtained in the vicinity of the proposed route is mostly used for highway construction and maintenance, and partly for concrete aggregate in the local area. Pit-run material is generally considered to constitute a fair to poor aggregate which can be significantly upgraded by appropriate methods. Opened pits may remain inactive for periods of a few years until local demand brings about temporary reopening. Users requiring high-quality aggregate ship material in by rail, or locally by truck.

Some pits, particularly those adjacent to the larger communities, may maintain records of production, but most pits supplying smaller needs may not, or do not, keep them. Sufficient information to permit predictions as to resources remaining is unavailable.

Potential for Discovery--Probably most deposits have been identified by local residents and by state and county highway departments. In most cases little or no information regarding reserves or quality of material is available, although rough estimates may be held by the highway departments.

Smaller deposits in meltwater channels are likely to be encountered prior to the first crossing of the Missouri River valley and after the second crossing. Larger deposits of glacial origin are more likely in the area southwest of the Missouri River between the two crossings. Knoll and ridge deposits may be found along the route prior to the first crossing, but probably will be most common after the second crossing. The Flaxville Plain gravel and its reworked equivalent is present only in northeast Montana.

Minor Resources--Building Stone. Massive sandstone formerly was quarried for local use mainly as building stone near Linton, Emmons County, North Dakota. The quarry reportedly was located in a tributary of the Missouri River near the proposed second pipeline crossing of that valley.

Quarrying has not been carried on for many years, and renewal of the operation is not likely in the present market.

Clay and Shale--Large quantities of claystone and shale are present in some of the bedrock formations of the region. In the vicinity of the proposed route the only use of clay has been for the production of face brick by a plant situated at Hebron, Morton County, North Dakota; the plant has been in operation since 1905 and now uses about 36,000 tons of clay a year. Kaolinite is the dominant clay mineral in the bedrock unit used, and abrupt changes in composition of the bed both vertically and laterally are common.

Large quantities of clay suitable for both brick and lightweight concrete aggregate are produced by stripping lignite, but the present market is too small to support additional development for these byproducts.

Volcanic Ash--A bed of volcanic ash 26 feet thick is located in the vicinity of Linton, Emmons County, North Dakota. This resource is estimated to contain 500 million tons of the material. It can be processed to meet requirements for fly ash and raw or calcined natural pozzolans for use in portland cement concrete. With the addition of lime, it can be used in stabilization of certain soils used in highway construction. The discovery of larger or better beds of volcanic ash is not likely.

Zeolites--The zeolite Clinoptilolite is present in significant quantities in certain bedrock layers exposed southwest of the Missouri River, but none is believed to be presently exploitable. The material constitutes a valuable industrial mineral used in chemical processing, and also in agriculture and animal husbandry. The discovery of larger or better beds is possible elsewhere in the state.

Salt and Potash--Salt constitutes as many as 11 principal beds that underlie all or parts of northeastern Montana and northwestern North Dakota. Eight of these beds have a total maximum thickness of at least 500 feet beneath the proposed route; of this thickness, approximately 10 feet is potash. The second uppermost of the eight beds is mined by solution at Williston through wells some 8,000 feet deep. The uppermost surface of the uppermost salt bed may be no closer to the ground surface beneath the route than 7,500 feet. No record of the quantity of the salt produced annually is readily available, but it is probably a fraction of one percent of all the salt produced in the United States. None of the potash is produced, although it is produced in great quantities from these same deposits north of the Canadian Border. No discovery of new deposits of salt or potash is likely.

Sodium Sulfate--In northeastern Montana, sodium sulfate is present as a brine in some undrained depressions in the ground moraine surface. Locally, these brines are underlain by as much as 80 feet of layered deposits of crystalline sodium sulfate precipitated from the brine. Some of these deposits lie just north of the proposed pipeline route in the vicinity of Big Muddy Creek, Montana. Within the two states the reserves are estimated at about 30.5 million short tons. Similar deposits are mined just across the Canadian Border. No production is reported from the two states, and the discovery of additional deposits is unlikely. The material is used in the production of paper, paint, glass and other industrial processes.

Porcelanite--Baked clay or shale, porcelanite, is widely known as "scoria" or "clinker", and is the product of natural firing of an overlying clay or shale bed by a burning bed of lignite. The reddish material is moderately to very dense, hard to very hard, and fragmented; the character of the material may vary greatly within a single deposit, which may be from 1 to perhaps as much as 15 feet thick. Occurrences are wide-spread and recognizable at a distance because of the characteristic color. They generally are found southwest of the Missouri River valley, where the rock is used as road metal, low-grade concrete aggregate, and decorative stone.

Leonardite--Thoroughly weathered lignite, or leonardite, is an earthy, medium brown material resembling powdered coal. It is associated to a greater or lesser degree with many natural exposures of lignite southwest of the Missouri River, and is produced commercially at four locations in western North Dakota, one of them not far from Williston. Its various industrial demands are small and include use as a soil conditioner dispersant, stain and viscosity-control agent in oil-drilling muds. No information is available about past production. Additional significant deposits may be found along the proposed route, but probably would be of little economic value.

Central Lowland Province

Geologic resources along the proposed route of the pipeline within the Central Lowland Province generally are well known. The principal resources in terms of production value are limestone and dolomite, petroleum and natural gas, sand and gravel and clay and shale. Other significant geologic resources along the proposed route include bituminous coal, peat, building stone, silica sand and quartzite.

Reserves of limestone, and dolomite, building stone, and of clay and shale are very great. Those of petroleum and natural gas, sand and gravel, coal and quartzite are moderate. Small reserves of peat are known. Specific sites for future exploitation of these reserves are not known to have been identified as is true for lignite coal in northeastern Montana and western North Dakota.

Of the named resources, coal is produced on a limited basis in Illinois; quartzite is not and has not been produced commercially in the vicinity of the proposed route, but is produced at several commercial quarries near New Ulm, Minnesota, and in nearby South Dakota.

The geologic resources listed above are described in the following pages. Some locations at which coal, sand and gravel, and clay and shale are produced in the states of Minnesota, Iowa and Illinois are indicated on the following maps (Figures 2.1.3.3-44, 2.1.3.3-45 and 2.1.3.3-46). Those resources that lie well beyond the corridor of the proposed route are given no attention here.

Perhaps the most important resources in the Central Lowland Province are the agriculture soil and the surface water and groundwater. These are described in Sections 2.1.3.4, and 2.1.3.5.

Petroleum and Natural Gas--Illinois, Indiana and western Ohio are among the oldest petroleum and natural gas producing states in the United States. The producing areas reached maturity by the turn of the century, and the present outlook for the future is bleak.

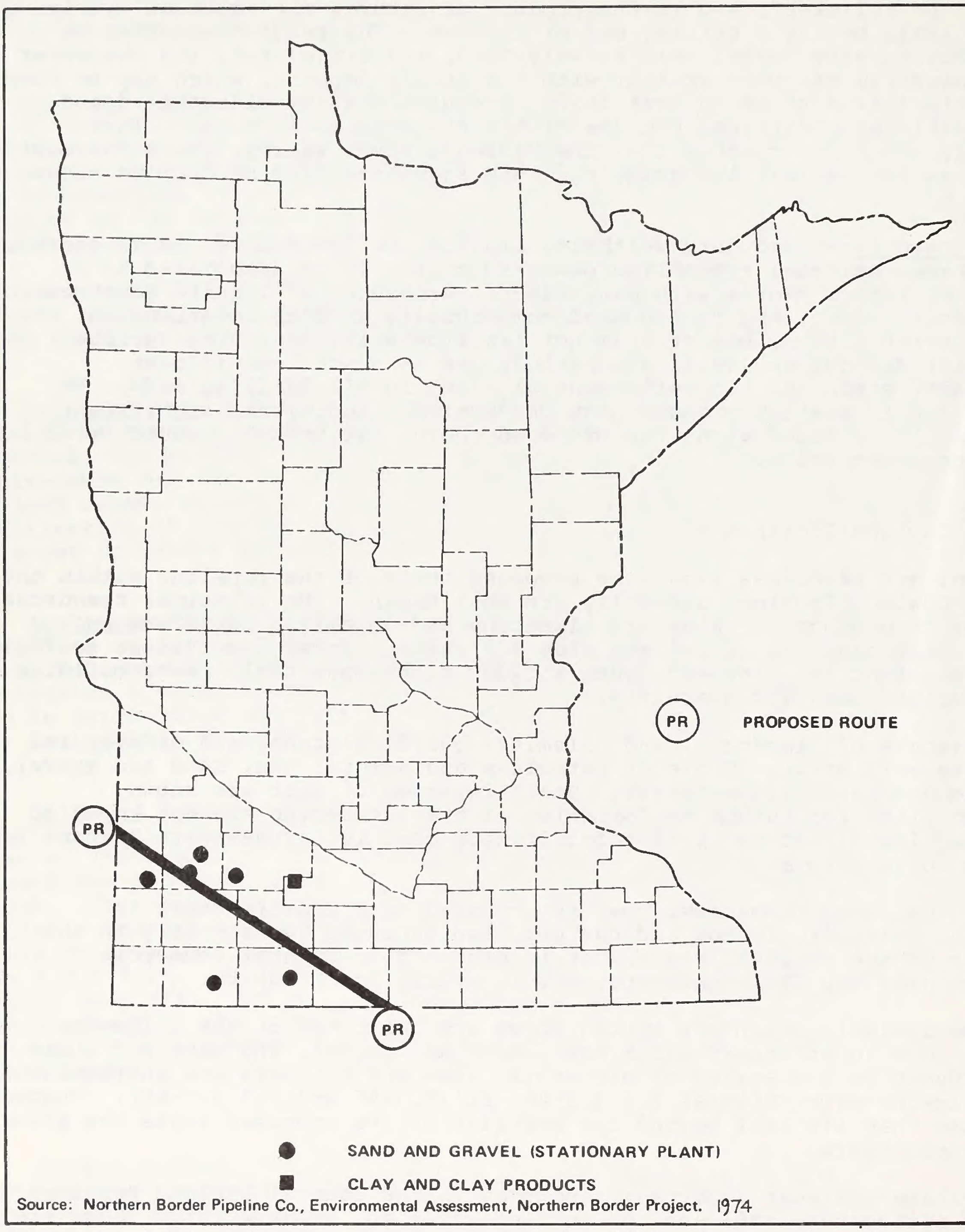
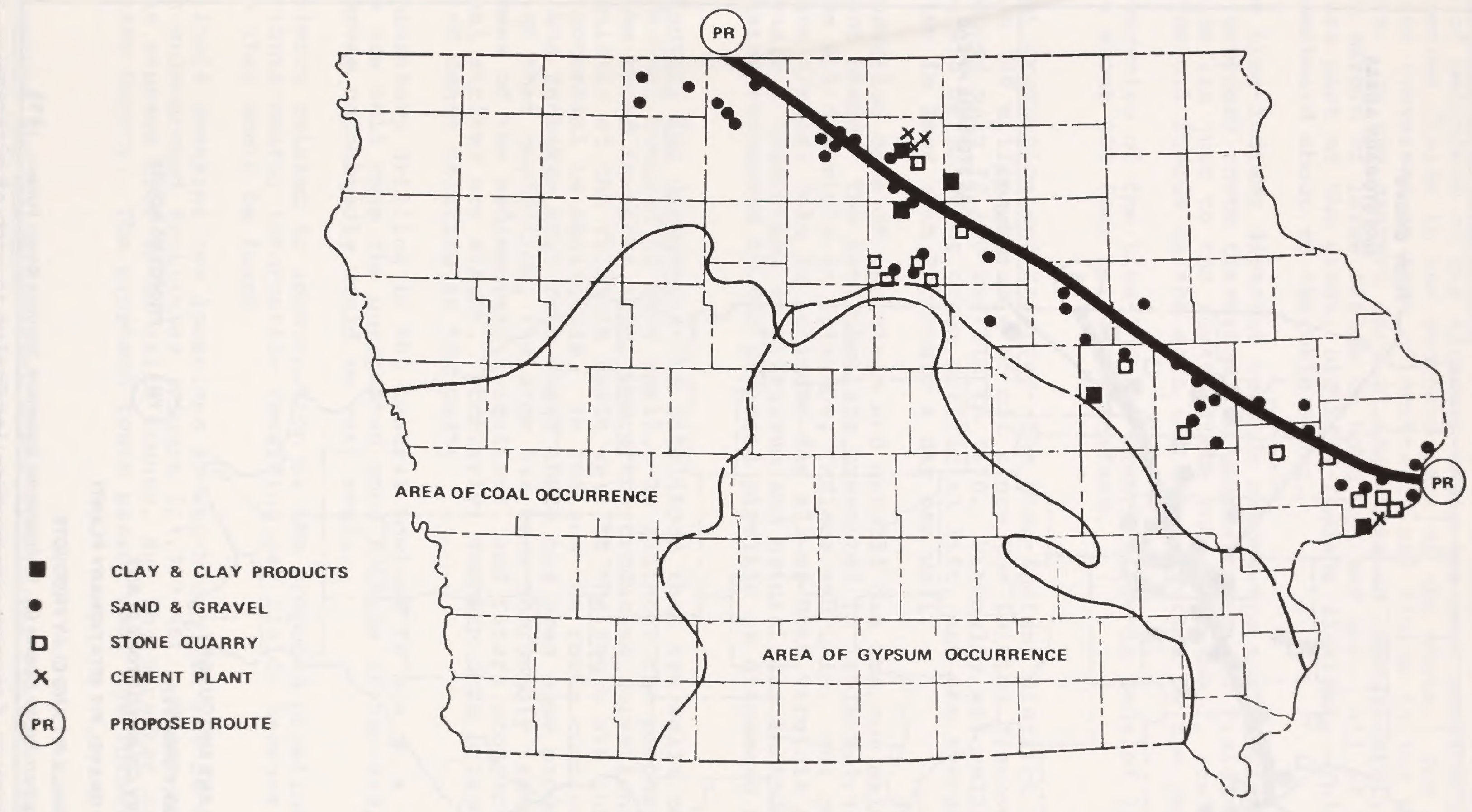
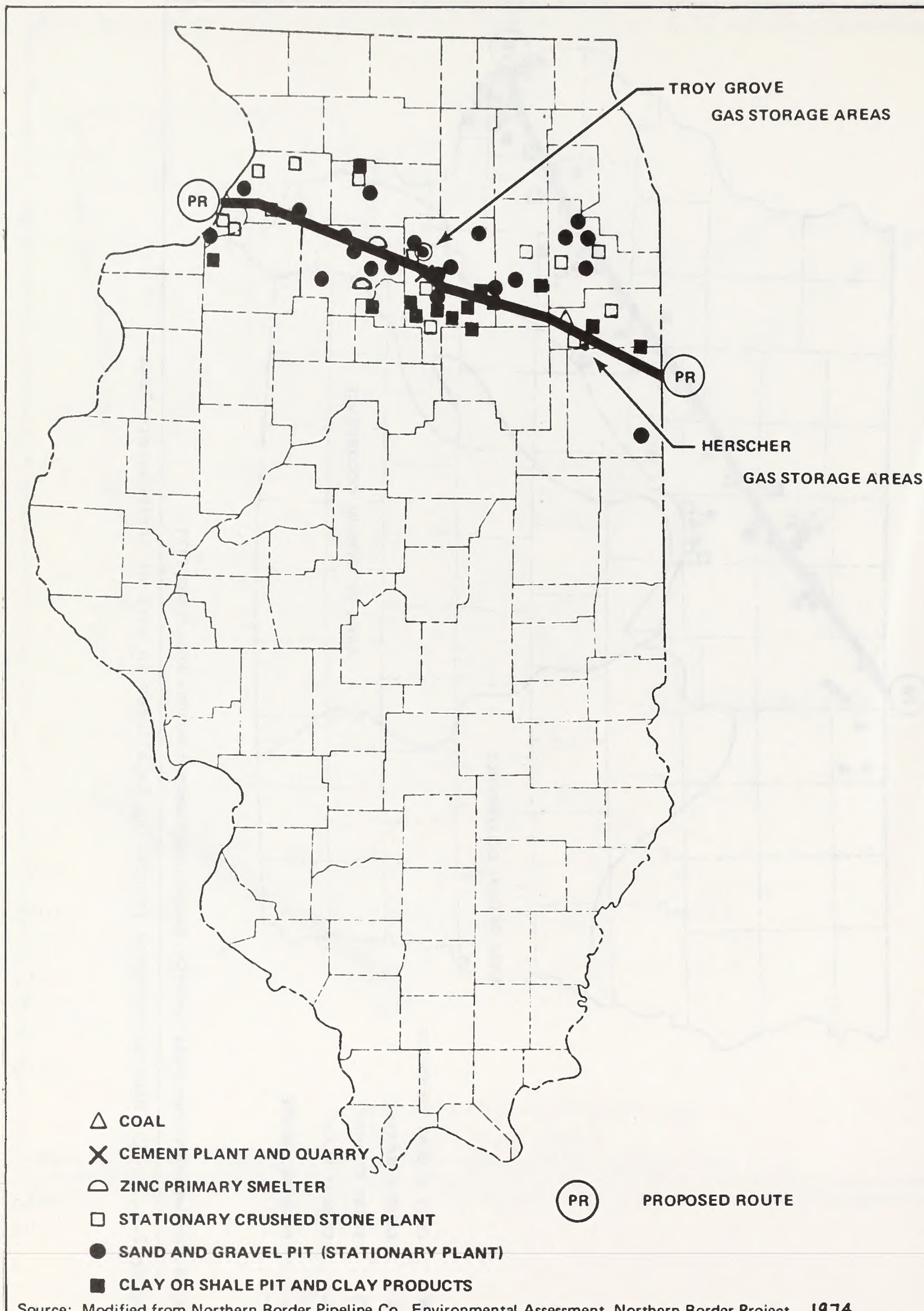


Figure 2.1.3.3-44 Mineral-resource processing localities in part of southwestern Minnesota



Source: Modified from Northern Border Pipeline Co., Environmental Assessment, Northern Border Project, 1974

Figure 2.1.3.3-45 Mineral-resource processing localities in part of northeastern Iowa



Spurce: Modified from Northern Border Pipeline Co., Environmental Assessment, Northern Border Project. 1974

Figure 2.1.3.3-46 Mineral-resource processing localities in part of northern Illinois

Known Producing Districts--In northern Illinois there has been no production of petroleum or gas although there has been considerable production from numerous fields in the southern part of the state. The proposed route in Indiana traverses an area of scattered oil fields in the western half of the state. In the eastern part of the state it approximately follows the northern margin of large fields of both oil and gas. All of these Indiana fields are part of the great, old Lima-Indiana district. This district extends southward about to the Ohio River.

The Lima-Indiana district extends across the northeastern part of Ohio, and the proposed route traverses the southernmost oil fields of this trend. Gas fields lie just to the south of the route but small, scattered fields border the oil fields on the east and are traversed by the route.

Reservoirs of the Lima-Indiana district are in beds of limestone and dolomite about 800 feet below the surface.

Past Production and Reserves--The Lima-Indiana district has produced more than 100 million barrels of oil since the initial discovery in 1886, but produced only 12,400 barrels in 1970. Virtually all wells produce only with the aid of pumps or other artificial lift, and the average daily production is less than 2 barrels a day per well.

Production data of petroleum and natural gas are not maintained on a consistent basis. The data that are presented in Table 2.1.3.3-1 include those for all districts in Illinois, Indiana and Ohio. For convenience and comparison similar data is included for all of West Virginia and Pennsylvania. Production of petroleum and natural gas in those parts of these states traversed by the proposed pipeline is discussed below.

Potential for Discovery--The likelihood that new wells can be developed in the Central Lowland is very small. In Illinois the proposed route lies across the broad Kankakee Arch, where the producing formations characteristic of the Illinois Basin well to the south are thin or absent and the potential is negligible. In Indiana the route continues across a part of the Kankakee Arch from which there has been some production. Because of that production, the area has been thoroughly tested by drilling to the base of the sedimentary formations, and future prospects of additional strikes are slight. Similarly, western Ohio prospects are slight because of dense drilling in the past.

Exploratory drilling in the Central Lowland is now at a very low level. Should a new well have the unexpected good fortune of success, the pool and its reserves undoubtedly would be very small.

Activity related to construction of the proposed pipeline is not likely to contribute useful information regarding new fields because of the depth at which they would be found.

Illinois contains two locations at which natural gas is stored temporarily in underground facilities (Figure 2.1.3.3-46). These are the Troy Grove gas storage area in La Salle County, and the Herscher gas storage area in Kankakee County. The proposed route passes near the former, and over the latter.

Limestone and Dolomite--Each state within the Central Lowland Province produces crushed limestone, dolomite or both at several quarries located near the proposed route. For example, Iowa has perhaps 16 producing

Table 2.1.3.3-1 Petroleum production, reserves and well development, by States

	Production 1/				Reserves 1/ end 1973		Average oil Production	Percent Oil Production		Wells Drilled 1973	
	1973		Cumulative								
	Oil	Gas	Oil	Gas	Oil	Gas	BO/well/D	Stripper 2/	Pumping	Exploratory	Developed
Illinois	29	3	3,098	1,452	152	381	3.4	95	100	196	415
Indiana	5	1	440	170	27	67	3.3	100	100	139	120
Ohio	9	90	800	5,012	125	1,179	1.6	70	98	60	1,444
West Virginia	8	168	708	14,309	115	2,320	0.5	100	100	80	621
Pennsylvania	3	79	1,295	8,756	40	1,494	0.3	100	100	97	1,045
Total U.S.	3,926	22,605	122,030	459,505	32,154	223,950	18.4	12	93	7,466	20,136

1/ Million barrels of oil; billion cubic feet of gas.

2/ Less than 10 barrels per day.

localities and Illinois five within several miles of the route. In addition, each state has numerous other crushed stone quarries at greater distances.

The crushed product is used mainly in highway construction and cement. About 80 percent is used as concrete and asphalt aggregate, and about 10 percent as agricultural lime. Common uses that consume relatively small amounts take the remaining 10%; these are: cement production, water-filtering sand, steel-making flux, highway construction, railroad ballast and riprap. Dimension stone, a product for which Indiana is particularly well known, apparently is not produced along the proposed route.

No information regarding the quantities or value of crushed limestone and dolomite is readily available. Reserves, although not estimated, are known to be very great.

Construction of the proposed pipeline is not likely to add any significant knowledge regarding reserves.

<u>Sand</u> <u>and</u> <u>Gravel</u>--Glacial deposits are practically the sole source of commercial sand and gravel production along the proposed route in the six states partly or wholly within the Central Lowland Province. Approximately 80 percent of the counties traversed by the proposed route are known to have active pits. In Minnesota, Iowa and Illinois, in a total of 30 counties there are 60 operating pits, with the number of pits ranging from one to five per county.

Two kinds of glacial deposits are used: those of ice-contact origin, and those that were deposited by meltwater and now constitute terraces or valley fills.

No records of production quantities or values are readily available, and reserves are rarely made públic information. It is likely that consumption of existing reserves will be completed, perhaps in the next 10 to 20 years.

The potential for discovery of additional, presently unknown deposits is extremely small.

<u>Minor</u> <u>Resources</u>--<u>Bituminous</u> <u>Coal</u>. Within the Central Lowland Province bituminous coal reportedly is produced at present only from strip mines in the extreme eastern part of Kankakee County, Illinois. Coal formerly was produced from strip mines and underground mines in Bureau County, Illinois, and in Grundy County, Illinois; the most recent production in these counties was from strip mines operating as recently as 1969 in Grundy County. Production is primarily from the No. 2 Coal, and is now mainly limited to coal as a byproduct of clay and shale mining.

The coal in these counties is classified as bituminous, and of C rank, on the basis of standard tests. On an "as received" basis the coal has a content of 10,500 to 11,700 Btu per pound, and from 1 to 4 percent sulfur.

Coal production in Kankakee County amounted to 519,000 tons in 1972, and in Bureau County to 417,000 tons in 1972 compared with 579,000 tons in 1971.

In La Salle County, strippable coal reserves amount to 39,000,000 tons from beds averaging 35 inches thick. Reserves exceeding a seam thickness of 28 inches and minable by underground methods are estimated at 1,080,000 tons. The maximum amount of strippable reserves required for the pipeline right-of-way would be approximately 1,600,000 tons; additional coal would be required for underground support practices.

In Grundy County, remaining strippable reserves are estimated at 46,300,000 tons using an average seam thickness of 32 inches. The reserves available by underground mining, figures on bed thickness exceeding 28 inches, is approximately 246,000,000 tons. The maximum commitment of strippable coal attributable to the pipeline right-of-way would approximate 1,400,000 tons, with additional amounts required for underground support practices.

Coal reserves in Illinois are well known. A detailed exploratory drilling program could yield some specific additional information regarding reserves, but construction of the proposed pipeline is unlikely to add significant new information.

Peat. Commercial production of peat in the vicinity of the right-ofway occurs at only 6 localities. One is located in Winnebago County, Iowa, two in Whiteside County, Illinois and one each in Wells and Fulton Counties, Indiana. These sources yield moss or reed sedge peat, or both. Most of the operators sell in both bulk and package form. No information is available on production quantities or value of reserves. The likelihood of discovery of now unknown peat deposits is extremely small.

Building Stone. Limestone and dolomite are major sources of dimension stone for use in buildings; sandstone is used locally in Ohio.

No information on production quantities or value is readily available. Reserves have not been determined, but are very great.

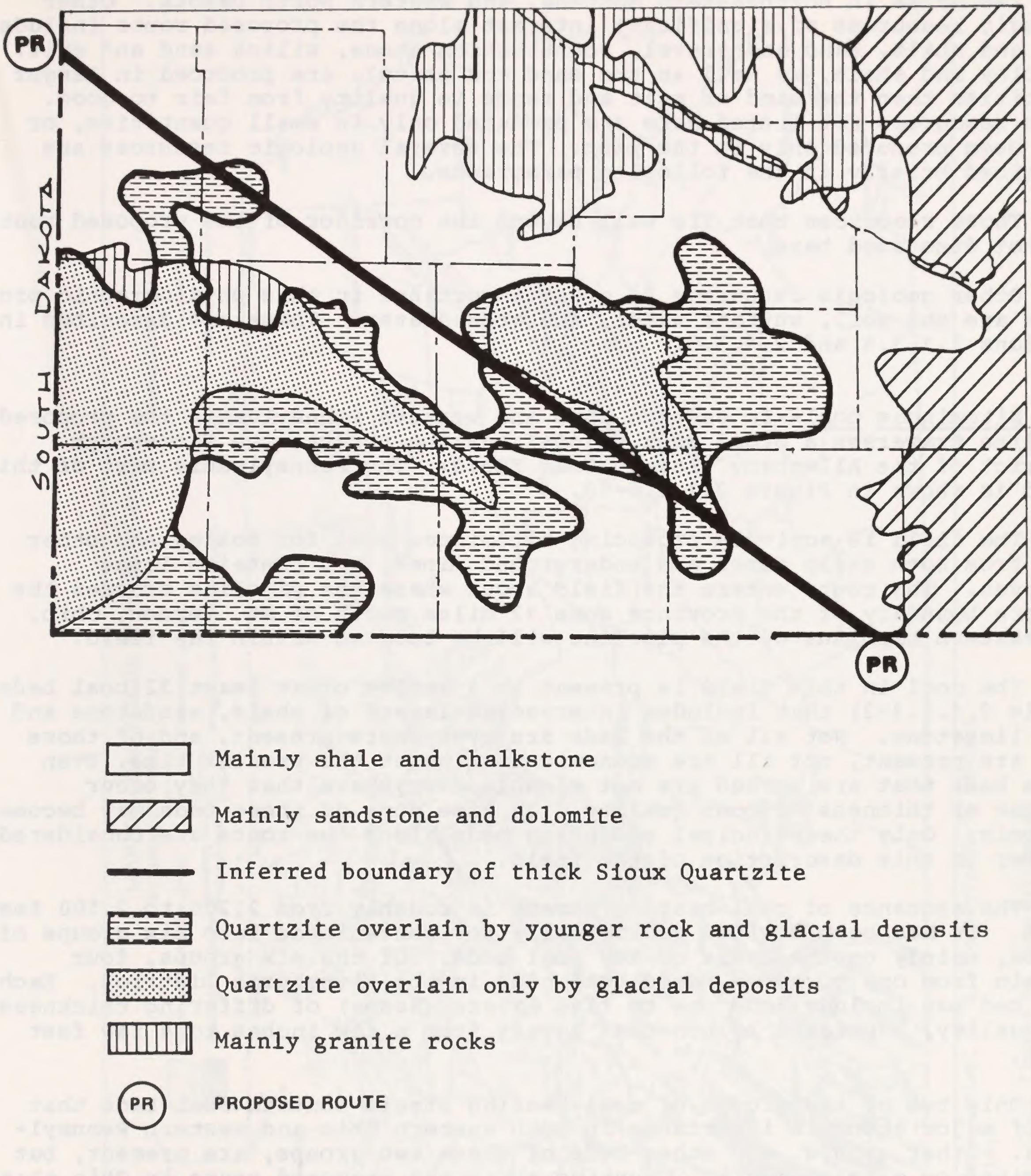
No unknown reserves are likely to be discovered through construction of this proposed pipeline.

Industrial Sand. Silica sand, an industrial material used by glass makers, steel molders and railroads, is produced in large quantities in La Salle County, Illinois. Neither quantities nor values produced are known to be published, and reserves are not reported. New deposits of silica sand are not likely to be discovered as a result of building the proposed pipeline.

Quartzite. The quartzite that underlies southwestern Minnesota yields aggregate of outstanding quality on crushing. It is not produced commercially along the proposed route, but is quarried near New Ulm, Minnesota, and at various adjacent localities in South Dakota. Production along the proposed route may become economic at some time in the future, most likely in Cottonwood County or the extreme northwest corner of Martin County (Figure 2.1.3.3-47).

Appalachian Plateaus Province

Within the Appalachian Plateaus Province geologic resources are well known. The principal resources in current production are bituminous coal, petroleum and natural gas, and crushed rock and building stone. Large resources of each of these are recognized in the province in close proximity to much of the proposed route. Specific sites for their near-future



Source: Modified from Austin, G. S., The Sioux quartzite, Southwestern Minnesota, 1972.

Figure 2.1.3.3-47 Areas in southwestern Minnesota probably underlain by quartzite development are not known to have been identified in the manner of lignitic coal resources in northeastern Montana, and western North Dakota. Other geologic resources of significant interest along the proposed route include: clay and shale, sand and gravel, construction stone, silica sand and salt. The clay and shale, as well as the sand and gravel, are produced in larger quantities than the sand or salt and range in quality from fair to good. Other resources not listed here are produced only in small quantities, or have been produced only in the past. The several geologic resources are described briefly in the following paragraphs.

Those resources that lie well beyond the corridor of the proposed route are not discussed here.

Other geologic resources of great importance in this physiographic province are the soil, surface water, and groundwater. These are described in Sections 2.1.3.4 and 2.1.3.5.

Bituminous Coal--In eastern Ohio and western Pennsylvania the proposed pipeline traverses a broad area of coal bearing strata, the Pittsburgh District of the Allegheny Plateau Coal Field. The Pennsylvania part of this field is shown in Figure 2.1.3.3-48.

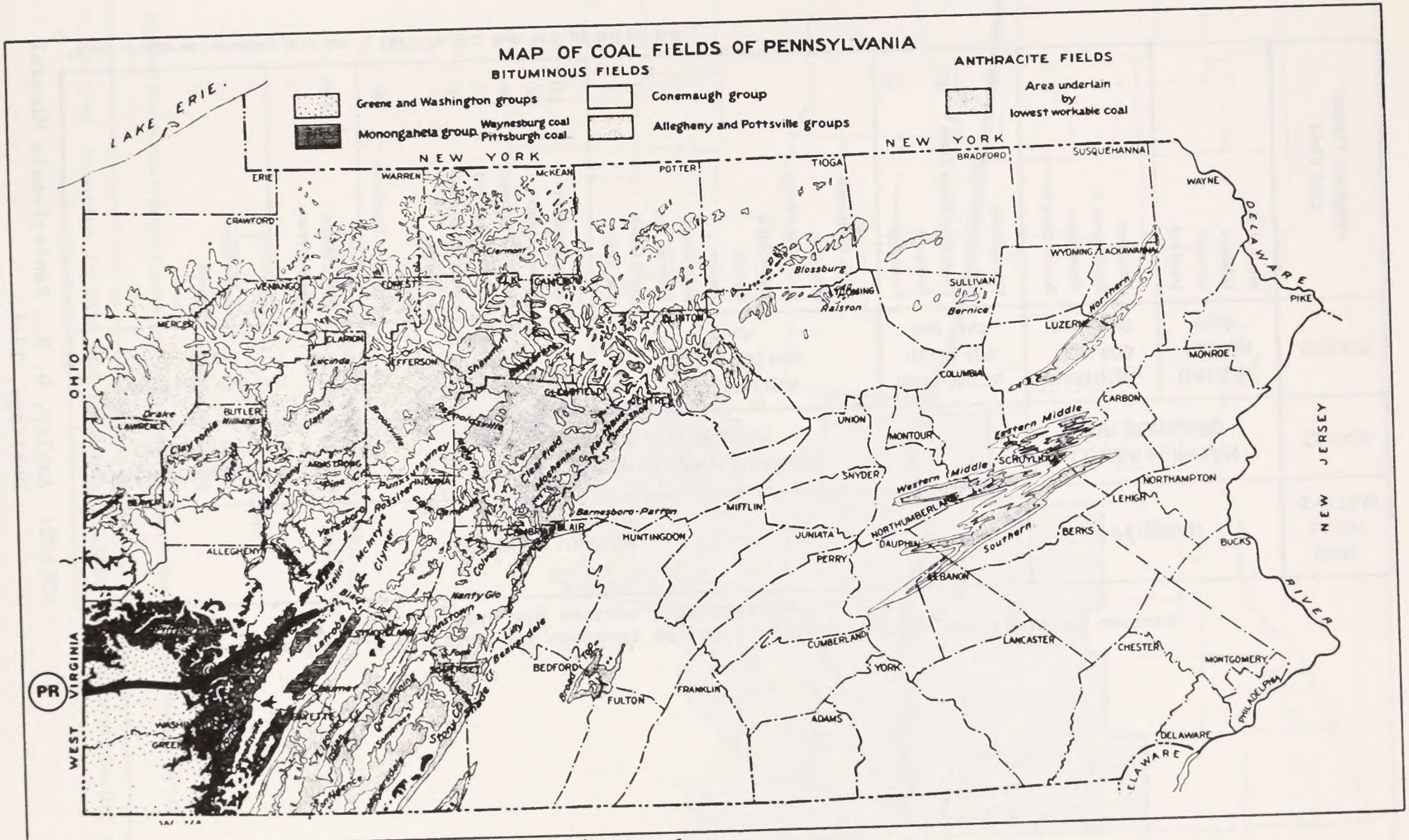
The field is actively producing bituminous coal for coking and other uses from both strip mines and underground mines, and contains large reserves. The route enters the field about where the pipeline crosses the western boundary of the province some 12 miles south of Mt. Vernon, Ohio. The eastern terminus of the pipeline will be located within the field.

The coal in this field is present in a series of at least 32 coal beds (Table 2.1.3.3-2) that includes intervening layers of shale, sandstone and some limestone. Not all of the beds are everywhere present, and of those that are present, not all are economic to mine at the present time. Even those beds that are worked are not minable everywhere that they occur because of thinness or poor quality. In time some of these beds may become economic. Only the principal producing beds along the route are considered further in this description of the field.

The sequence of coal-bearing strata is roughly from 2,200 to 2,500 feet thick. It has been divided geologically for convenience into six groups of strata, mainly on the basis of key coal beds. Of the six groups, four contain from one to seven named coal beds in the Pittsburgh District. Each coal bed may include from one to five layers (seams) of differing thickness and quality, separated by non-coal layers from a few inches to a few feet thick.

Only two of the groups of coal-bearing strata contain coal beds that are of major economic importance in both eastern Ohio and western Pennsylvania. Other groups, and other beds of these two groups, are present, but are mined on a local basis. Counties along the proposed route in Ohio that are producing coal are shown in Figure 2.1.3.3-49.

In eastern Ohio five coal beds are important. They are, in descending order, the Meigs Creek Coal (the Sewickley Coal of Pennsylvania), from 1 to 4 feet of coal with a parting of less than 2 feet, the Pittsburgh Coal, from 4 to about 6 feet thick, the Upper Freeport Coal, from 3.5 to 5 feet thick, and Lower Freeport Coal, 3.5 to 5 feet thick, the Middle Kittanning Coal, about 3 feet thick, and the Lower Kittanning Coal, about 4 feet thick. Among the 10 principal coal beds of the Appalachian Plateau, in terms of likely reserves, these beds are estimated to rank second, first, fourth, fifth and seventh, respectively. Seventy percent of the state's production



SOURCE: Modified from Ashley, G. H., Pennsylvania's Mineral Heritage, 1944.

Figure 2.1.3.3-48 Coal fields of Pennsylvania

Table 2.1.3.3-2 Principal coalbeds of the Allegheny plateau coalfield of eastern Ohio and western Pennsylvania

GEO-LOGIC SYSTEM	SERIES	GROUP	Allegheny Plateau Coal Field	
PERMIAN	LOWER PERMIAN OR DUNKARD	GREENE 750 feet thick	Windy Gap	
			Gilmore	
			Nineveh	
			Dunkard	
		WASHING-TON 400 feet thick	Jollytown	
			Washington A.	
			Washington	
			Waynesburg A.	
PENNSYLVANIAN	UPPER PENNSYLVANIAN OR PITTSBURGH	MONONGA-HELA 400 feet thick	Waynesburg	(6)*
			Uniontown	
			Sewickley(**Meigs Creek**)	(8)
			Redstone	
			Pittsburgh	(2)
		CONEMAUGH 600 to 900 feet thick	Little Pittsburgh	
			Franklin	
			Little Clarksburg	
			Wellersburg	
			Barton	
			Harlem	
			Bakerstown	
			Thomas	
			Brush Creek	
			Mahoning	
		ALLEGHENY 250 feet thick	Upper Freeport	(1)
			Lower Freeport	(4)
			Upper Kittanning	(5)
			Middle Kittanning	(7)
			Lower Kittanning	(3)
			Snodgrass	
			Clarion	
			Pardoe or Brookville	(9)
	LOWER PENNSYLVANIAN OR POTTSVILLE	180 to 1,450 feet thick	Upper Mercer	(10)
			Lower Mercer	
			Quakertown	
			Sharon	

*Rank of reserves remaining as of Jan. 1, 1927 (Pa. G.S. Bull. M 6, pt. III) pp. 8-9

SOURCE: Ashley, G. H., Pennsylvania Mineral Heritage, 1944.

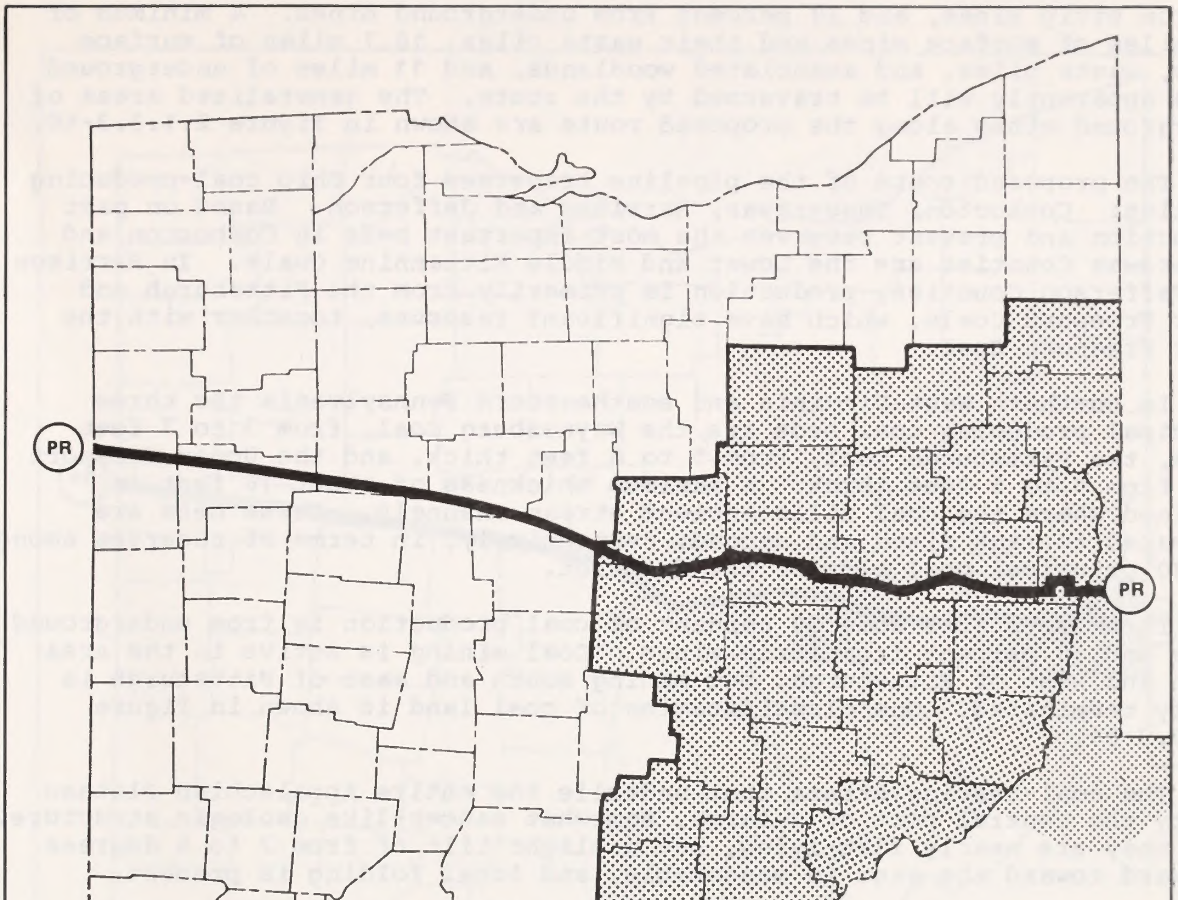


Figure 2.1.3.3-49 Counties in Ohio and the West Virginia Panhandle producing coal and with reserves

is from strip mines, and 30 percent from underground mines. A minimum of 1.2 miles of surface mines and their waste piles, 16.7 miles of surface mines, waste piles, and associated woodlands, and 11 miles of underground mines apparently will be traversed by the route. The generalized areas of underground mines along the proposed route are shown in Figure 2.1.3.3-50.

The proposed route of the pipeline traverses four Ohio coal-producing counties: Coshocton, Tuscarawas, Harrison and Jefferson. Based on past production and present reserves the most important beds in Coshocton and Tuscarawas Counties are the Lower and Middle Kittanning Coals. In Harrison and Jefferson Counties, production is primarily from the Pittsburgh and Lower Freeport Coals, which have significant reserves, together with the Upper Freeport Coal.

In northern West Virginia and southeastern Pennsylvania the three principal producing coal beds are the Waynesburg Coal, from 3 to 7 feet thick, the Pittsburgh Coal, from 5 to 6 feet thick, and the Upper Freeport Coal from 4 to 6 feet thick. A maximum thickness of about 16 feet is attained where the coal fills ancient stream channels. These beds are estimated to rank sixth and second, respectively, in terms of reserves among the 10 principal coal beds of the district.

In these states some 90 percent of coal production is from underground mines and 10 percent from strip mines. Coal mining is active in the area south and west of Pittsburgh, but mining south and east of Pittsburgh is mainly terminated. One classification of coal land is shown in Figure 2.1.3.3-51.

The coal-bearing strata that underlie the entire Appalachian Plateau occupy the central part of a large, somewhat saucer-like geologic structure. Thus they are nearly flat-lying, but a slight tilt of from 2 to 4 degrees downward toward the east is measurable, and local folding is present.

Coal in the Pittsburgh District has been classified as "Bituminous" on the basis of standard tests. The same tests have also shown that the coal can be assigned to several different ranks within that class. The moisture content of the coal ranges from about 2 to 3 percent by weight, and volatile matter constitutes some 30 percent on a dry, mineral-free basis.

The Btu (British Thermal Unit) content of coal from these beds ranges from about 12,611 to 14,800 Btu per pound, with an average of perhaps 13,500 Btu per pound as received. The sulfur content ranges from approximately 0.5 to 14.0 percent, with an average of some 2.4 percent. Published results of Btu and sulfur-content analyses for selected beds of the three-state area are shown on page 199.

In the area traversed by the proposed pipeline, various coal beds, but especially the Pittsburgh Coal, lie at or near the ground surface and are thus strippable locally. The maximum thickness of overburden stripped from surface pits is about 100 to 150 feet. Elsewhere these same beds are mined underground.

Potential for Discovery of Additional Resources--The potential for discovery of now unknown resources, or beds, of coal is extremely poor owing to both surface and subsurface investigations that have been carried on in the past. However, the possibility that a test drilling program can yield additional information regarding the coal reserves of specific beds is excellent. This is particularly true for those beds that have received less attention to date. The construction of the pipeline probably will yield no significant additional information about coal beds or reserves because of its shallow depth.

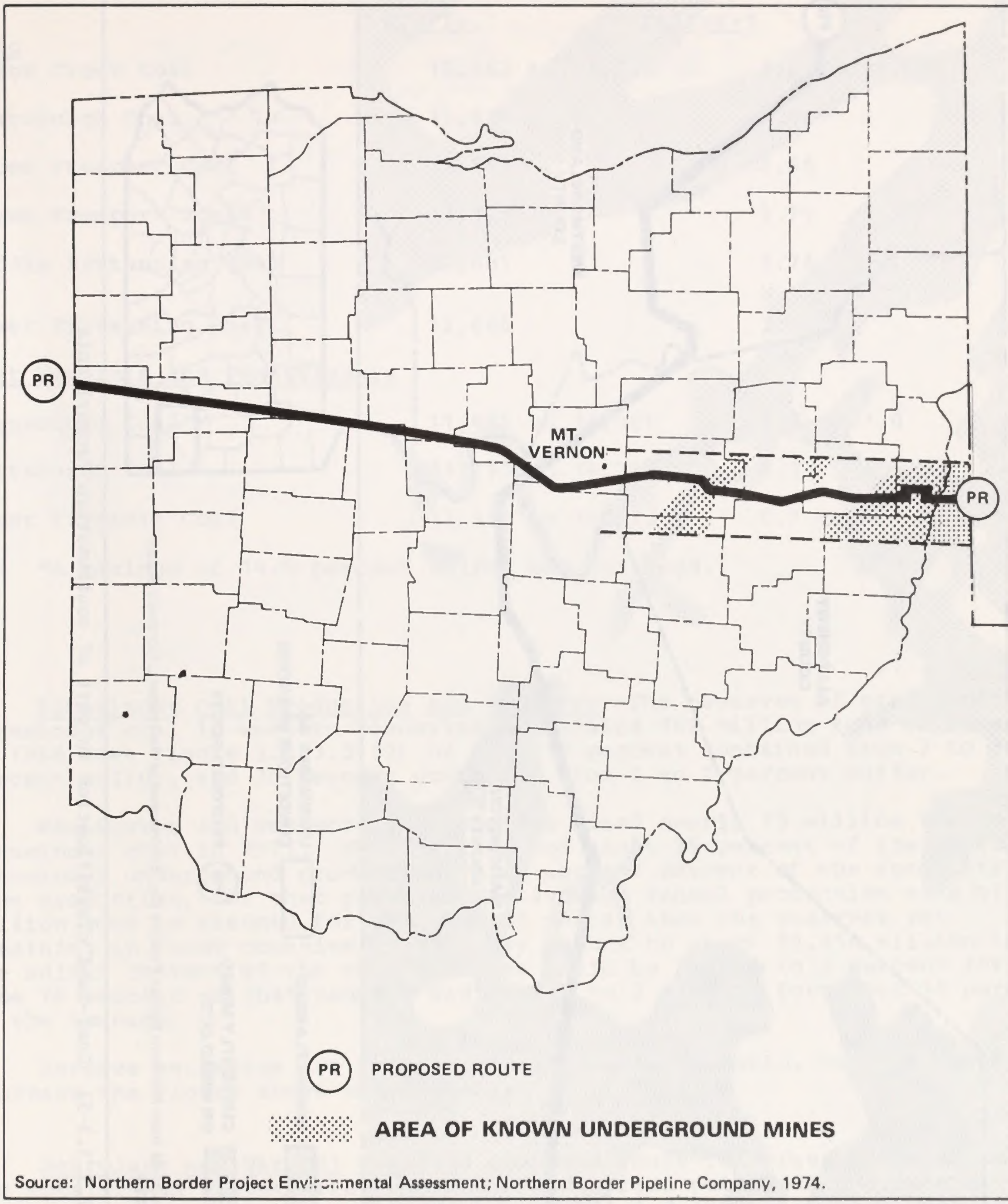
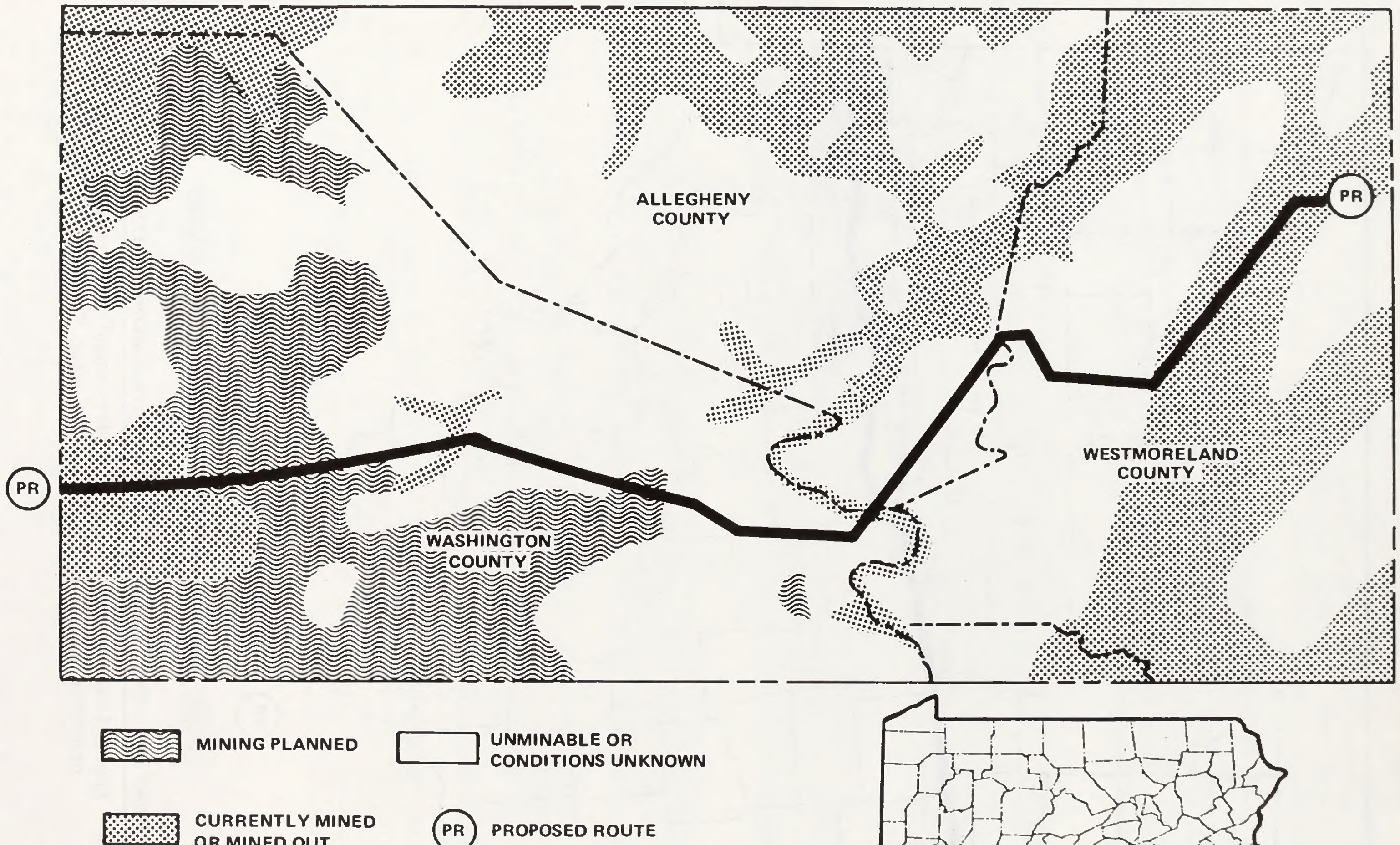


Figure 2.1.3.3-50 Approximate areas of known underground coal mining along the proposed route in Ohio and the West Virginia Panhandle



Source: Modified from Northern Border Pipeline Co., Environmental Assessment, Northern Border Project, 1974.

Figure 2.1.3.3-51 Coal-land classification in part of southwestern Pennsylvania

Published Result of Btu and Sulfur-Content Analyses of Selected Coal Beds of the Pittsburgh District

	BTU/lb.	Sulfur-%
Ohio		
Meigs Creek Coal	12,062 to 12,228	3.02 to 5.02
Pittsburgh Coal	12,919	3.40
Upper Freeport Coal	12,611	2.65
Lower Freeport Coal	13,127	2.79
Middle Kittanning Coal	12,681	3.76
Lower Kittanning Coal	12,686	3.48
West Virginia and Pennsylvania		
Waynesburg Coal	11,400 to 14,000	1.0 to 7.0
Pittsburgh Coal	13,170 to 14,340	3.3
Upper Freeport Coal	12,910 to 14,110	0.7 to 4.1

*A maximum of 14.0 percent sulfur was obtained.

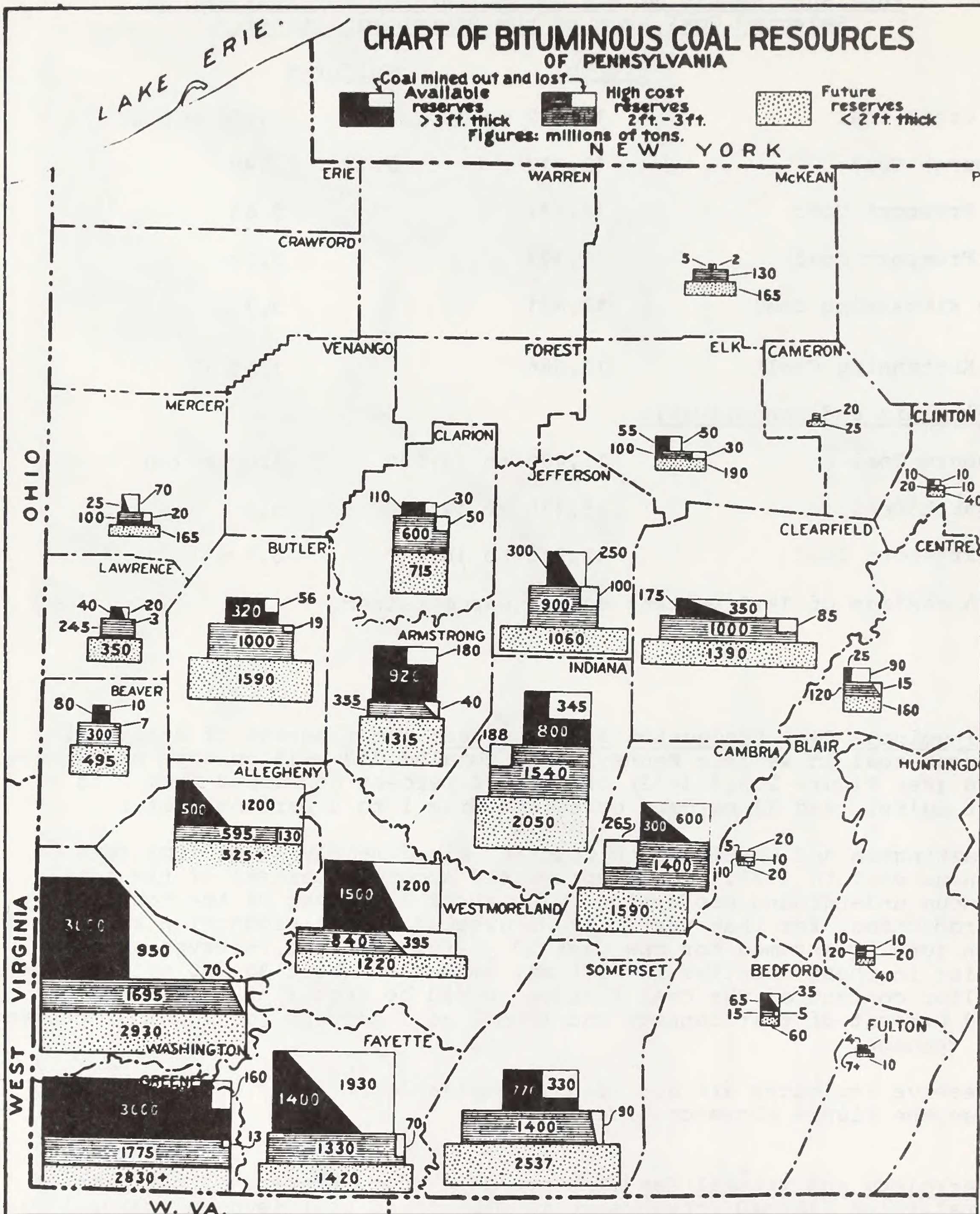
Bituminous Coal Production and Reserves--The reserves of strippable bituminous coal in western Pennsylvania totaled 752 million tons on January 1, 1968 (see Figure 2.1.3.3-52) of this 70 percent contained from 2 to 3 percent sulfur, and 30 percent contained from 1 to 2 percent sulfur.

Washington and Westmoreland Counties mined nearly 15 million tons of bituminous coal in 1971. This represented about 26 percent of the total bituminous underground production, plus about 7 percent of the total strip mine production, for that year. If an average annual production rate of 14 million tons is assumed for the past 30 years, then the reserves yet remaining in those counties in 1974 may amount to about 10,750 million tons. The sulfur content of the coal reserves would be from 2 to 3 percent for some 70 percent of that tonnage and from 1 to 2 percent for about 30 percent of the tonnage.

Reserve estimates are not readily available for Ohio, but they would increase the figure above considerably.

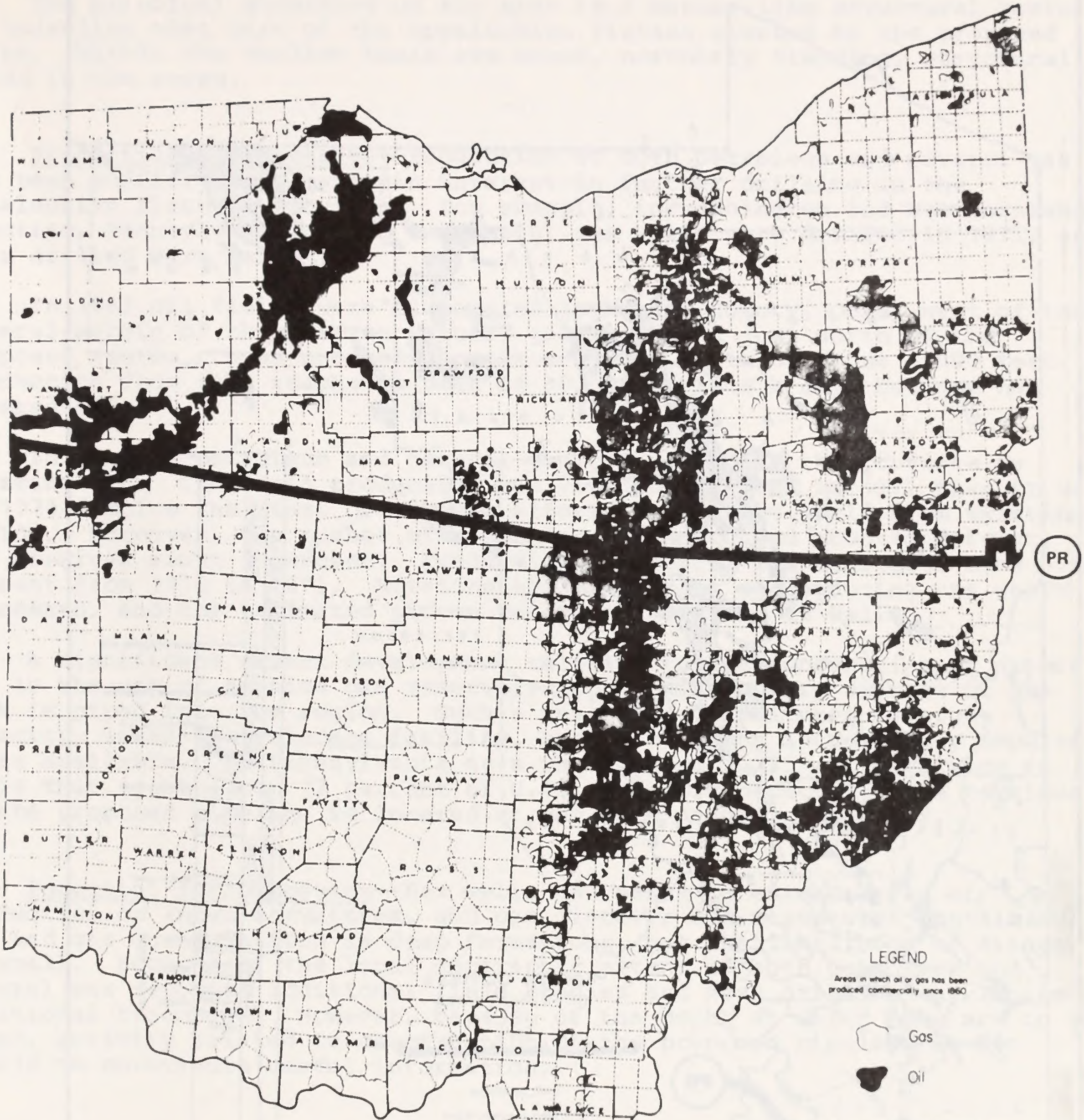
Petroleum and Natural Gas--The proposed route traverses that part of the Appalachian Plateau Province where widespread petroleum and natural gas production occurs (Figures 2.1.3.3-53 and 2.1.3.3-54). Although coal may constitute the most valuable resource in both the province and in Pennsylvania, in that part of Ohio within this province petroleum and natural gas well may be the most valuable resource.

The petroleum and natural gas is obtained from a series of perhaps a dozen permeable sandstone beds scattered throughout a sequence of strata roughly 12,000 feet thick. The character of these beds, together with their structural form, is such that the accumulations of oil and gas are not wide-spread and continuous, but rather are very restricted both horizontally and



Source: From Ashley, G. H., Mineral Resources, *in* Pennsylvania's Mineral Heritage; Pennsylvania Topographic and Geologic Survey, 1944.

Figure 2.1.3.3-52 Diagram showing bituminous coal resources in western Pennsylvania by counties



SOURCE: Modified from Noble, A. G., and Korsok, A. J., Ohio - An American Heartland, 1975.

Figure 2.1.3.3-53 Petroleum and natural gas fields in Ohio

SOURCE: Modified from Ashley, G. H., Pennsylvania's Mineral Heritage, 1944.

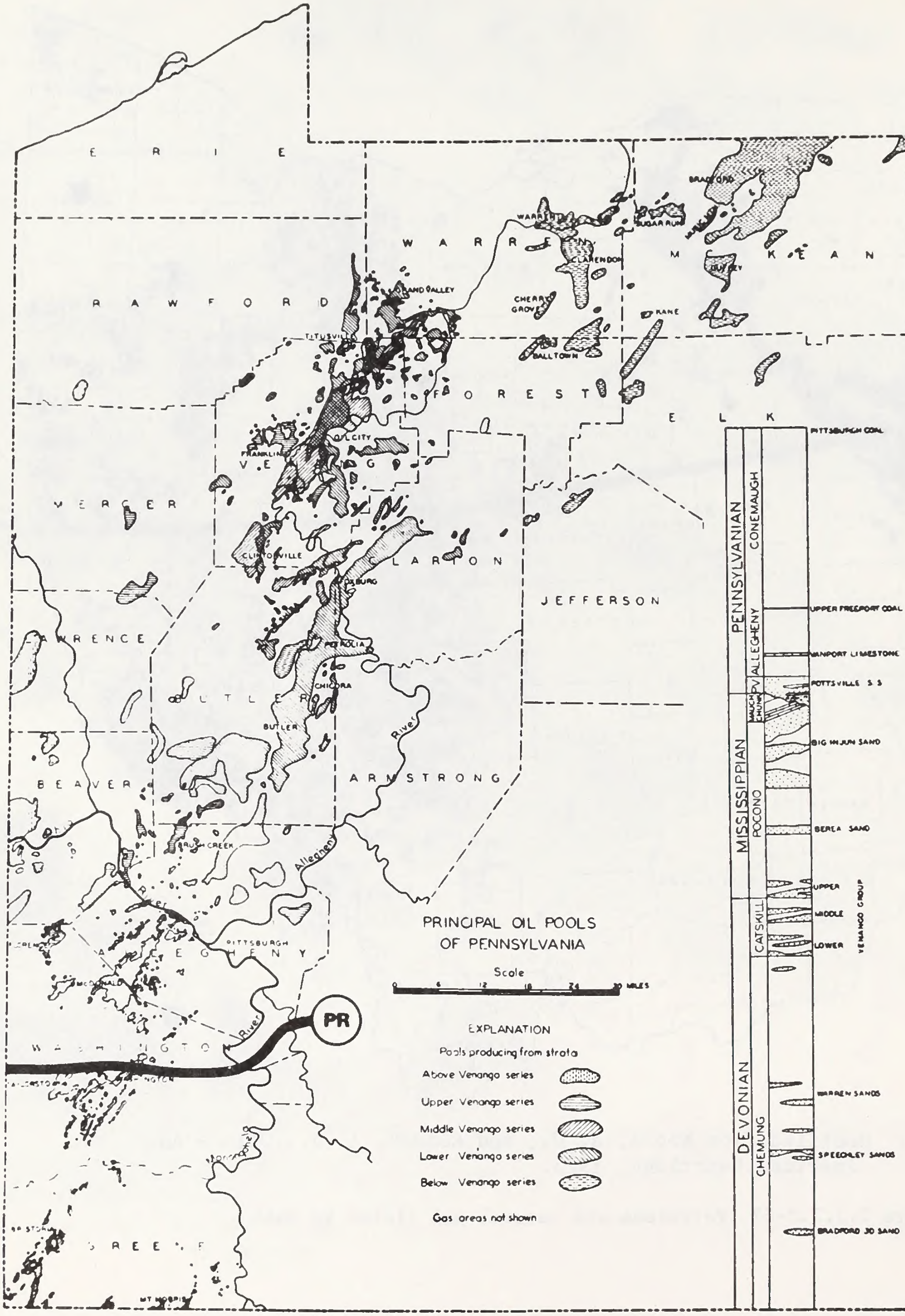


Figure 2.1.3.3-54 Principal petroleum fields in Pennsylvania

vertically. The most shallow sandstones that produce are a few thousand feet deep.

The principal structure of the area is a saucer-like structural basin. It underlies that part of the Appalachian Plateau crossed by the proposed route. Within the shallow basin are minor, northerly trending, structural folds in the rocks.

Production and Reserves--Production of both petroleum and natural gas has been sufficient to maintain interest in further drilling in the Appalachian Plateaus Province. For example, in Washington and Westmoreland Counties, Pennsylvania, eight successful gas wells were drilled in 1971, and four drilled were barren.

In 1961 oil fields were discovered in Morrow County, Ohio, west of the general margin of the Clinton natural gas field and just north of the proposed route. These producing pools are at a depth of about 3,000 feet. Production from them reached a peak of 30,000 barrels a day, but now has tapered off.

In general petroleum and natural gas production in the province is tapering off. Crude oil production was 7.2 percent less in 1971 than it was in 1970 despite the start of several efforts to improve yield from existing fields. Moreover, the number of producing wells dropped about 5 percent, and reserves about 9 percent. Production of natural gas decreased some 0.5 percent from 1970 to 1971. Nevertheless the number of producing gas wells increased, and the estimated proven reserves increased as well.

A significant recent development relative to the consumption of natural gas is the use of emptied gas reservoirs for the temporary storage of gas that is piped into the region. Such a reservoir constitutes a large-capacity, lower-cost storage facility, and is becoming increasingly popular where available. In Pennsylvania as a whole, some 2,135 wells service 66 pools that equal about 17 percent of U.S. reservoir capacity. The terminus of the proposed pipeline is located at one such natural reservoir.

Potential for Discovery--New wells can serve to extend areas of production on known structures, and can discover new structures containing oil and gas accumulations in deep formations, but the likelihood of either is small. Because of the local geographic extent of both petroleum and natural gas deposits additional field studies and test drilling may locate additional resources. However, because of the depth at which they are to be found, activity related to construction of the proposed pipeline is not likely to contribute useful information.

Limestone--Probably the third most valuable geologic resource in the Appalachian Plateaus Province is limestone. That produced in the vicinity of the proposed pipeline route is somewhat impure, and used mainly for agricultural purposes. Other principal uses are in highway construction and maintenance, railroad ballast, and concrete aggregate.

Several beds are available for use and total production is large. One bed that locally is well exposed is about 130 feet thick. Generally about 90 percent of the rock is calcium carbonate (limestone), the remainder consists of impurities.

Minor Resources--Clay and Shale. Large quantities of clay and shale are used in the Appalachian Plateaus Province, mainly in the production of brick and tile. Some underclay is obtained in the Pittsburgh area for the manufacture of firebrick because of its high alumina content.

Shale is much more abundant than fireclay, and about twice as much shale is used. The shale is present in several different beds, and others are available. In addition to brick and till some shale may be used in the production of lightweight aggregate for construction use.

Clay mined in the vicinity of the proposed route is called underclay because of its position immediately beneath a coal bed. Although much less clay is used relative to the amount of shale used, the underclay has a per ton value of about $7.50, some three times that of shale.

Both clay and shale are obtained from open, or pit, mines but some clay is also obtained from underground working. The thickest bed of fireclay is reportedly about 8 feet, and is beneath the Mercer Coal. Other beds of fireclay underlie the Upper Freeport Coal and the Lower Kittanning Coal. Of these the Upper Freeport Coal underclay is mined at the most localities.

Sand and Gravel. Construction and industrial uses in the Appalachian Plateaus Province require production of large amounts of sand and gravel, and Westmoreland County in southwestern Pennsylvania is a major producing area in this province along the proposed pipeline route.

There are two major kinds of deposits: those forming river terraces, and those that partly fill valleys. They differ significantly in character, and so in use. The terraces contain larger amounts of sand and gravel, but the material is so weathered that the upper part of each deposit is of little use. The pebbles have become "rotted", any iron present is oxidized, and only the sand-size fraction is likely to have value. The valley-fill deposits, although smaller, are not weathered and so are wholly useable.

Production of sand and gravel remained essentially stable through 1971, according to the latest published data, although the value per ton increased slowly. As much as 90 percent of the product is used in some form of construction. About half of the sand and nearly all the gravel is used in building construction; in addition at least a third of the sand goes into paving, but the amount of gravel used in this way is very small.

Sandstone. Beds of sandstone are numerous, and are used locally in construction. The rock in places is impure and flaggy in character, and small amounts are used mainly in landscaping. Other beds are massive and have been used in the past as a source of commercial building stone.

The Homewood Sandstone is available in large quantities for crushing to yield a high-silica sand used in molds for steel, grinding and polishing, furnace sand and railroad sand.

Salt. The commercial production of salt in southwestern Pennsylvania is reported to have taken place in the past, but no operation is presently known to be active. The salt was obtained by pumping water down wells less than 1,000 feet deep, and recovering brine for evaporation. As the brine was weak, the process apparently was shut down as uneconomic. Additional beds of salt that have never been developed commercially lie at a depth of 6,500 feet or more.

Geologic Hazards

Geologic processes are a normal part of the natural environment. At some time and in some place, any geologic process may become a hazard to the health and welfare of man, and pose a threat to his property or his environment.

The following processes are significantly active in shaping the environment in the vicinity of the proposed pipeline route:

Process	Effect
Earthquakes	ground shaking
Faulting	ground displacement
Landsliding	landslides, rockslides, rockfalls, and debris flows
Subsidence	mine collapse, soil compaction
Erosion	removal of material
Sedimentation	deposit of material
Meander migration	channel shift
Flooding	erosion
Corrosion	scaling, expansion
Swelling clays	heaving soil

The character and general distribution of these processes, as they are known to exist in the vicinity of the proposed route, are described below. Because of the close relation of some of these processes, for example: earthquakes and faulting, certain of them are grouped for increased understanding.

Seismicity and Earthquakes

The historical frequency and distribution of earthquakes in an area is the seismicity of that area, but the historical frequency and distribution is not in itself necessarily an indicator of earthquake probability (seismic risk). In part the likelihood of earthquakes is related to the tectonic environment of an area, where "tectonic" refers to the stresses present in the earth's crust. When those stresses become too great for the strength of the rocks, the strata yield, perhaps by bending, but commonly by rupture. If the break, or fault, extends to the ground surface, displacement occurs. Not all faults extend upward to the ground surface, but movement along any fault, even deep ones, can cause shaking of the earth's crust (earthquakes) which may or may not be strong enough to be felt. In some circumstances the faulting may occur so slowly (creep) that surface displacement is not accompanied by ground shaking.

An earthquake is the ground-shaking that results from abrupt crustal displacement along a fault. The displacement may occur either at depth or shallowly, and the location of the ground surface above the displacement is the earthquake epicenter. Ground vibrations also can be caused by human activity, but these generally are not called earthquakes.

Ground shaking strong enough to be felt has occurred at numerous localities in the 10-state region traversed by the proposed pipeline route. Most of these earthquakes caused no damage to man-made structures, but a few caused moderate to considerable damage. Several of the stronger earthquakes in the 10-state region occurred in the area to be traversed by the proposed route.

The extent and character of damage to a building of known design caused by an earthquake of specified frequency, amplitude, acceleration, velocity, and duration is predictable with moderate success. Such predictions are based on engineering analysis and experience. A pipeline, by its circular cross-section, length, and burial within loose earth materials, differs from a frame building. The response of a large-diameter pipeline to ground shaking is not well known, although it may suffer less damage under comparable earthquake conditions than a frame building.

Damage to a man-made structure is determined largely by the force imposed on it by the acceleration caused by the shaking. However, the intensity of ground shaking is governed by several variables. The most significant variable is the character of the local geology. Generally, ground shaking is considerably greater on poorly consolidated deposits. Moreover, the thicker the non-consolidated deposit and the finer its median grain size, the more destructive the shaking, especially if the deposit is saturated. Damage can also be caused by earthquake-induced landslides, rockfalls, soil flowage, and soil compaction.

If it is known where earthquakes have occurred in the past, and how strong the shaking has been, damage may be avoided either by avoiding construction, or by designing construction to meet expected ground shaking. However, at those places where earthquakes are infrequent or of deep origin, there may be little or no evidence at the ground surface to suggest the presence of a fault, or the existence of a potential hazard. As a result evaluation of the possible hazard depends in part upon a history of prior earthquakes, and in part on knowledge of the stress conditions in the earth's crust as represented by the earthquake record and geologic structures. Such knowledge permits assessment of the earthquake probability, or seismic risk, of an area.

The historical earthquake record consists mainly of the times and geographic distribution of shaking that has been observed. The length and completeness of the record varies considerably from place to place across the country. In the vicinity of the proposed pipeline route the historical record of earthquakes is only about 100 years in the west and 200 years in the east.

Where the record is short, the recurrence interval for earthquakes may be greater than the length of the historical record. In that case the geologic record can be helpful because of the length of time it can represent. However, its contribution here is small, for the stresses and conditions within the crust (the tectonic environment) of the 10-state region are not well known. In the following assessment of the earthquake hazard of the region traversed by the proposed route, both the historic and geologic records have been considered insofar as they are available. The historic record necessarily has been given somewhat greater emphasis.

The stress energy released in an earthquake is an expression of its magnitude, and permits its classification on a scale of 10. The scale is exponential, however, and where applied to shallow earthquakes an increase of 1 unit on the magnitude scale signifies approximately a 32-fold increase in seismic energy released. The use of recording instruments is needed to calculate the amount released in each event.

The severity of shaking at a given location represents the intensity of an event. Intensity is based on the sensations of people, and the visible affects on natural and man-made objects. One scale of these affects that is in common use in this country is the Modified Mercali Intensity (MMI) Scale which has 12 classes, or units. This scale has 2 middle ranges of values keyed to the observation of damaging effects of shaking on structures. The severity of shaking is characterized by descriptive terms which correspond with the mid-range MMI Scale values as shown below.

Degree of Damage	Intensity Scale (MMI)
Minor	V, VI
Moderate	VII
Considerable	VIII and above

The rate at which seismic events of damaging intensity has occurred in the past is a key to predicting the rate and severity of events in the future, if that record is long enough. To facilitate comparison, the rate is expressed in terms of events per 100,000 square kilometers per century, or similar phrasing.

Seismic Risk Zones

The map in figure 2.1.3.3-55 portrays seismic risk zones in the 10-state region traversed by the proposed route. The map is based essentially on the available seismic record, for an analysis which relates the earthquakes to geologic structure is lacking. In the western part of the region the record is short and events are sparse.

In any given area an earthquake of somewhat greater intensity than the maximum so far recorded can occur during the lifetime of the pipeline.

In the Great Plains Province, that part of the Central Lowland west of the Mississippi River, and the Appalachian Plateaus Province, the proposed route passes through zones in which no damage, or only minor damage to buildings, can be expected during the lifetime of the pipeline. This represents an occurrence rate of four or fewer damaging events per century per 10,000 square kilometers. Infrequent, erratically distributed earthquakes that cause no damage, or only minor damage, can be expected in these areas in the future.

In westernmost Montana, part of the adjacent Rocky Mountain Province, there are zones of significantly greater damage potential to buildings. Future seismic events in that province are expected to be more frequent, and some will be of greater intensity than those in the vicinity of the proposed route. It appears unlikely that these would cause damage to buildings or to the pipeline, although some may be felt in that area.

In the eastern part of the Central Lowland Province the proposed route passes through areas of increased risk where moderate to considerable damage to buildings and minor damage to the pipeline can be expected during the lifetime of the pipeline. This represents an occurrence rate of 80 or more events greater than Intensity IV per century per 100,000 square kilometers. Earthquakes of Intensity VII and VIII have been recorded at a rate of three or more per century per 100,000 square kilometers. Earthquakes of Intensity VII or VIII are probable. An earthquake of Intensity IX is possible. An earthquake of Intensity VII or more is most likely to occur in west-central Ohio.

Historic Earthquakes

Figure 2.1.3.3-55 also represents the known distribution of those earthquakes that have been classified as of Intensity IV or greater, and thus caused damage or were considered potentially damaging.

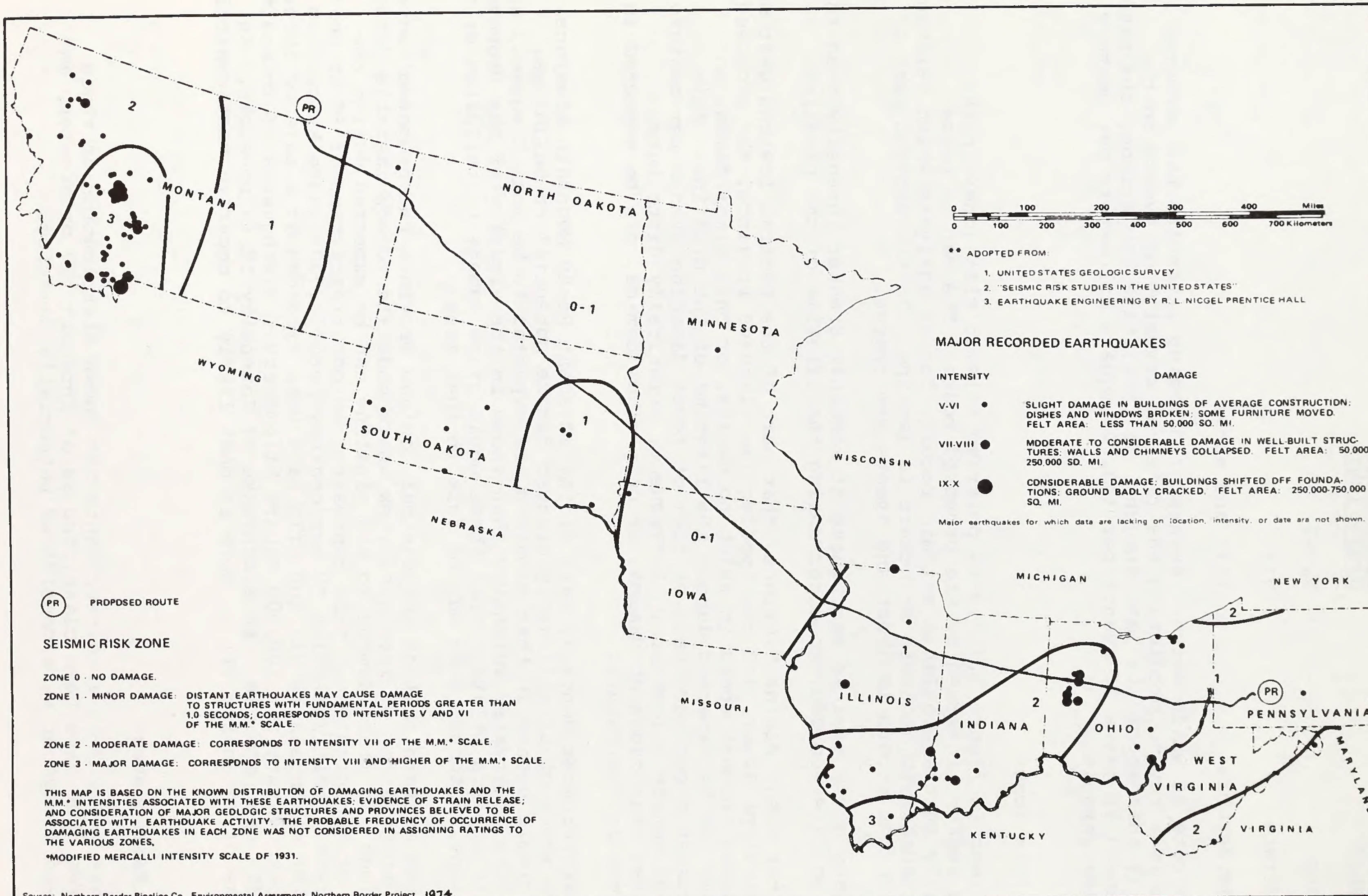


Figure 2.1.3.3-55 Seismic risk and major recorded earthquakes of the 10-State Region

In general, damaging earthquakes in the northern Great Plains Province have been infrequent and erratically distributed. Intensities of V and VI are reported, with slight damage to buildings; such earthquakes are believed to be felt over an area of less than 50,000 square miles. Regional analysis which relates earthquakes to geologic structure is lacking. Infrequent, erratically distributed earthquakes that cause no damage or perhaps only minor damage can be expected in this province.

In that part of the Central Lowland Province west of the Mississippi River, damaging earthquakes also have been infrequent and erratically distributed. Additional earthquakes that cause no damage, or perhaps only slight damage, may occur. They probably will be infrequent and erratically distributed, but are more likely in the southeastern part of South Dakota than elsewhere in this part of the province. This is suggested by a structural trend that extends from Oklahoma and eastern Kansas northward into southeastern Iowa. Some of the seismic events that occur in adjacent northern Illinois may be felt, but little or no damage from future earthquakes in that area is likely.

In that part of the Central Lowland Province east of the Mississippi River earthquakes have been more frequent than west of the river. The earthquakes east of the river also are more localized and of greater intensity. Most have been in the vicinity of Anna, Shelby County, Ohio, and some of these have reached intensities of VII and VIII. They caused moderate to considerable damage in structures, and were felt over an area of 50,000 to 250,000 square miles. These earthquakes may be associated with a technically active geologic structure believed to extend from southeastern Missouri northeast to the St. Lawrence River, and perhaps associated with the structurally deep Illinois Basin in southern Illinois and Indiana.

Two earthquakes of Intensity VII to VIII have occurred in the northern part of Illinois, but they appear to be erratically distributed. Perhaps these events in northern Illinois may be related to the Illinois Basin or associated features. Northern Illinois can expect earthquakes with slightly greater frequency, and of somewhat greater intensity than in the area to the west, but less so than in western Ohio.

Western Ohio can expect to experience earthquakes with greater frequency relative than other parts of the proposed route. One or more of these events may cause moderate to considerable shaking and severe damage.

The likelihood of such events is greatest in the vicinity of Anna, Shelby County. The hazardous area near Anna appears to be somewhat elliptical in form, and to trend slightly east of north. The proposed route crosses the most critical area for a distance of roughly 35 miles, some 12 to 15 miles north of Anna. No major faults are known in this area, but the concentration of earthquakes indicates that movements on unrecognized or concealed faults have caused the events.

In the Appalachian Plateaus Province, most significant earthquakes have occurred in northeastern and southcentral Ohio; few have occurred in western Pennsylvania. Most of those that have occurred have been of no greater intensity than V-VI, but one earthquake of Intensity VII-VIII occurred a considerable distance from the proposed route. In the future, additional earthquakes are more likely in eastern Ohio than in western Pennsylvania, and probably will be infrequent, erratically distributed, and cause only minor shaking.

Areas that Amplify Shaking

Shaking commonly is greater in poorly consolidated beds of earth materials than in hard bedrock. Moreover, the thicker the beds and the finer and better sorted the particle size, the more destructive is the ground motion, particularly if the material is water saturated. The amplitude of the earthquake waves and the accelerations they yield can be several times greater in some materials than in hard bedrock.

Loosely emplaced man-made fill, alluvium, colluvium, and deltaic beach, swamp, and lake-bottom deposits are among those materials that can magnify shaking. Even dry sand, however, can undergo some increase relative to the degree of shaking experienced by granite, for example. Along the proposed route the pipeline will traverse alluvium which partly fills many valleys and colluvium which mantles many hill slopes. Swamp deposits are present, mainly east of the Mississippi River, but appear to have been avoided. The mere existence of such materials along the route, however, is not of itself assurance that hazardous amplification will occur, as other factors also affect response. One area that might cause amplification is the Glacial Lake Dakota plain, traversed for a distance of about 35 miles near Aberdeen, South Dakota.

This surface is underlain by glacial-lake bottom deposits that consist mainly of layered silt and clay, with some fine to very fine sand. Together these locally range in thickness from almost nothing to more than 30 feet. The materials are saturated by a high water table. Other areas that could amplify shaking can exist elsewhere along the route, but detailed studies of the route are necessary for their identification.

When loose, cohesionless earth materials are shaken by a strong earthquake there is a tendency for the material to compact, becoming more dense. This causes settlement of the ground surface and loss of support. Sufficient information to identify locations where compaction may occur is not available.

If loose to semi-cohesive saturated materials that are confined by impermeable materials are shaken strongly, the tendency to compact increases the pressure of the fluid on the earth particles. A result can be liquefaction, and actual flowage of the earth material. This causes loss of support. Sufficient information to identify locations where compaction may occur is not available.

Faulting

A fault is a break in the continuity of the earth's crust, with dislocation of the crust along the fracture. The relative dislocation may be in any direction, and may happen abruptly or extremely slowly. In some places displacement is presumed to have occurred without an actual fault fracture having been identified. Where a fracture is not proven, the feature may be referred to as a "zone of weakness."

Direct damage to manmade structures that straddle a fault is caused by the relative displacement along the fracture of the rock and earth material on either side. Indirect damage is caused by ground shaking (earthquake) that may be caused by the displacement.

Faults generally are identified and located by field observation, interpretation of geologic information and by instrumental (geophysical) methods. Some faults may be concealed at the ground surface, and yet be readily identified at depth; concealment generally is caused by a mantle of glacial deposits or alluvium.

The direct relation of faults to earthquakes is clear. Therefore, knowledge of the frequency of earthquakes and the location of their centers is helpful in locating faults and identifying those that are active.

Faults are commonly described as active (probably subject to renewed movement), or inactive (probably not subject to renewed movement). The term "active fault" is defined by the Nuclear Regulatory Commission (formerly part of the Atomic Energy Commission) as a fault along which movement can be demonstrated by any one of several lines of evidence to have occurred at least once during the last 30,000 years, or to have occurred several times during the last 500,000 years.

Movement along a fault is generally difficult to ascertain, as useful evidence, if produced, is soon destroyed by erosion, weathering or vegetative growth. Thus acceptable evidence to prove a fault active is generally lacking. Known faults generally are characterized as "probably" or "possibly" active or "inactive".

An alternative to proof of movement is the demonstration of the relation of a fault to earthquake tremors strong enough to be recorded on instruments set to record only strong ground motion.

Faults generally are shown on geologic maps by a line, the length of which represents the distance which the fault is known or believed to extend. Because the actual fracture may be covered by younger geologic materials, the ends of the fault may lie well beyond where they are drawn. Thus any fault that (1) is within several miles of the proposed route, (2) is considered as active and (3) is so oriented that if projected it would cross the pipeline, warrants serious consideration of the hazard it may present to the line.

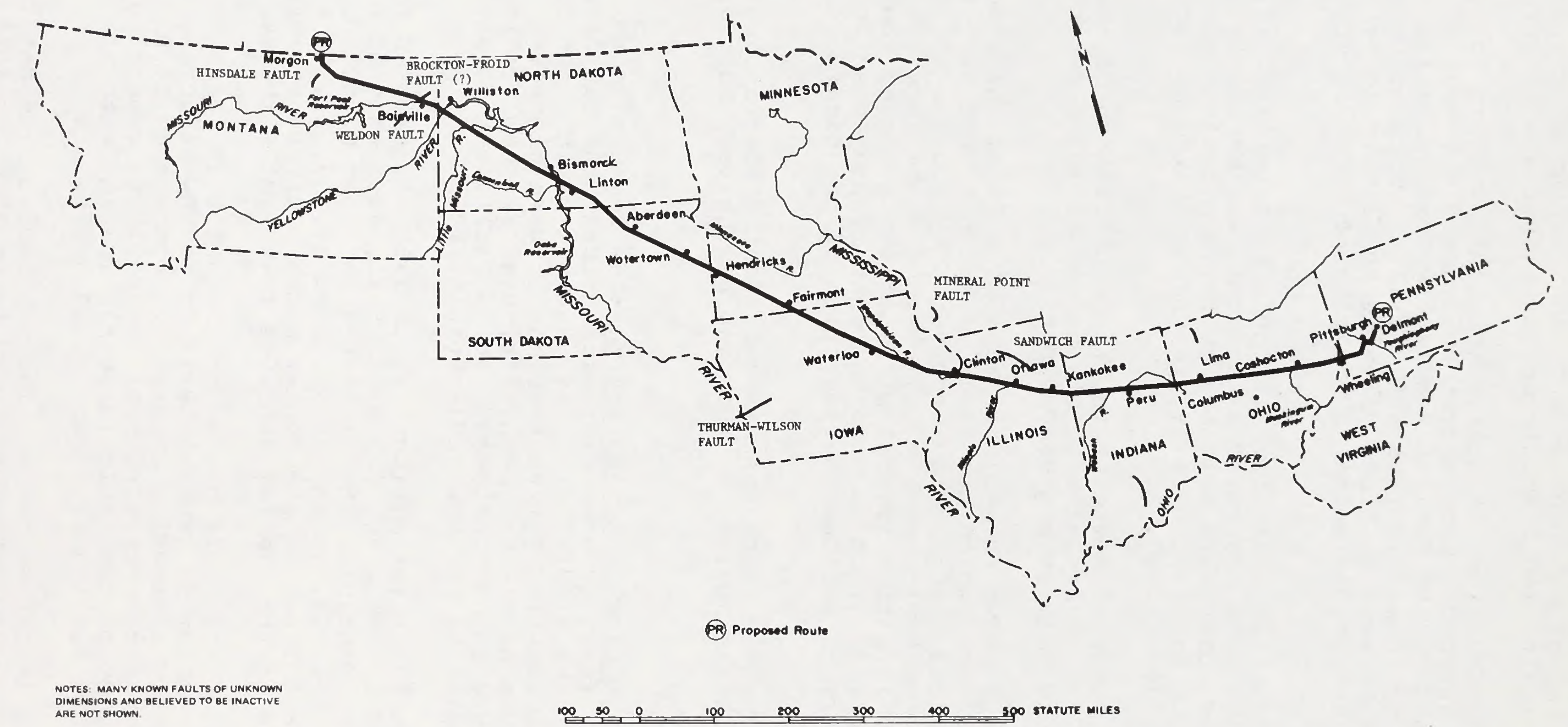
Along the proposed route there are several identified principal faults (Figure 2.1.3.3-56). One is active, another may be active. Most are inactive.

<u>Distribution of Historically Active Faults</u>--One feature in northeast Montana appears to be a fault to some earth scientists, but has been considered a feature of the glacial drift by others. Dislocation along a fracture has not been identified but neither has it been disproven. One seismic event of unproven nature has been attributed to the locality. For these reasons the feature is not believed to be a fault, but it may be a "zone of weakness", and so is here called a "fault(?)".

The Brockton-Froid fault zone (Figure 2.1.3.3-57) is crossed by the proposed route in the E 1/2 sec. 10, T.29N, R. 54E., just east of Big Muddy Creek, Roosevelt County, Montana. The fault trends about N. 60° E, can be traced across parts of Tps. 28, 29 and 30 N., Rgs. 51, 52, 53, 54 and 55 E., and crosses the southeast flank of the Poplar Dome. Surface expression is a striking linear feature in the glacial deposits that mantle the bedrock.

The surface trace of the fault can be followed for at least 25 miles, but it may be much longer for it probably extends southwest across the Missouri River. The trace is readily apparent on both sides of Big Muddy Creek, but eastward beyond the creek part of the fault is concealed beneath windblown sand. The trend of the fault is nearly in line with the northeast-trending Weldon Fault (see Figure 2.1.3.3-57).

The Hinsdale Fault is proven to be a fault by subsurface data. It lies 12 miles south of the proposed route, is known to be 25 miles long, and trends about N. 50° E. The fault cuts across the southeast flank of the



SOURCE: Modified from Cohee, G. V., and others; Teutonic Map of the United States, U.S. Geological Survey, 1962.

Figure 2.1.3.3-56. Principal known or inferred faults in the vicinity of the proposed route.

Figure 2.1.3.3-56 Principal known or inferred faults in the vicinity of the proposed route

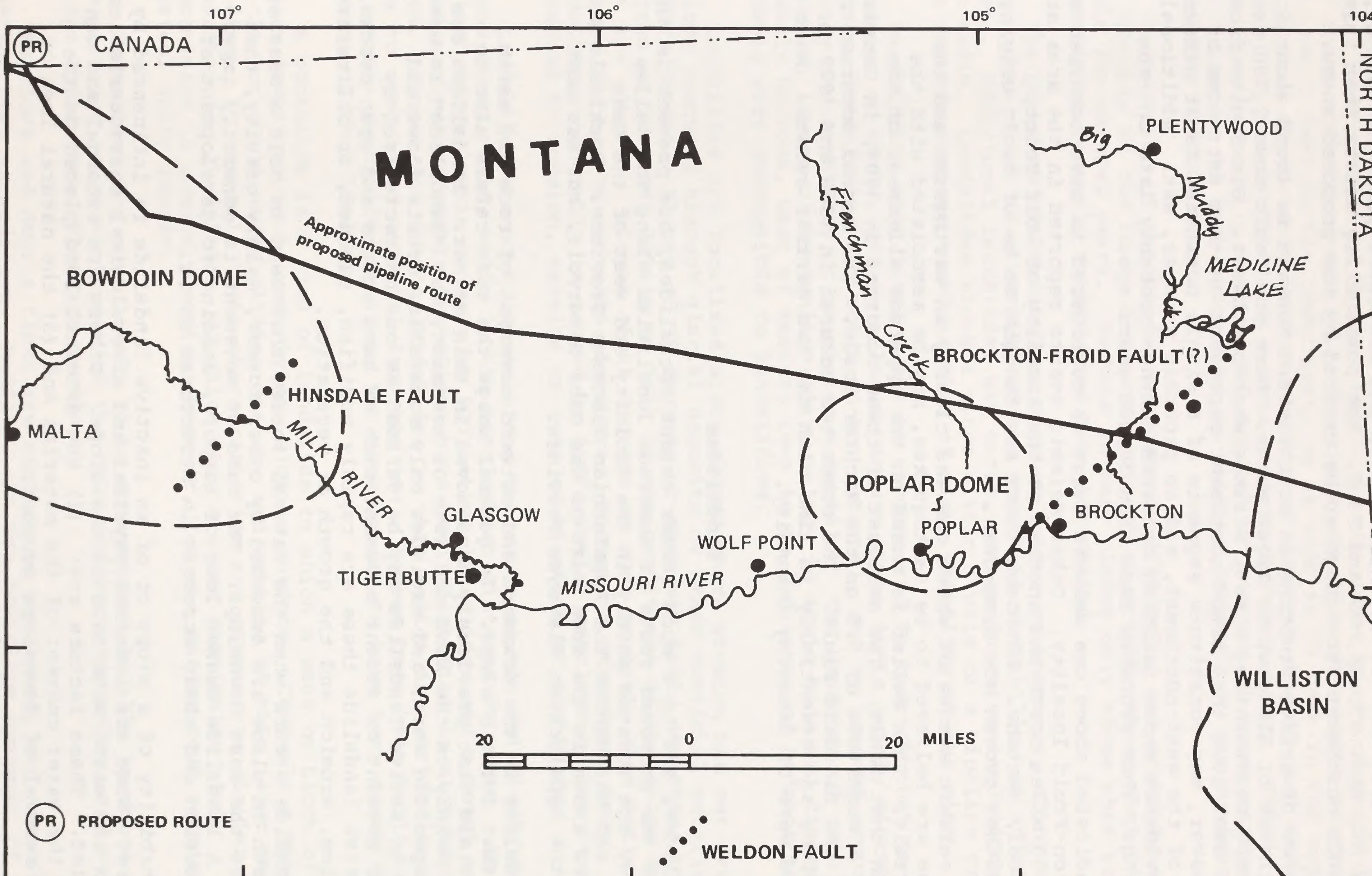


Figure 2.1.3.3-57 Relation of the proposed pipeline route to the principal geologic structures of northeastern Montana

Bowdoin Dome, lies athwart the Milk River, and traverses parts of Tps. 29, 30, 31, 32 N., Rgs. 35, 36, 37 and 38 E. The possibility exists that this fault extends northeast far enough to be crossed by the proposed route.

Evidence of active faulting in northeastern Montana is found about 6.5 miles southeast of Glasgow, in Tiger Butte. Here one fault some 2,700 feet long, perhaps representing a set, strikes west-northwest. Six faults from 200 to 600 feet long that trend northeast represent another set; some of these, however, may constitute segments of a single northeast fault offset by faults of the west-northwest, and so probably younger, set. Additional geologic evidence shows faulting occurred during--probably late in--the Great Ice Age, thus probably less than 30,000 years ago.

As indicated above one seismic event is considered to have occurred at the Brockton-Froid locality. Other seismic events reported in the area are one about 50 miles north and another at the locality of Wolf Point, Roosevelt Co., Montana. Although these are thought to be of fault origin, that is neither proven nor disproven.

Four seismic events of which one was clearly an earthquake and the other three are believed to be earthquakes, may be associated with the Hinsdale Fault. This belief is based on the apparent alignment of the events with that fault. The earliest of these occurred in 1909, in Canada and was of a magnitude of 5.5 on the Richter Scale. The second occurred in 1956 along the Hinsdale Fault. The other two occured in 1968 and 1972 in Montana, along and essentially in line with the two earlier events. None of these three were of damaging intensity.

Landslides

Landslides, and to a much lesser extent rockslides, are present in the vicinity of the proposed route at numerous localities along the valley walls. They are located mainly in the vicinity and west of the Oahe Reservoir, and throughout the Appalachian Plateaus Province. Rockfalls and mudflows are known in the area west of the Oahe Reservoir, but are most likely in the Appalachian Plateaus Province.

A landslide is the downward and outward movement of rock and earth materials that forms a slope. In general usage the term refers also to those materials that previously have moved in this manner. Landslides are classified mainly on the kind and rate of movement, but "landslide" is used here as a specific term, and excludes only rockfalls, debris flows and mudflows. An active landslide may be defined as one characterized by evidence of present or recent movement such as bare scarps and open cracks. In an inactive landslide these are rapidly modified, subdued, or obliterated by weathering, erosion and the growth of vegetation.

A landslide occurs when the natural forces that tend to hold a mass of rock or earth in place are exceeded by other forces, mainly gravity, that tend to move the mass downslope. The rate of movement is generally imperceptable. A landslide causes loss of support, leading to development of tension, torsion and shear stresses in structures on it.

The stability of a slope or of an inactive landslide is influenced by many factors. Some are internal physical and mineralogical characteristics of the rock and earth materials in the slope. Others are external and can be controlled. These factors are: (1) the external load placed on the slope, (2) the water content of the material and (3) the natural loss or artificial removal of downslope support.

Two kinds of landslides are known in the vicinity of the proposed route. Some consist of slumped blocks in the upper part and grade downslope into loose soil-like material. The thickness of such a slide may range from less than 5 feet in the lower part, to as much as 50 feet in the upper part. The surface of movement is commonly curved (concave-upward) and marked at the head of the landslide by a more or less distinct scarp. Other landslides especially small ones, consist of a layer of loose weathered rock from 1 foot to 10 feet thick that is sliding downward on the surface of the underlying bedrock slope.

Recognition of landslides is commonly difficult, and probably many in the vicinity of the route are unrecognized, especially those that have been stable for several years. Perhaps in many places only those that are presently or recently active have been identified.

The presence of landslides, whether active or inactive, along the proposed route serve as a warning of the potential instability of adjacent slopes. Additional landslides may occur, or now-inactive landslides may move again. Landslides along a slope within a mile of a pipeline crossing site warrant serious consideration of slope stability at the site.

Landsliding most likely will be encountered in bedrock that consists of claystone or shale, and to a lesser amount where it is mainly siltstone. However, landsliding may occur in any material, and by loss of support destroy the stability of overlying materials. The presence of thin yellowish layers of bentonitic clay, mainly in shale beds and disseminated in shaly bedrock, west of eastern Iowa is an indicator of bedrock that is probably very susceptible to landsliding.

Landslides are localized along slopes where erosion has cut draws and valleys downward through glacial deposits or other surficial materials into bedrock strata. Slopes of 15 degrees or more may fail, and those of 30 degrees or more are likely to fail if the conditions of the slope environment are altered. Slopes of 45 degrees or more probably have failed in places, and may be unstable elsewhere. Damage to structures from landsliding generally is caused by differential settlement, but it also may be caused by torsion, tension or some combination of the three.

Landslides are most common along the route on the relatively steep slopes along valley walls in the Appalachian Plateaus Province. In southwestern Pennsylvania as many as 800 active landslides and a total of about 2,500 active and stable landslides have been identified in Allegheny County alone. Slopes and stable landslides in this region are particularly sensitive to removal of material from the toe. Houses have been built on some of the stable landslide deposits, but none appear to have been reactivated because of this loading.

A rockslide is a kind of landslide in which a mass or block of rock slides downslope on an underlying, sloping surface. Commonly a thin layer of clay or shale makes sliding easier, and wetting of this layer facilitates sliding. In general, their characteristics and causes are similar to those described for landslides, of which they are one particular kind. Recognition is commonly easier, however, for the harder rock retains physical unity longer.

Rockslides are most likely to be encountered locally in those parts of the pipeline route northwest of the Oahe Reservoir crossing, and especially in the Appalachian Plateaus Province.

Mudflows and debris flows are similar in character, and are considered together here as mudflows. Mudflows are the downslope movement of saturated, loose soil and rock debris by very fluid to viscous motion. They are generally caused by saturation of loose debris, soil materials or alluvium deposited by minor streams. The saturation may be due to prolonged rainfall, snowmelt or the discharge of springs and the rate of movement ranges from slow to rapid. Geologically mudflows and debris flows are particular kinds of landslides.

Along the proposed route mudflows occupy natural channels. Initially barren, the scars left by flowage and the surfaces of the deposits become overgrown in less than 5 years. They are then most readily distinguished by the difference in age of the vegetation from adjacent slopes. In many cases surface flowage patterns can be recognized with ease, and may or may not encompass trees or other obstruction. If one mudflow is identified, others may be present in adjacent channels, and more are expectable in the future.

Mud and debris flows can cause loss of support, damage by impact and damming or blocking. The mass of debris deposited may in itself constitute damage to property.

Mud and debris flows are most likely to occur along the route between the Canadian border and the Oahe Reservoir crossing, and in the Appalachian Plateaus Province. In the western area slopewash and streamflow rapidly accumulate quantities of loose sediment in drainageways, but vegetal growth is not rapid enough to hold the debris in place in case of drenching rain or rapid snowmelt. These mudflows generally are likely to be less than 100 cubic yards in volume.

In the Appalachian Mountains to the east debris flows are numerous. They can occur if, after 2 to 3 days of rain, or perhaps 20 or more inches of rain in one day, there is a rainfall of more than 5 inches in about one hour. If the rainfall reaches 9 inches in an hour debris flows are almost sure to occur. These flows can be as large as several thousand cubic yards. In 1949 a debris flow emptied a pipeline trench of backfill.

Movement of a rock mass downward and outward from a cliff or ledge is a rockfall. Geologically it is one particular kind of landslide. By general usage the term also refers to those rock masses that have moved in this manner. Rockfalls occur when the natural forces that tend to hold a rock mass in place are exceeded by forces, mainly gravity, that tend to pull the mass downward. Thus they are an expression of slope failure because of loss of stability. Some falls along the route have occurred because of cracks separating the rock from the main mass widen because of root- or frost-heave.

The rock falls freely from the source to a gentler slope below, down which it may roll, bound, or slide. The distance that it travels depends mainly on the shape and size of the mass, the height of fall and the steepness of the slope. Size of the mass depends on the thickness of the rock layer, and spacing of fractures in the rock. Damage is caused by impact or by loss of support.

Rockfalls are uncommon along the proposed route. They are most likely to occur (a) in bedrock terrain along the steep walls of valleys between the Canadian border and the Oahe Reservoir, and (b) on the steep valley-side slopes of the Appalachian Plateaus Province. Those in the west are likely to be small in size for the sandstone beds that may yield rockfalls are moderately thin. Those in the east are likely to fall from relatively thick layers of limestone, dolomite, or sandstone, and commonly may be from 5 to 25 cubic yards, but might be as large as 300 to 500 cubic yards.

Subsidence

Along the proposed pipeline subsidence caused by a variety of geologic processes includes: (1) collapse due to underground mining; (2) fluid removal including petroleum, brines and ground water; (3) limestone solution and (4) compaction of loose sediment including windblown silt or sand, and organic silt, is possible. Only the first is known to have actually caused subsidence.

Subsidence Due to Underground Mining

Subsidence is sinking of the ground surface. It is characterized by essentially vertical rather than horizontal movement. In areas of underground mining subsidence is caused by collapse of the overlying rock. Along the proposed route collapse and surface subsidence may be caused by the removal of coal and limestone. No underground mining of other geologic resources along the route is known.

The loss of support caused by the removal of coal, or eventually by the collapse of pillars and timber supports in the mine, concentrates earth stresses about the mine walls and roof, causing their structural failure. This process progresses upward, and to a minor degree outward. Eventually those strata immediately underlying the ground surface fail and the surface subsides. As subsidence is uneven, damage to structures is caused by tensional, torsional and compressive stresses.

Popular opinion, even in mining regions, commonly holds that: (1) the area affected by subsidence can be predicted accurately if the mined area and its depth is known, (2) subsidence will terminate within some specific time that differs with locality and (3) an underground mine at more than some locally specified depth will not cause surface subsidence. None of these is a safe assumption.

The area affected by subsidence is said to be limited by the vertical angle of 67 degrees from the horizontal. The angle is known to be steeper in beds of strong rock than in beds of weak rock. Nevertheless the angle varies with the physical characteristics of the overlying rock, and the angle is not predictable with safety.

The belief that collapse and subsidence will terminate by some locally popular time, perhaps 50 or even 100 years, after the completion of mining, is poorly founded. In part it may be related to the known depth of mining, but as it does not consider several other factors such as the strength of rock layers and the pattern of mining, a time limit is undependable.

In Rock Springs, Wyoming, for example a total of 50 feet of subsidence is reported to have occurred over a part of a coal mine that was worked in 1869. Some 15 feet of that subsidence took place abruptly in February 1975.

Moreover, the mined-out area generally is poorly known. Coal mines, in part because of the very nature of coal beds, commonly have erroneous records, especially of mining prior to about 1900. The depth of the mining is generally better known.

The opinion that an underground mine below some locally specified depth will not cause subsidence is also undependable. Coal mines in Wales at depths of more than 2,400 feet still cause subsidence.

Coal has been mined underground locally in North Dakota and Illinois in the past. The proposed route is not believed to cross any of the numerous old underground mine areas in North Dakota. An old underground mine reportedly is crossed by the route on the north bank of the Illinois River; other old mines in Illinois may be crossed. No present underground mining is reported in those areas. Underground mines at depths as great as 700 feet are significantly more common in eastern Ohio and southwestern Pennsylvania, and the possibility that the proposed route crosses an old mine area there is thus great.

Removal of petroleum and ground water from reservoirs and aquifers may cause subsidence of the ground surface. Although the proposed route traverses areas where these fluids have been produced, none is reported as having identifiable subsidence.

The proposed route does pass near the Troy Grove underground natural gas storage area in northwestern La Salle County, Illinois, and traverses the Herscher underground natural gas storage area in southern Kankakee County, Illinois. No subsidence is reported at either the Herscher storage area or the Troy Grove area.

Subsidence Due to Compaction

The rearrangement of loose particles of soil or other earth materials from a less dense to a more dense fitting, or packing, so that they occupy less space, is compaction. During rearrangement the total volume of the material decreases, causing the ground surface to subside. This means loss of support to structures, causing various stresses.

Along the proposed pipeline route three kinds of earth materials may compact and so cause subsidence: (1) wind-blown silt ("loess"), (2) wind-blown sand, and (3) earth materials with more than 10 percent organic content. As the pipeline is to be placed at a minimum depth of about 7 feet, it is likely that with only scattered exceptions the base of the pipe will lie very near or below the base of the compactible material.

Wind-blown silt, readily identified by its exceptionally good sorting and peculiar vertical columnar structure, retains its natural compaction very well until saturated. Wetting destroys the weak calcium carbonate cement that holds the particles together, and allows them, when under extra load, to compact.

Wind-blown silt is widespread on the upland surface from northeastern Montana to central Ohio, but its thickness is generally from a few to several inches. Greater thicknesses are most likely on the eastern side of major glacial drainage routes, such as the Missouri, Mississippi and Illinois Rivers. Areas of thick wind-blown silt in the vicinity of the route are located in eastern South Dakota, and northwestern Illinois.

The route passes between the thickest deposits. They form a narrow discontinuous belt capping the bluffs along the east side of the Mississippi River Valley. Commonly these deposits are more than 16 feet thick, but less than 32 feet. They thin eastward to a thickness of only a few feet over a distance of several miles. In general the route traverses an upland in part of eastern South Dakota, Illinois, Indiana, and western Ohio, mantled by from 2 to 6 feet of wind-blown silt.

Thick deposits of wind-blown sand are readily identified by their dune topography, and by the loose, well-sorted character of the material. The proposed route traverses wind-blown sand at three localities. One such locality, which extends about 2-5/8 miles along the pipeline, is located about 3 miles east of Big Muddy Creek, Montana. The sand is perhaps 25 feet thick.

A second area contains patches of sand dunes with indistinct margins, so that the length of the route that traverses dune topography is not clear. The most distinct patch of these dunes is located midway between the Mississippi River and Rock River, and extends for 5/8 of a mile along the proposed route. Remaining deposits of this dune area are scattered for a distance of some 28 miles along the route east of the Rock River, and are believed to be less than 5 feet thick.

The third area is a wooded patch of dunes located in the southeast corner of Jasper County about 7 miles south-southeast of Renssalaer, Indiana. Somewhat farther east, between the Tippecanoe and Eel Rivers, thin patches of wind-blown sand with indefinite borders are believed to be present.

Earth materials with more than 10 percent organic content by weight are subject to compaction by compressive loading, for example by the result of construction. Agricultural soils along the pipeline may have this much or more organic material in their upper part from eastern South Dakota to eastern Ohio.

The amount of organic materials can increase to more than 50 percent in peat deposits present in northern Illinois, Indiana and central Ohio. None of these are known to be crossed by the proposed route.

Erosion

Normal or "geologic" erosion is a common occurrence on the land surface. Soil particles are removed by either wind or water, which are two of the geologic agents responsible for topographic changes on the earth's surface. In a stable ecosystem, the vegetative cover protects the surface soils so that the rate of soil loss is in balance with soil-building processes, and geologic changes in the topography progress at a normal rate (see Section 2.1.3.2).

Where land is abnormally disturbed, as it will be by pipeline construction activities, accelerated erosion occurs. The impacts from accelerated erosion along the pipeline right-of-way are discussed in Section 3.1.2.4 (Soils). Soil particles eroded from the unprotected surface of the right-of-way will be carried by the wind or water to adjoining land where they can damage existing vegetation and can leave unstable surfaces subject to further erosion.

Sedimentation involves the deposition of eroded particles. When accelerated erosion occurs, the rate of introduction of sediment into stream channels increases and the streams carry abnormal sediment loads (Section 2.1.3.5). Most stream-borne sediment is deposited within a distance of several yards to perhaps 50 miles from the point of origin. Very fine particles may be carried almost indefinitely. Factors too numerous and complex to discuss here determine the place of deposit but the dominant factor is water velocity.

Land subject to accelerated sheet and rill erosion also yield abnormal amounts of water. Without the vegetative protection, percolation into the soil is reduced and water that normally enters the soil profile runs off the surface. This increases channel flow and causes abnormal soil erosion in gullies and from streambanks.

As sheet and rill erosion of soil are covered in Section 3.1.3.4, this section deals primarily with gully and streambank erosion as specific geologic hazards to the pipeline. Areas of hazard from gully erosion will be primarily where the pipeline traverses steep slopes and where increased runoff rates create or enlarge active gullies. These areas are described in Section 3.1.3.4 and include the following pipeline segments:

Montana--the badland topography of the Frenchman, Rock, Willow and Bitter Creek drainages in Phillips and Valley Counties and the Little Muddy Creek area in Roosevelt County (23 miles).

North Dakota--the Little Missouri Badlands and the Coteau du Missouri Escarpment (123 miles).

South Dakota--approaches to the James and Sioux Rivers.

Illinois--approaches to the Illinois River and Pecumsaugan Creek.

Indiana--the sloped escarpment along the Wabash River near Peru, Indiana (7 miles).

Ohio--approximately 100 miles of the Appalachian Plateau Province in eastern Ohio.

West Virginia and Pennsylvania--nearly all of the route in these states will be subject to the hazard of erosion.

Streambank erosion will be a potential geologic hazard at all planned stream crossings. The degree of hazard will depend upon incidence of high stream flow (see Section 2.1.3.5). The hazard of erosion is found in the loss of support to structures that it causes, the possible exposure of the pipeline to external damage, and the potentially severe loss of soil, unsightly gullying and damage from increased sedimentation.

Flooding and Flood Scour

The overflow of water onto land not usually submerged is flooding. Along the proposed route it may be seasonal in character, caused by snowmelt and spring rains, or occasionally caused by infrequent and irregular thunderstorms.

In either case the effects are (1) a major increase in erosive power, expressed by the size of fragments and the quantity of material carried, and (2) a temporarily raised water level. On recession of the water to normal level, the reduced discharge results in slower flow, causing deposition of sediment in the flooded area.

Significant seasonal flooding is likely to occur on any of the year-around streams crossed by the proposed pipeline, especially the larger rivers from the Mississippi eastward, inclusive. It may occur on small streams and those that flow only part of the year.

Abnormally severe erosion of a flooded area during flooding is flood scour. The most severe scour generally is concentrated within the margins of the normal channel, but scour may occur at any flooded locality. The depth of scour reflects the general water velocity plus, perhaps, the additional velocity increase caused by localized turbulence. The turbulence may have been initiated by some natural irregularity of the channel surface, such as a stone, or a break in channel profile, or it may be caused by some man-made structure.

The depth of excavation by flood scour may be great. Prior to construction of the great Missouri River dams, scour by the spring flood in that river at Omaha is reported to have been at least 30 feet locally. The scoured pits did not last long; generally they were filled by the normal deposition of sediment prior to the next seasonal flood.

Flood scour to a depth of 8 feet or more in channels crossed by the proposed pipeline route is most expectable in the larger rivers, notably the Mississippi River and those of the east. The number of smaller streams, especially those crossed along the western part of the route, that scour to a depth of 8 feet or more is not known.

Meander Migration

The normal progressive, lateral (cross-valley) and longitudinal (down-valley) shift of meanders is meander migration. The migration basically is caused by more rapid erosion of the channel bank on the outside of meanders than on the inside. This causes the meanders to erode both laterally and down-valley, through the fill that underlies the valley floor. As erosion progresses, sediment mainly is deposited on the inner channel bank, and along the cross-valley segments of the channel, on the up-valley channel bank.

As the entire channel, which may be as much as 20 feet deep in a major river such as the Wapsipinicon River, migrates, the valley fill is in a sense eventually excavated and refilled to a depth of perhaps 20 feet throughout the valley in the course of time.

The migration rates of meanders in most rivers is poorly known. Apparently no data is available on those parts of streams crossed by the proposed pipeline. The minimal data available from other parts of the county indicate that lateral migration of meanders can occur at a rate as great as 30 feet in a single year. Longitudinal migration has had little study, but appears to be less than about 10 feet per century. The rate of meander migration in the vicinity of stream crossings along the proposed route is unlikely to exceed these data.

External Corrosion

External deterioration caused by chemical or electrochemical activity is external corrosion. The process commonly attacks buried metals and portland cement concrete. Oxidation of materials, whether above ground or buried, is not considered here. Deterioration poses the hazard of pitting with eventual perforation, and loss of structural integrity.

Deterioration may involve two processes, although they are difficult to distinguish and the result is the same. The two probably cannot be separated in a field situation. One is direct attack, as by an undiluted acid and is expressed by a chemical reaction. The other is somewhat more indirect, as attack by an electrolyte in water. This may include chemical activity, but it mainly involves a galvanic cell (electrical circuit), and the flow of an electric current, however, weak.

Two sources of corrosion are expectable along the proposed route. One is sulfuric acid derived from the chemical breakdown of naturally occurring minerals in both the bedrock and the surficial materials. Its attack almost wholly will be on buried metals. The rate of corrosion from this cause will be greatest in the Appalachian Plateaus Province, nearly as great in northern Illinois and in northeastern Montana and western North Dakota, and significantly less in the glaciated terrain between.

The second expectable cause of corrosion will be sodium sulfate taken into solution by groundwater from bedrock and the large quantities naturally present locally in surficial materials. This compound will attack some types of portland cement concrete. The likelihood of attack will be greatest in northeastern Montana and western North Dakota; it will be minor to absent elsewhere along the route.

The sulfuric acid mainly is the result of a chemical reaction between the minerals pyrite and marcasite, free oxygen either in the air or dissolved in water, and groundwater. The products of the reaction are ferrous sulfate and sulfuric acid. Additional reactions, the rate of which are increased by certain bacteria invariably present, yield additional sulfuric acid.

Pyrite and marcasite are iron-sulfide minerals that are common and widespread in nature. They are very common in coal and adjacent strata. Thus they are expectable in eastern Montana, western North Dakota, northern Illinois and the Appalachian Plateaus Province. They are also widespread in dark shales, and to a lesser degree in dark siltstones. Together these form a large part of the bedrock from the Canadian border to eastern Iowa, and are interbedded with limestone, dolomite and sandstone throughout the remainder of the route.

In addition, some pyrite and marcasite are present in the till mantling the bedrock, because the till is composed of ground-up bedrock and is largely of local derivation at any locality.

A partially compensating factor for this widespread source of natural sulfuric acid may be the presence of beds rich in calcium carbonate (limestone) in the bedrock sequence along the proposed route, mainly in Illinois, Indiana and western Ohio. Significantly fewer beds are present in the Appalachian Plateaus Province, and those west of eastern Iowa are commony much less pure. Ground-up limestone is thus present in the overlying till, also. Whether in the bedrock or the till, or even if dissolved in the groundwater, the calcium carbonate acts to neutralize the sulfuric acid on contact.

Undiluted sulfuric acid if present can attack buried iron and steel by direct chemical reaction if the metal is unprotected. The sulfuric acid and ferrous iron react to yield ferrous sulfate and water. This consumes the sulfuric acid as well as the steel. However, if the sulfuric acid is diluted by water, the potential for electrolytic attack is present. The solution of sodium sulfate also creates an electrolyte.

External corrosion of buried metals is commonly caused by electrochemical activity similar to that in a fluid-electrolyte battery. For that reason the corrosion is generally referred to as "electrolytic corrosion". The soil moisture or groundwater surrounding the buried metal in most locations serves as the electrolyte due to chemicals leached from the soil and held in solution. A spontaneous current flows from the anode to the cathode, causing corrosion of the anode; the cathode is unaffected. In time, perhaps six months to a year the process can become self-neutralizing, and additional corrosion can be very slow.

Corrosion is not limited along the proposed route to the attack of metals. The presence of sodium sulfate (Glauber salt) in both the bedrock and the till, chiefly in northeastern Montana and western North Dakota, causes corrosion of most portland cement concretes. The chemical reaction is fundamentally that of sodium sulfate reacting with calcium carbonate to yield calcium sulfate and sodium carbonate.

The chemical reaction causes expansion of the concrete, eventually destroying its structural integrity.

Presence of deleterious salts in soil along the proposed route, including sodium sulfate, is commonly indicated by white "blooms", patchy coatings of the material that accumulate on the ground surface where the groundwater table meets the ground surface. The bloom is caused by movement to the surface of groundwater containing sodium sulfate dissolved from the earth materials in passing; at the surface the moisture evaporates, leaving a residue of the salt.

Degradation of Water Quality

Water moving through thoroughly fragmented, highly permeable rock and earth materials dissolves soluble minerals and other materials, and facilitates chemical reactions between the water, various minerals whether dissolved or not, air, and other materials that may be present. The amount of material dissolved or reacting is greater with fragmented material than it would have been with the same material before excavation because of the greater surface area of the fragmented material.

Some of the dissolved materials (solutes) and reaction products generally are considered detrimental to water quality; others are considered acceptable. The principal solute of detrimental character along the proposed route is sodium sulfate (Glauber salt). The principal chemical reaction of detrimental nature yields sulfuric acid.

A second cause of degraded water is pyrite and marcasite; these are commonly present in coal and yield sulfuric acid as described above. The acid, diluted by ground water, may be diverted through a trench backfill and enter a ground- or surface-water supply, causing its degradation.

The hazard of "soured" groundwater generally is reduced along the route by the fact that the pipeline would be trenched into glacial deposits. They contain lesser quantities of the undesirable materials, for the glacial deposits consist of eroded bedrock, only part of which is of local derivation. The hazard also will be reduced somewhat by the fact that the sulfuric acid will react chemically with calcium and magnesium carbonates (limestone and dolomite) in the bedrock and glacial deposits, and dissolved in the groundwater. This reaction neutralizes the sulfuric acid.

Discoloration of water is caused by its movement through coal beds and mine dumps where it dissolved organic compounds and perhaps iron oxides formed by the reactions that yield surfuric acid (see Section 3.1.3.3).

Piping and Settlement

The subsurface erosion (loosening, removal and transportation) of fine particles of earth materials by the movement of groundwater is piping. Once begun, the process may develop progressively, moving gradually greater quantities of material. It is most likely to occur along interfaces between layers of sediment composed of differing particle sizes both in natural deposits and in artificial deposits such as earth-fill dams. It commonly occurs along the interface of natural deposits or backfill with construction such as pipe or poured concrete.

Erosion of the fine materials, if allowed to continue, can eventually cause settlement or perhaps landsliding in either natural or artificial deposits. Poured-concrete foundations and pipes are likely to lose support and may lose structural integrity.

Water movement through backfill may or may not be seasonal. If alternate wetting and drying occurs, the physical disintegration (slacking) of some materials can occur unless it consists of nonslacking material such as sand and gravel or crushed rock. Similarly, if the material remains saturated for extended periods of time loss of cohesion may occur, and the material recompacts. In either case the volume of the material is reduced, settlement occurs and the support of overlying construction is reduced, with possible loss of structural integrity.

Swelling Clays

Some clay minerals in bedrock strata along the proposed route swell on wetting and shrink on drying. The amount of swelling or shrinking that occurs depends mainly on the kind of clay mineral, and the purity of the deposit. An increase of 2 to 10 times the original volume is not uncommon if allowed to swell freely, and a pressure as great as some 20,000 pounds per square foot has been measured. The physical change is caused by the absorption of water molecules into spaces between the plates of the clay minerals, pushing those plates apart. The process can be cyclical so the clay may swell and shrink repeatedly. The amount of swelling and shrinking undergone, depends in part on the amount and kind of clay, the amount of moisture available, the extent of drying and the amount of calcium carbonate intermixed. Damage can be caused by heaving, the affect of which is essentially similar to loss of support.

Along the proposed route swelling clays constitute ivory to yellowish, grayish, locally somewhat greenish, laminae, many less than 1 inch thick, composed of highly plastic, waxy looking material with a roughly cubical breakage pattern. Wherever these layers are observed, the same material probably is present in disseminated, unapparent form in the adjacent strata. The clay in the laminae, however, may not be of the swelling type. Testing may be necessary to prove its swelling character and the potential pressure produced.

The clays are the result of the chemical decomposition, mainly through oxidation, of ash from volcanoes that erupted during the geologic past. Very rapid accumulation yields laminae, slow accumulation yields disseminated deposits.

Along the proposed route swelling clays will probably be encountered in clay and shale strata of marine origin that extend from the Canadian border to the vicinity of Big Muddy Creek, Montana and from the vicinity of the second crossing of the Missouri River in South Dakota to eastern Iowa. Marine shales commonly contain these clays in considerable quantities. The presence of the swelling clays are a significant factor in the wide-spread landsliding that characterizes these strata.

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Maps

U.S. Geological Survey, National Topographic Maps, Series 1:250,000
(nearly 4 miles to 1 inch)
(Maps are listed in geographic sequence from west to east along the proposed route)

Map Title	Serial No.
Glasgow, Montana	NM-13-10
Wolf Point, Montana, North Dakota	NM-13-11
Williston, North Dakota	NM 13-12
Waterford City, North Dakota	NL 13-3
McClusky, North Dakota	NL-14-1
Bismarck, North Dakota	NL 14-4
Jamestown, North Dakota	NL 14-5
Aberdeen, South Dakota, North Dakota	NL 14-8
Milbank, South Dakota, Minnesota, North Dakota	NL 14-9
Watertown, South Dakota, Minnesota	NL 14-12
New Ulm, Minnesota	NL 15-10
Fairmont, Minnesota, Iowa	NK 15-1
Mason City, Iowa, Minnesota	NK 15-2
Waterloo, Iowa	NK 15-5
Dubuque, Iowa, Wisconsin, Illinois	NK 15-6
Davenport, Iowa	NK 15-9
Aurora, Illinois	NK 16-7
Chicago, Illinois, Indiana, Michigan	NK 16-8
Danville, Illinois, Indiana	NK 16-11
Muncie, Indiana, Ohio	NK 16-12
Marion, Ohio	NK 17-10
Canton, Ohio, Pennsylvania, West Virginia	NK 17-11
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2.1.3.4 Soils

The existing condition of the soils along the proposed route must be understood so that disturbance of them by an embedded pipeline and associated structures can be adequately analyzed in terms of economic and environmental values. The nature and properties of the soils are described.

Soil Classification

There is a standardized system of soil classification used throughout America. Soils are classified by: order, (the broadest category), suborders, great groups, subgroups, families and series. The association of soil series along the proposed route are central to the descriptory material in Section 2.1.3.4.

Maps in the section show, on a state-by-state basis, the groupings of associated soil series. Within a given area, two or three soil series are described by name, but there usually are lesser amounts of other unnamed soils. A particular "soil series" is essentially uniform in its differentiating characteristics and in the arrangement of its layers.

Soil series are differentiated on the basis of the color, texture, structure and chemical nature of each horizon; the number, thickness and sequence of horizons; the thickness of the solum or true soil, i.e., the combined thickness of the surface and subsoil horizons; and the origin and nature of the parent material. Significant variation in one or more of these characteristics is the basis for distinguishing among the different series. The name of a soils series identifies it, but does not indicate its individual characteristics. Soil series with the same name in different areas have similar properties within the range defined for the particular series.

Listed below are brief descriptions of the major soil associations and series encountered along the proposed route. Data are not available to quantify the distances of each soil series crossed. Such quantification is available locally for some areas, but a detailed soil survey of the route has not been prepared. The soil associations crossed by the proposed pipeline are shown on the State maps. Major soil characteristics for dominant soil series likely to be encountered are shown in Figures 2.1.3.4-1 through 2.1.3.4-9 and Tables 2.1.3.4-1 through 2.1.3.4-9 for each state traversed by the proposed pipeline.

Soil Associations Along Proposed Route

Montana Soil Associations

Harlem-Havre Association--This association occurs on low lying lands along Porcupine, Cottonwood, Big Muddy, Shotgun Creeks and the Poplar River. The series' within this association consist of about 60 percent Harlem soils, 25 percent Havre soils, 10 percent Bowdoin soils and 5 percent minor soils.

The minor soils in the association are the Ideon, Glendive and Vanda series.

Lisam-Cabbart-Shale Outcrop Association--This association is shallow to deep, gently rolling to steep, well drained loam, clay loam and clay soils formed in materials weathered from soft sandstone, shale and shale outcrop

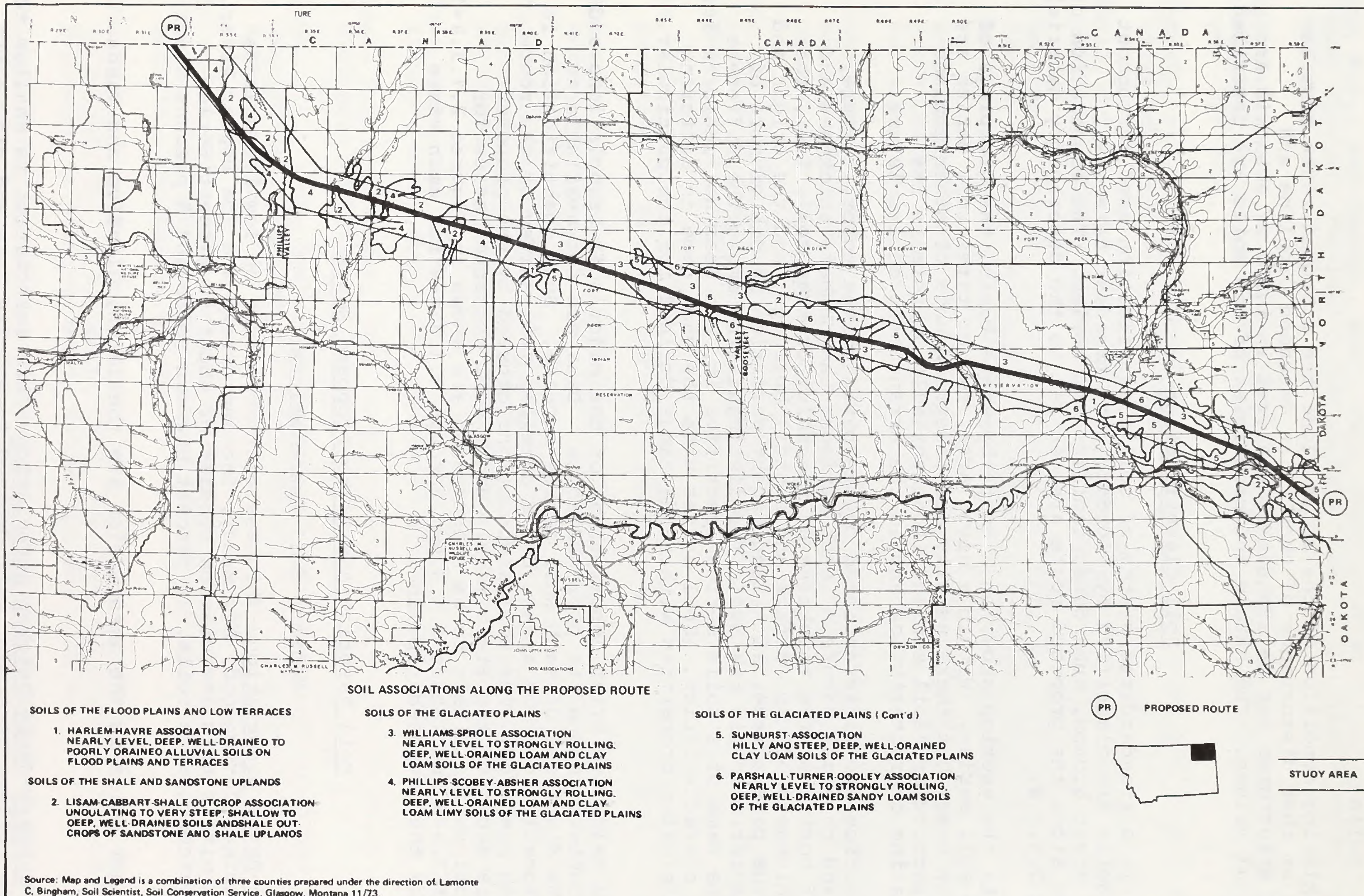


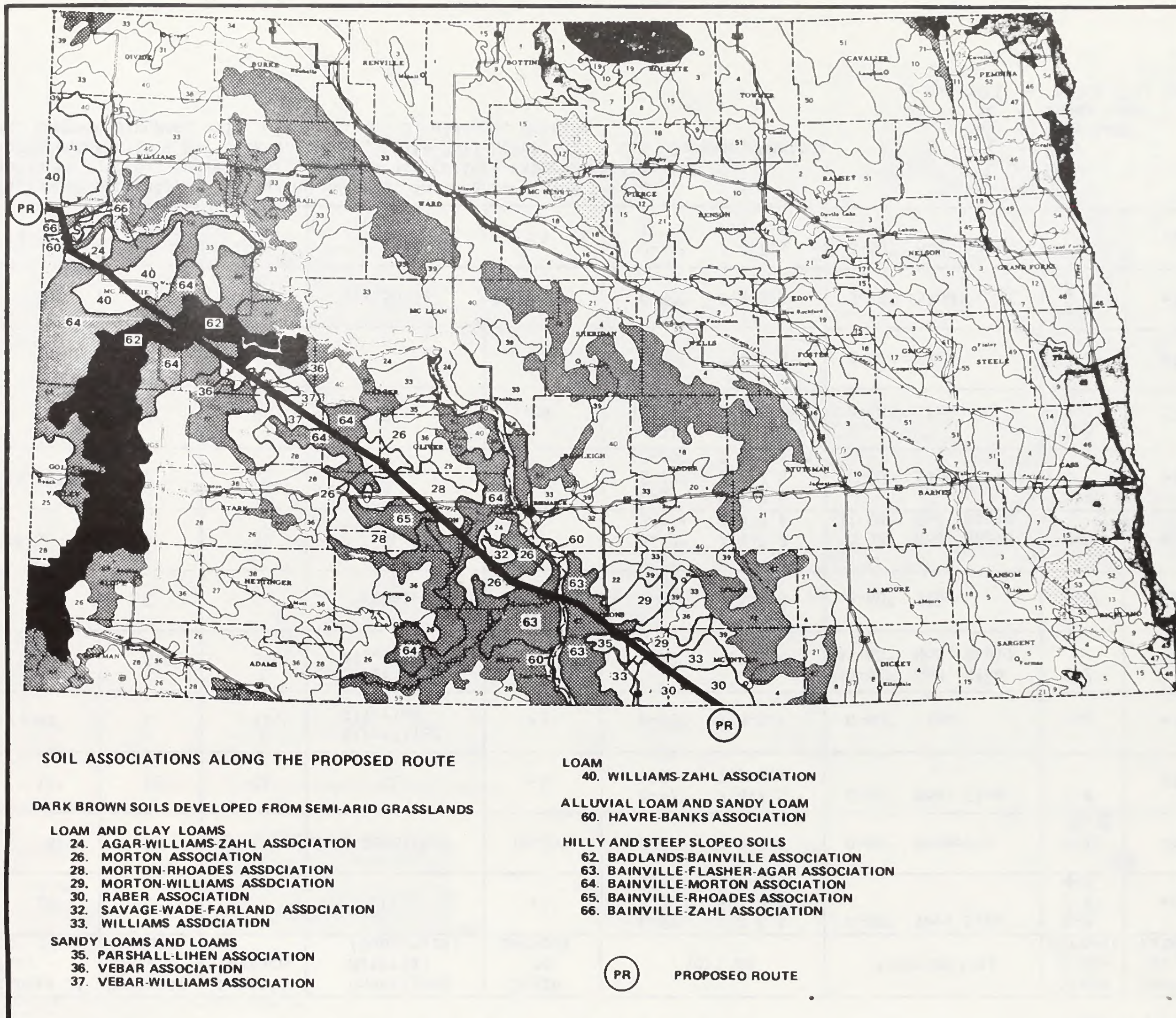
Figure 2.1.3.4-1 General soil map of northeastern Montana

Table 2.1.3.4-1 Estimated properties of major soils along the proposed route in Montana

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
ABSHER	Upland fans, Terraces & Till Plains	20"	L	C	CL	>5'	0-6" 7.4-8.4 6-20" 8.4-9.0 20" + 7.9-8.4	0-60" Very Slow	0-2 2-4 4-8	>6'
CABBART	Rolling to Moderately Steep Uplands	4"	L	L	Soft Sandstone	10-20"	0-60" 7.9-8.4	0-60" Moderate	8-15 15-35	>6'
EVANSTON	Upland fans & Footslopes	17"	CL	CL	CL	> 5'	0-17" 7.4-7.8 17" + 7.9-8.4	0-60" Mod. Slow	2-4	>6'
HARLEM	Floodplain	> 60"	C	SICL	Stratified Alluvium	>5'	0-60" 7.9-8.4	0-60" Slow	0-2	>6'
HAVRE	Floodplain	>60"	SICL	SICL	Stratified Alluvium	>5'	0-60" 7.9-8.4	0-45" Mod. Slow 45-60" Mod. Rapid	0-2	>6'
LISAM	Shale Uplands	12"	C	C	Shale	12-20"	0-60" 7.4-7.8	0-60" Slow	5-35	>6'
PARSHALL	Uplands & Terraces	16-36"	SL	SL	SL	> 5'	0-6" 6.6-7.3 6-32" 7.4-7.8 32" + 7.9-8.4	0-32" Mod. Rapid 32-60" Mod. Rapid	0-5	>6'
PHILLIPS	Glacial Till Uplands	15-38"	L	CL	CL	>5'	0-5" 6.1-7.3 5-12" 7.4-7.8 12-60" 7.9-8.4	0-60" Slow	0-9	>6'
SCOBEY	Glacial Till Uplands	15"	CL	CL	CL	>5'	0-11" 7.4-7.8 11" + 7.9-8.4	0-60" Slow	0-8 8-15	>6'
SUNBURST	Till Uplands & Valley Sideslopes	4"	CL	CL	C	>5'	0-60" 7.4-7.8	0-60" Slow	5-35	>6'
THEBO	Upland Shales	16"	C	C	Soft Shale	20-30"	0-60" 7.9-8.4	0-60" Slow	2-8 8-;5	>6'
WILLIAMS	Till Uplands	14-24"	L	CL	CL	>5'	0-11" 7.4-7.8 11" + 7.9-8.4	0-60" Mod. Slow		>6'

*This table developed from: National Cooperative Soil Survey Reports, Soil Conservation Service
Soils in Montana, Bulletin 621, Montana Agriculture Experiment Station
Conferences with - Mr. Jack W. Rogers, State Soil Scientist, S.C.S. Bozeman, Montana
Mr. Lamonte Bingham, Soil Scientist, S.C.S. Glasgow, Montana

L - Loam
C - Clay
CL - Clay Loam
SL - Sandy Loam
SICL - Silty Clay Loam



Source: Adapted from the General Soil Map, North Dakota Agricultural Experiment Station, Fargo, North Dakota.

Figure 2.1.3.4-2 General soil map of North Dakota

Table 2.1.3.4-2 Estimated properties of major soils along the proposed route in North Dakota

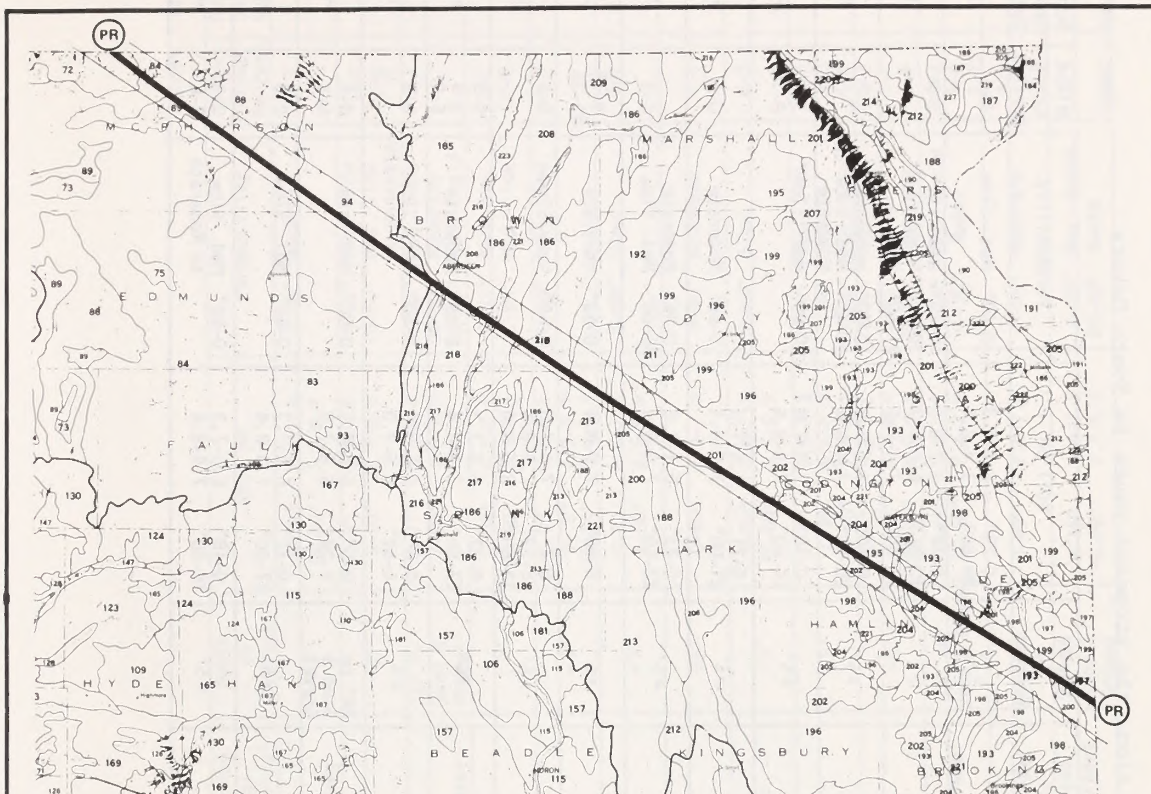
Sheet 1 of 2

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
AGAR	Loess Mantled Uplands	22"	SIL	SIL	L	>5'	0-60" 6.6-7.3	0-16" Moderate 16-60" Mod. Rapid	0-3 3-6	>6'
BADLANDS	Steep Breaks	< 10"	Variable	Variable	Shale & Sandstone	10"	Variable	Variable	30-65 65 +	>6'
BAINVILLE	Ridge Crests & Valley Sides	2-5"	SIL	SIL	Loamy Shale	24" to Soft Shales	0-60" 8.4-10.0	0-24" Mod. Slow 24-60" Slow to Very Slow	6-50	>6'
BANKS	Bottomlands	3-12"	LS	S	Sand & Gravel	12" to Sand & Gravel	0-60" 7.4-7.8	0-12" Mod. Rapid	0-6	>6'
FARLAND	Stream Terraces	18-32"	SIL	SICL	SL	>5'	0-5" 6.4-7.0 5-32" 6.6-8.0 32-60" 8.4-9.6	0-60" Moderate	0-3 3-6 6-9	>6'
FLASHER	Steep Sides of Hills & Ridges	2-25"	FSL	LFS	LFS	50" to Soft Sandstone	0-4" 6.5-7.2 4-50" 6.8-7.8	0-4" Mod. Rapid 4-50" Moderate	6-35	>6'
HAVRE	Floodplain	>60"	SICL	SICL	Stratified Alluvium	>5'	0-60" 7.2-9.0	0-60" Moderate	0-3	>6'
LIHEN	Terraces & Rolling Uplands	6-30"	LFS	LFS	LFS	>5'	0-60" 6.2-7.4	0-60" Mod. Rapid	2-6 6-15	>6'
MORTON	Upland Plains	3-12"	SIL	SICL	Siltstone & Soft Shale	36" to Siltstone or Soft Shale	0-5" 6.6-7.3 5-18" 6.6-7.8 18-36" 7.4-8.4	0-36" Moderate	0-3 3-6 6-9	>6'
PARSHALL	Outwash Plains & Terraces	23-48"	FSL	FSL	FSL	>5'	0-30" 6.8-7.2 30-60" 8.5-9.0	0-60" Mod. Rapid	0-3	>6'
RABER	Undulating Ground Moraines	20"	L	CL	CL	>5'	0-60" 7.4-7.8	0-22" Moderate 22-60" Slow	0-3 3-9	>6'
RHOADES	Upland Flats	27"	SL	SICL	Clayey Shale	>5'	0-3" 6.4-7.0 3-27" 7.3-8.4 27-60" 8.1-9.3	0-3" Moderate 3-27" Slow 27-60" Slow to Mod. Slow	0-3	>6'
SAVAGE	Low Terraces	22-35"	SICL	SICL	SL	>5'	0-6" 6.8-7.2 6-26" 7.0-8.2 26-60" 8.4-9.6	0-26" Moderate 26-60" Mod. Slow	0-3	>6'

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
VEBAR	Uplands & Stream Terraces	25-45"	FSL	FSL	LFS	> 5'	0-60" 6.2-7.8	0-35" Mod. Rapid 35-60" Rapid	3-6 6-9	> 6'
WADE	Terraces & Broad Valleys	20"	SIL	SIC	SIC	> 5'	0-3" 6.4-7.0 3-25" 7.3-8.4 25-60" 8.1-9.3	0-3" Moderate 3-25" Slow 25-60" Slow	0-3	> 6'
WILLIAMS	Side Slopes of Hills & Ridges	15-24"	L	CL	L	> 5'	0-10" 6.6-7.3 10-24" 7.4-7.8 24-60" 7.9-8.4	0-24" Moderate 24-60" Slow	0-3 3-6	> 6'
ZAHL	Crests of Hills & Ridges	5-12"	L	L	L	> 5'	0-5" 7.4-7.8 5-60" 7.9-8.4	0-20" Moderate 20-60" Slow	6-15 15-35	> 6'

This table developed from: National Cooperative Soil Survey Reports, Soil Conservation Service
Major Soils of North Dakota, Bulletin 472, North Dakota State University
Soil Survey Report, Bulletin 473, North Dakota State University
Conferences with Mr. Franklin Miller, State Soil Scientist, Soil Conservation Service, Bismarck, North Dakota

LFS - Loamy Fine Sand
FSL - Fine Sandy Loam
SL - Sandy Loam
S - Sand
L - Loam
SIL - Silt Loam
CL - Clay Loam
SICL - Silty Clay Loam
SIC - Silty Clay
C - Clay



McPHERSON, EDMUNDS, BROWN, SPINK, DAY, CLARK, CODINGTON, HAMLIN, DEUEL & BROOKINGS COUNTIES

SOIL ASSOCIATIONS ALONG THE PROPOSED ROUTE

SOILS OF THE COOL DRY PLAIN (TYPIC BOROLL AREA)

NEARLY LEVEL TO ROLLING LOAMY AND SILTY SOILS
72 BEARPAW ASSOCIATION
83 WILLIAMS ASSOCIATION
84 WILLIAMS – TONKA ASSOCIATION

ROLLING AND STEEP LOAMY SOILS
88 WILLIAMS – ZAHL ASSOCIATION

UNDULATING LOAMY SOILS WITH SANDY AND GRAVELLY SUBSTRATA
89 STADY ASSOCIATION

UNDULATING ASSOCIATION OF FRIABLE AND CLAYPAN SOILS
94 NIOBELL – NOONAN ASSOCIATION

(PR) PROPOSED ROUTE

Source: South Dakota State University, 1971.

SOILS OF THE COOL MOIST PRAIRIE (UDIC BOROLL AREA)

GENTLY UNDULATING TO ROLLING SILTY AND LOAMY SOILS
185 BARNES – WILLIAMS ASSOCIATION
186 BEOTIA – GREAT BEND – HARMONY ASSOCIATION
192 KRANZBURG ASSOCIATION
193 KRANZBURG – BROOKINGS – VIENNA ASSOCIATION
196 POINSETT – WAUBAY ASSOCIATION
197 SINGSAAS – OAK LAKE ASSOCIATION
198 VIENNA – LISMORE ASSOCIATION

ROLLING AND STEEP LOAMY SOILS
199 FORMAN – AASTAD – PARNELL ASSOCIATION
200 FORMAN – BUSE ASSOCIATION
201 FORMAN – BUSE – AASTAD – PARNELL ASSOCIATION
202 POINSETT – BUSE ASSOCIATION

NEARLY LEVEL TO ROLLING LOAMY SOILS WITH SANDY & GRAVELLY SUBSTRATA
204 FORDVILLE – ESTELLINE ASSOCIATION
205 RENSHAW – FORDVILLE ASSOCIATION

LEVEL TO GENTLY SLOPING CLAYEY SOILS
213 PEEVER – CAVOUR ASSOCIATION

NEARLY LEVEL CLAYPAN SOILS
216 ABERDEEN – EXLINE ASSOCIATION
218 HARMONY – ABERDEEN – EXLINE ASSOCIATION

ALLUVIAL SOILS, CLAYEY
221 LAMOURE ASSOCIATION

Figure 2.1.3.4-3 General soil map of northeastern South Dakota

Table 2.1.3.4-3 Estimated properties of major soils along the proposed route in South Dakota

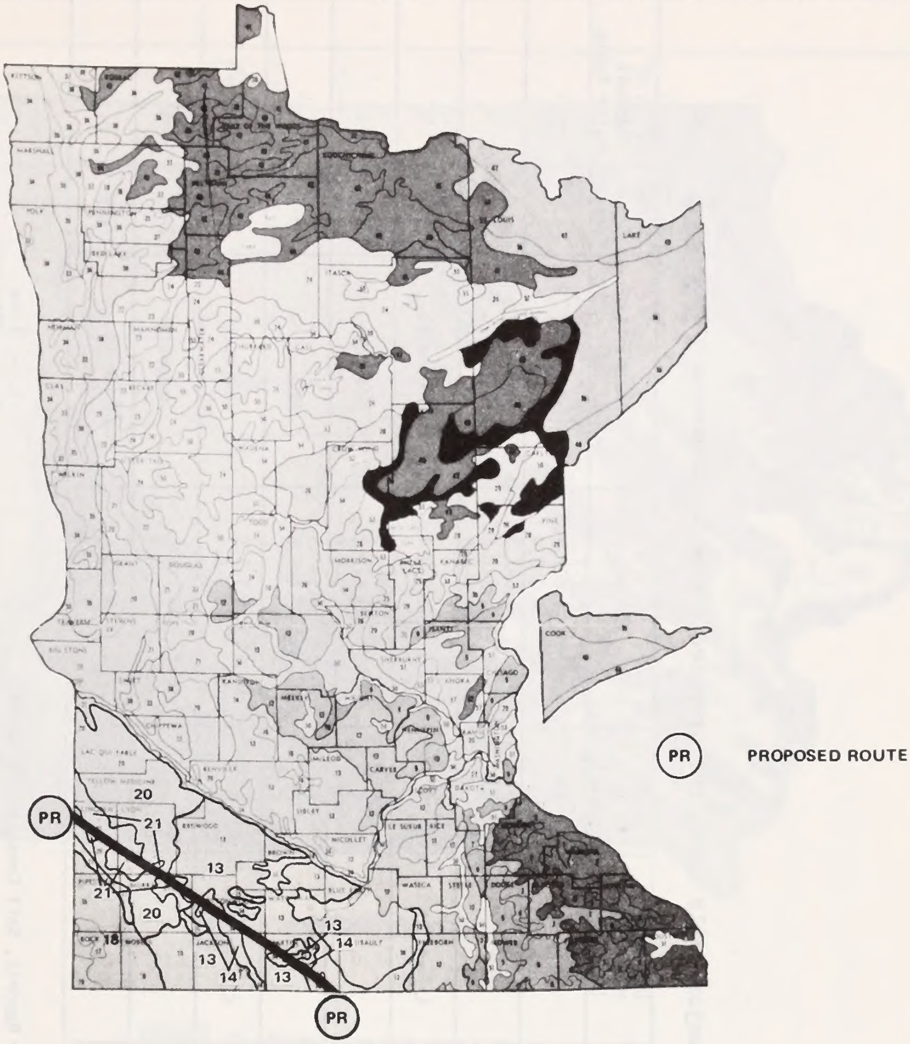
Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
AASTAD	Glacial Moraines & Till Plains	18-34"	CL	CL	CL	>5'	0-29" 6.6-7.3 29-60" 7.4-8.4	0-60" Mod. Slow	0-4	3-6'
ABERDEEN	Glacial Lake Plains	18-42"	SICL	SIC	SICL	>5'	0-10" 6.2-6.5 10-21" 6.6-7.3 21-60" 7.4-7.9	0-10" Moderate 10-21" Slow 21-60" Slow	0-3	1-3'
BARNES	Glacial Till Plains	10-22"	L	L	L	>5'	0-20" 6.6-7.3 20-60" 7.4-8.4	0-20" Moderate 20-60" Mod. Slow to Moderate	3-6	>6'
BEARPAW	Glacial Till Plains	15-26"	CL	C	CL	>5'	0-10" 7.4-7.8 10-60" 7.8-8.4	0-60" Mod. Slow	3-9 9-15	>6'
BEOTIA	Nearly Level Uplands	16-32"	SIL	SIL	SIL	>5'	0-21" 6.6-7.3 21-60" 7.9-8.4	0-60" Moderate	0-3	>6'
BROOKINGS	Level Upland, Flats & Swales	21-35"	SICL	SICL	L	>5'	0-23" 6.1-7.8 23-60" 7.9-8.4	0-36" Moderate 36-60" Mod. Slow	0-3	3-6'
BUSE	Glacial Moraines	7"	L	--	L	>5'	0-60" 7.9-8.4	0-60" Moderate	9-15 15-35	>6'
CAVOUR	Level to Sloping Uplands	20-34"	L	C	CL	>5'	0-8" 7.4-7.8 8-19" 7.9-8.4 19-60" 8.5-9.0	0-60" Very Slow	0-9	3-6'
ESTELLINE	Stream Terraces & Outwash Plains	24-36"	SIL	SICL	Sand & Gravel	36"	0-27" 6.6-7.3 27-60" 7.9-8.4	0-60" Moderate	0-3 3-6 6-9	>6'
EXLINE	Glacial Lake Plains	19"	SIL	C	SICL	>5'	0-6" 6.6-8.4 6-60" 8.5-9.0	0-60" Very Slow	0-3	1-3'
FORDVILLE	Stream Terraces & Outwash Plains	24"	L	L	Sand & Gravel	24" to Sand & Gravel	0-6" 5.8-6.5 6-24" 6.6-7.8	0-60" Moderate	0-6 6-9	>6'
FORMAN	Glacial Till Plains	11-26"	CL	CL	CL	>5'	0-17" 6.6-7.3 17-60" 7.3-8.4	0-60" Mod. Slow	0-6	>6'
GREAT BEND	Glacial Lake Plains	14-20"	SIL	SIL	SIL	>5'	0-18" 6.6-7.3 18-60" 7.9-8.4	0-60" Mod. Slow to Moderate	0-3 3-6	>6'

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
HARMONY	Level Lake Plains	18-40"	SICL	SIC	SIL	>5'	0-15" 7.4-7.8 15-60" 7.9-8.4	0-60" Moderate	0-3	3-6'
KRANZBURG	Smooth Glacial Plains	20-36"	SICL	SICL	CL	>5'	0-8" 6.6-7.8 8-60" 7.4-8.5	0-25" Mod. Slow 25-60" Mod. Slow to Moderate	0-3 3-6	>6'
LAMOURE	Level Bottomland	24-36"	SICL	SIL	SL	36" to Sand & Gravel	0-7" 7.4-8.4 7-60" 7.9-9.0	0-34" Mod. Slow 34-52" Moderate 52-60" Mod. Rapid	0-3	0-1'
LISMORE	Glacial Till Upland Flats	23-43"	SICL	CL	CL	>5'	0-24" 6.1-6.5 24-60" 7.4-7.8	0-32" Moderate 32-60" Mod. Slow	0-2 2-6	3-6'
NIOBELL	Glacial Ground Moraine	16-30"	L	CL	L	>5'	0-9" 6.6-7.3 9-19" 7.9-8.4 19-60" 8.5-9.0	0-60" Very Slow	0-3	3-6'
NOONAN	Glacial Till Plains	18-24"	L	CL	L	>5'	0-6" 6.6-7.3 6-60" 8.5-9.0	0-60" Slow	0-3	3-6'
OAK LAKE	Smooth Upland Flats	7"	SIL	L	L	>5'	0-60" 7.4-7.8	0-60" Moderate	0-3	3-6'
PARNELL	Depressions in Glacial Moraines	30-60"	SICL	SICL	SICL	>5'	0-15" 6.6-7.3 15-60" 6.1-6.5	0-60" Slow	0-3	0-1' or Ponded
PEEVER	Level to Sloping Uplands	21-56"	CL	C	CL	>5'	0-7" 6.6-7.3 7-39" 6.6-8.4 39-60" 7.9-8.4	0-7" Mod. Slow 7-39" Slow 39-60" Mod. Slow	0-3 3-6 6-9	>6'
POINSETT	Level to Undulating Uplands	20-26"	SIL	SIL	SIL	>5'	0-7" 6.6-7.8 7-22" 7.4-8.4 22-60" 7.9-9.0	0-7" Mod. Slow 7-22" to 22-60" Moderate	0-3 3-6 6-9	>6'
RENSHAW	Terraces & Escarpments	10-20"	L	L	Sand & Gravel	15" to Sand & Gravel	0-15" 6.6-7.3 15-30" 7.4-7.8	0-15" Mod. Rapid 15-30" Rapid	0-3 3-6 6-25	>6'
SINGSAAS	Level to Rolling Ground Moraine	25"	L	L	CL	>5'	0-60" 7.4-7.8	0-60" Moderate	0-3 3-6	>6'
STADY	Stream & Outwash Terraces	18"	L	L	Sand & Gravel	29" to Sand & Gravel	0-15" 6.6-7.3 15-29" 7.4-8.4	0-29" Mod. Rapid 29-60" Rapid	0-3	>6'

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
TONKA	Basins & Depressions	28-40"	SIL	SICL	SICL	>5'	0-34" 5.6-6.5 34-60" 6.6-7.8	0-60" Mod. Slow	0-3	0-1'
VIENNA	Glacial Till Uplands	20-37"	SICL	SICL	L	>5'	0-5" 6.0-6.5 5-23" 6.6-7.8 23-60" 7.9-9.0	0-5" Mod. Slow-Mod. 5-23" Mod. Slow 23-60" Mod. Slow-Mod.	0-3 3-6 6-9	>6'
WAUBAY	Nearly Level Till Glacial	26-43"	SIL	SICL	SIL	>5'	0-22" 6.6-7.8 22-60" 7.9-9.0	0-60" Mod. Slow	0-3	3-6'
WILLIAMS	Glacial Till Uplands	15-24"	L	CL	L	>5'	0-10" 6.6-7.3 10-24" 7.4-7.8 24-60" 7.9-8.4	0-24" Moderate 24-60" Slow	0-3 3-6	>6'
ZAHL	Till Plains & Valley Sides	12-30"	L	--	CL	>5'	0-5" 7.4-7.8 5-60" 7.9-8.4	0-20" Moderate 20-60" Slow	3-35	>6'

This table developed from: National Cooperative Soil Survey Reports, Soil Conservation Service
Soils of South Dakota, Soil Survey Series No. 3, South Dakota State University
Soil Atlas and Crop Production Guide for Northeastern South Dakota, Extension Circular No. 684, South Dakota State University
Conferences with Mr. D. L. Bannister, State Soil Scientist, S.C.S., Huron, South Dakota

L - Loam
SIL - Silt Loam
CL - Clay Loam
SICL - Silty Clay Loam
SIC - Silty Clay
C - Clay



SOIL ASSOCIATIONS ALONG THE PROPOSED ROUTE

MEDIUM TO FINE TEXTURE SOIL OF SOUTH-CENTRAL MINNESOTA
13 CLARION-NICOLLET-WEBSTER
14 CLARION-STORDEN
15 IHLEN-ROCK OUTCROP
16 TRUMAN-MARNA

SILTY PRAIRIE SOIL OF SOUTHWESTERN MINNESOTA
18 KRANZBURG-VIENNA-MOODY

MEDIUM TO FINE TEXTURED PRAIRIE AND PRAIRIE BORDER SOILS OF WESTERN MINNESOTA
20 BARNES-AASTAD-FLOM
21 BARNES-BUSE-PIERCE

COARSE TO MEDIUM TEXTURED PRAIRIE SOILS FORMED FROM GLACIAL OUTWASH
50 ESTHERVILLE-WADENA-HUBBARD

Source: U.S.D.A. University of Minnesota Agricultural Extension Service.

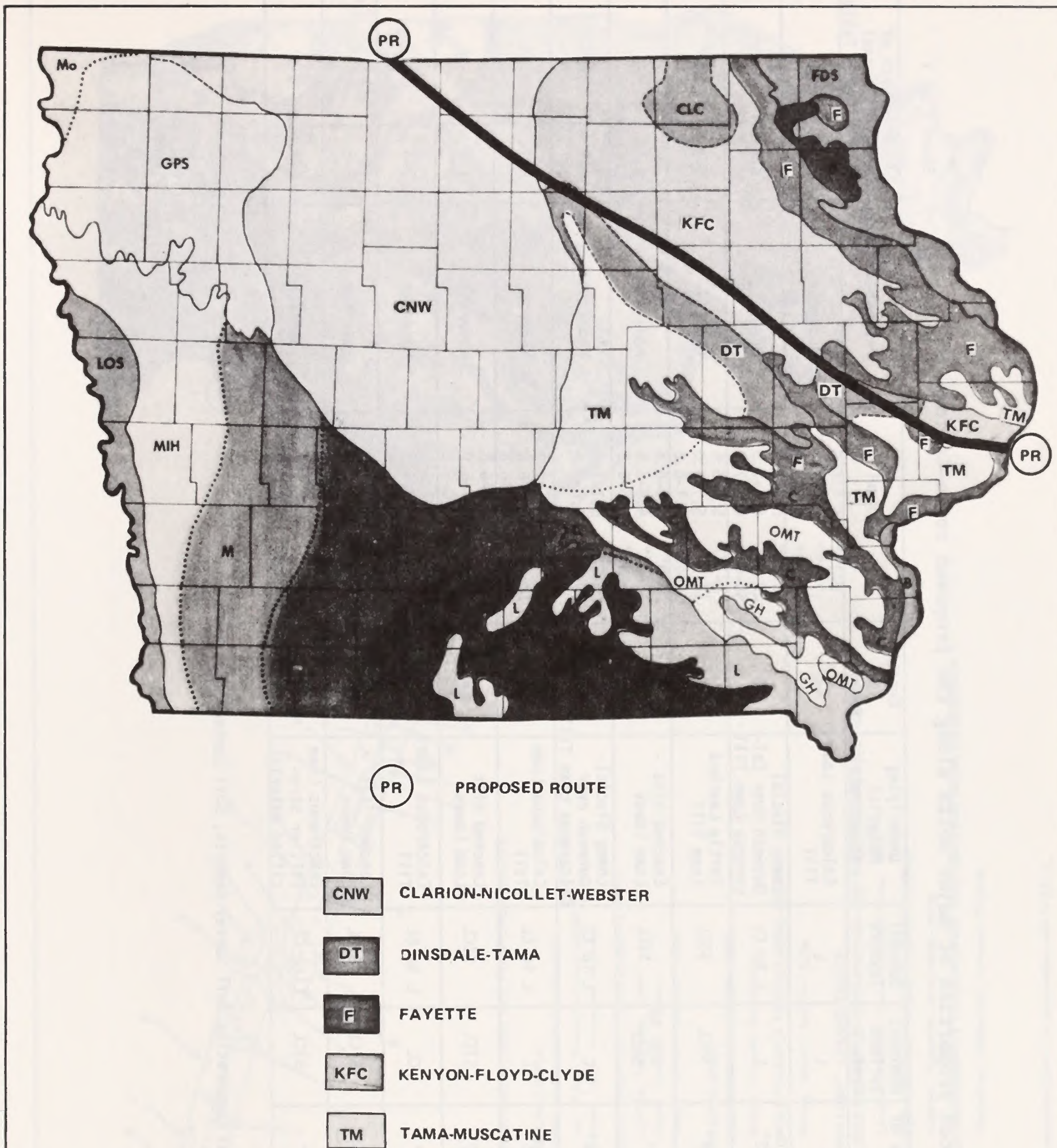
Figure 2.1.3.4-4 General soil map of Minnesota

Table 2.1.3.4-4 Estimated properties of major soils along the proposed route in Minnesota

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
ɅASTAD	Glacial Till Plains	13"	CL	CL	CL	6'	0-29" 6.6-7.3 29-32" 7.4-7.8 32-60" 7.9-8.4	Moderate	0-2	3-6'
ЗARNES	Glacial Till Plains	6"	L	L	L	6'	0-6" 6.6-7.3 6-18" 6.6-7.8 18-60" 7.4-8.4	Moderate	1-6	6'
ЗASE	Glacial Till Plains	6"	L	L	L or CL	6'	0-60" 7.9-8.4	Moderate	25	6'
:LARION	Calcareous Glacial Till	17"	L	L	L	6'	0-17" 6.1-6.5 17-32" 6.6-7.3 32-60" 7.9-8.4	Moderate	2-6	6'
'LOM	Glacial Till Plains	15"	CL	CL	CL	6'	0-15" 6.5-7.3 15-20" 7.4-7.8	Mod. Slow	0-2	0-3'
'ICOLLET	Loamy Glacial Till of Uplands	12"	CL	CL or L	CL or L	6'	0-12" 6.1-6.5 12-40" 5.6-6.5	Moderate	0-6	3-6'
STORDEN	Calcareous Glacial Till Uplands	8"	L	L	L	6'	0-8" 7.4-7.8 8-60" 7.4-8.4	Moderate	2-35	6'
WEBSTER	Glacial Till or Sediments	17"	CL	CL	L	6'	0-17" 6.6-7.3 17-31" 6.6-7.8 31-60" 7.9-8.4	Moderate to Moderate Slow	0-2	0-1'

'his table developed from: National Cooperative Soil Survey Reports, Soil Conservation Service

L - Loam
CL - Clay Loam



Source: Iowa State University in cooperation with Soil Conservation Service, U.S.D.A. WRO, FFR, & RID, 1964.

SOIL ASSOCIATIONS ALONG THE PROPOSED ROUTE

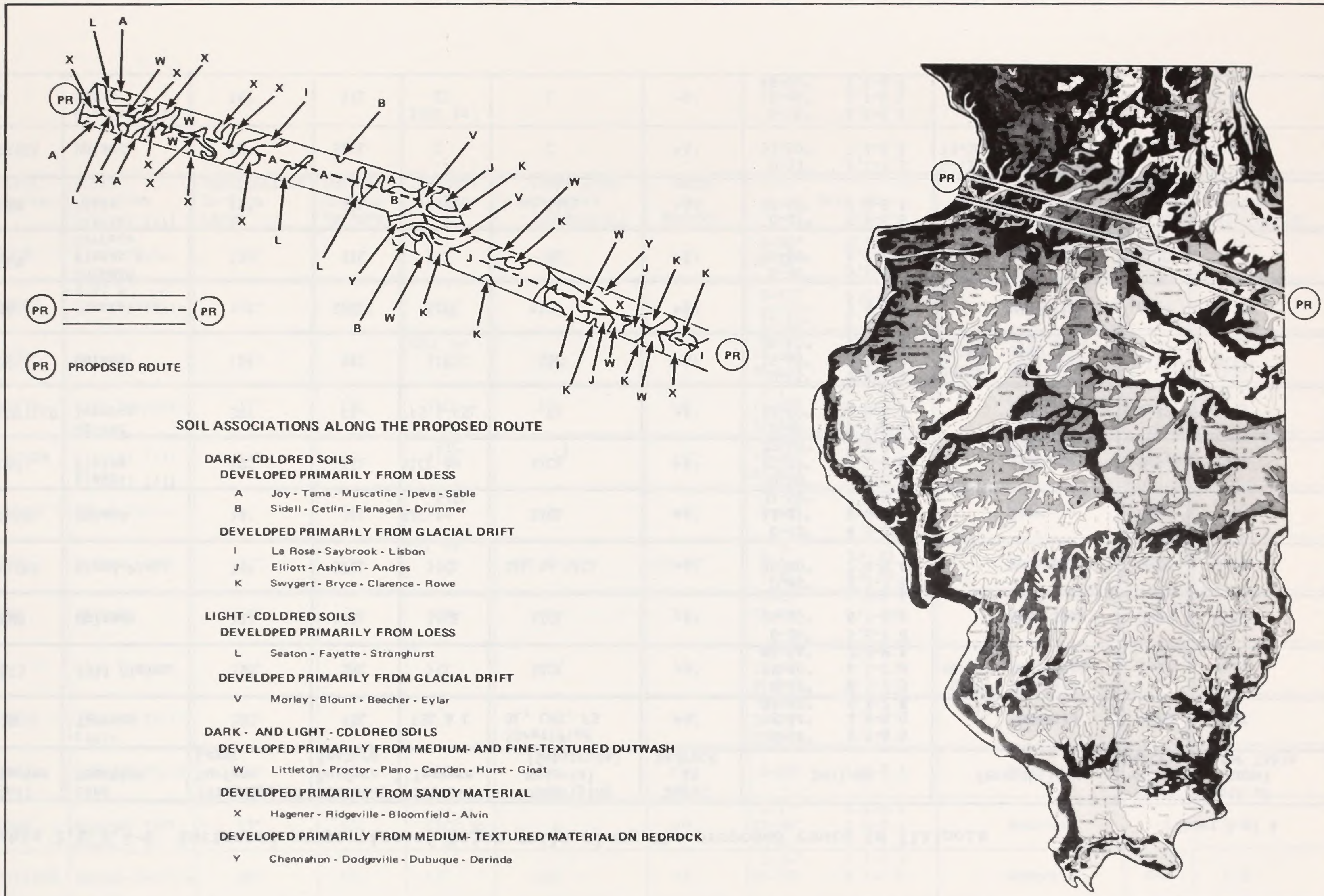
Figure 2.1.3.4-5 General soil map of Iowa

Table 2.1.3.4-5 Estimated properties of major soils along the proposed route in Iowa

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
CLARION	Upland Highs & Ridges	17"	L	L	Calcareous Loam Till	>6'	0-17" 6.1-6.5 17-32" 6.6-7.3 32-60" 7.9-8.4	Moderate	2-9	>6'
CLYDE	Upland Swales	15-22"	L	L to CL	Loamy Glacial Outwash over Calcareous Loam Till	>6'	0-20" 6.1-7.3 20-50" 6.6-7.3 50-60" 6.6-7.8	Moderate	0-2	0-1'
DINSDALE	Upland	12-16"	SICL	SICL	Partly Leached Loam Till	>6'	0-14" 5.6-6.6 14-32" 5.1-6.0 32-60" 5.1-6.6	Moderate	2-9	>6'
FAYETTE	Upland Ridges & Side Slopes	2-4"	SIL to SICL	SICL	Leached Silt Loam Loess	>6'	0-8" 5.0-6.6 8-46" 4.6-5.6 46-60" 5.6-6.6	Moderate	2-14	>6'
FLOYD	Upland	15-18"	L	L to CL	Loamy Glacial Outwash over Calcareous Loam Till	>6'	0-50" 6.1-7.3 50-60" 6.6-7.8	Moderate	1-2	1-3'
KENYON	Upland	12-16"	L	L to CL	Calcareous Loam Till	>6'	0-12" 5.1-6.6 12-50" 5.1-6.0 50-60" 6.0-6.6	Moderate	5-14	3-6'
MUSCATINE	Upland Ridges	15-20"	SICL	SICL	Leached Silt Loam Loess	>6'	0-17" 6.0-6.8 17-46" 5.1-6.0 46-60" 6.0-6.8	Moderate	1-3	1-3'
NICOLLET	Upland Intermediate Highes	12"	CL	L to CL	Calcareous Loam Till	>6'	0-12" 6.1-6.5 12-40" 5.6-6.5 40-60" 7.4-7.8	Moderate	1-3	3-6'
TAMA	Upland	12-16"	SICL	SICL	Leached Silt Loam Loess	>6'	0-15" 5.8-6.8 15-52" 5.1-6.0 52-67" 6.0-6.8	Moderate	2-5	> 6'
WEBSTER	Upland Flats	17"	SICL	L to CL	Calcareous Loam Till or Stratified Material	>6'	0-17" 6.6-7.3 17-31" 6.6-7.8 31-60" 7.9-8.4	Moderate	0-2	0-1'

This table developed from: National Cooperative Soil Survey Reports, Soil Conservation Service

L - Loam
CL - Clay Loam
SIL - Silty Loam
SICL - Silty Clay Loam



Source: University of Illinois Agriculture Experiment Station in cooperation with U.S.D.A., S.C.S.

Figure 2.1.3.4-6 General soil map of Illinois

Table 2.1.3.4-6 Estimated properties of major soils along the proposed route in Illinois

Sheet 1 of 4

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH		Permeability		Slope Group Percent	Depth of Seasonal Water Table
ALVIN	Terrace	18"	FSL	FSL & L	Stratified SL, LFS, FS	>6'	0-18" 18-44" 44-68"	5.1-6.5 4.5-6.0 5.1-7.8		Moderate	1-20	3-6'
ANDRES	Till Plains	19"	SIL	CL	SICL	>6'	0-19" 19-46" 46-54"	6.1-7.3 6.1-7.8 7.8-8.4	0-46" 46-54"	Moderate Mod. Slow	1-3	1-3'
ASHKUN	Uplands	11"	SICL	SICL	SICL	>6'	0-26" 26-60"	5.6-7.8 6.1-8.4		Mod. Slow	0-2	0-1'
BEAUCOUP	Flood Plain	14"	SICL	SICL	SIL to SICL	>6'	0-46" 46-60"	6.1-7.8 7.4-8.4		Moderate	0-2	0-1'
BEECHER	Upland	13"	SIL	SIC to SICL	SICL	>6'	0-13" 13-31" 31-50"	4.5-6.0 4.5-6.5 7.4-8.4		Slow	0-6	1-3'
BLOUNT	Glacial Till Plains	10"	SIL	SICL to SIC	SICL	>6'	0-10" 10-32" 32-60"	5.1-6.5 4.5-6.5 7.4-8.4		Slow to Mod. Slow	0-5	1-3'
BLOOMFIELD	Upland Terrace	38"	FS	FS & FSL	FS	>6'	0-38" 38-80"	5.1-6.5 5.6-6.5		Mod. Rapid	0-32	>6'
BRYCE	Upland	12"	SIC	SIC	SIC	>6'	0-15" 15-38" 38-60"	5.6-7.8 6.6-8.4 7.4-8.4	0-15" 15-60"	Mod. Slow Slow	0-2	0-1'
CALCO	Floodplain	31"	SICL	SICL	SICL	>6'		7.9-8.4		Mod. Slow	0-2	0-1'
CAMDEN	Outwash Plains & Terrace	13"	SIL	SIL	SL	>6'	0-36" 36-60"	5.1-6.0 5.6-7.3		Moderate	0-30	3-6'
CATLIN	Glacial Till Plain	12"	SIL	SICL	L or SICL	>6'	0-42" 42-60"	5.6-6.5 7.4-8.4		Moderate	3-7	3-6'
CLARENCE	Upland	13"	SICL	C	C	>6'	0-33" 33-50"	6.1-7.3 7.4-8.4	0-13" 13-50	Mod. Slow Very Slow	0.6'	1-3'
DANA	Glacial Till Plain	16"	SIL	SICL to CL	L	>6'	0-16" 16-48" 48-60"	5.6-6.5 5.1-6.5 7.4-8.4		Moderate	6-12	3-6'

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH		Permeability		Slope Group Percent	Depth of Seasonal Water Table
DARWIN	Flood Plain	14"	SIC	SIC	SICL	> 6'	0-56" 56-68"	6.1-7.8 7.3-8.4		Very Slow	0-2	0-1'
DRUMMER	Till & Outwash Plain	14"	SICL	SICL	L	>6'	0-41" 41-47" 47-60"	5.6-7.3 6.1-7.8 6.6-8.4		Moderate	0-2	0-1'
ELLIOTT	Uplands	14"	SIL	SICL or SIC	SICL	>6'	0-14" 14-36" 36-48"	5.6-6.5 5.6-7.8 7.4-8.4	0-14" 14-36" 36-46"	Moderate Mod. Slow Mod. Slow	1-3	1-3'
FAYETTA	High Terrace	11"	SIL	SICL	SIL	> 6'	0-11" 11-47" 47-73"	5.1-6.0 4.5-5.5 5.1-5.5		Moderate	3-12	3-6'
FLANAGAN	Glacial Till Plain	18"	SIL	SICL	L	>6'	0-18" 18-45" 45-60"	5.6-6.5 5.6-7.3 7.4-8.4		Moderate	1-3	1-3'
HAYMOND	Flood Plain	8"	SIL	SIL	SIL	> 6'	0-60"	61-65		Moderate	0-2	6'
HESCH	Bottom Land	10"	FSL	FSL to L	FSL to L	>20-40"	0-7" 7-15"	5.6-7.3 5.6-6.3		Moderate	0-2	1-3'
IPAVA	Uplands	16"	SIL	SICL	SIL	>6'	0-42" 42-83"	5.6-7.3 6.1-7.8		Moderate	0-12	1-3'
JOY	High Terrace	19"	SIL	SIL	SIL	>6'	0-19" 19-48" 48-74"	5.6-7.3 5.1-6.6 6.1-7.8		Moderate	0-12	1-3'
LA ROSE	Glacial Till Plain	10"	SIL	CL	L	>6'	0-10" 10-20" 20-60"	6.1-7.3 5.6-6.5 7.4-8.4		Moderate	7-15	3-6'
LAWSON	Outwash Plain	30"	SIL	SICL	SIL	> 6'	0-60"	6.6-7.3		Moderate	0-3	1-3'
LISBON	Glacial Till Plain	17"	SIL	SICL to CL	L	>6'	0-17" 17-30" 30-60"	5.6-6.5 5.6-7.3 7.4-8.4		Moderate	1-3	1-3'
LITTLETON	Stream Terrace	26"	SIL	SIL	SIL	>6'	0-26" 26-50"	6.1-7.3 6.1-7.8		Moderate	0-4	1-3'

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
MILLINGTON	Bottom Land	15"	L	L	Stratified SCL, SIL, SICL, L	>6'	0-50" 7.4-8.4	Moderate	0-2	0-1'
MORLEY	Glacial Till Plains	8-14"	SIL	SIC	SICL	>6'	0-42" 5.6-6.5 42-48" 7.4-8.4	Mod. Slow to Slow	1-12	3-6'
MUSCATINE	Upland Divides	16"	SIL	SICL	SIL	>6'	0-16" 5.1-5.5 16-48" 5.1-6.6 48-64" 7.4-7.8	Moderate	0-12	1-3'
NAPPANEE	Till & Lake Plains	8"	SIL	C	SIC	>6'	0-14" 5.6-6.0 14-28" 6.6-7.8 28-42" 7.4-8.4	Very Slow	0-4	1-3'
PLANO	Plain & Stream Terraces	12"	SIL	SICL	Stratified Outwash or Sandy Loam	>6'	0-12" 6.1-7.3 12-45" 5.6-6.0 45-60" 6.8-8.4	Moderate	0-12	3-6'
PROCTOR	Stream Terrace	14"	SIL	SICL to CL	Stratified L, SIL, SL	>6'	0-14" 5.6-7.3 14-36" 5.6-6.5 36-80" 6.1-7.3	Moderate	0-12	3-6'
RIDGEVILLE	Outwash Plain & Terraces	20"	FSL	SL & SCL	FS	>6'	0-40" 5.6-6.5 40-60" 6.6-7.8	Moderate	0-5	1-3'
SABLE	Upland	16"	SICL	SICL	SIL	>6'	0-16" 6.1-7.3 16-60" 7.6-7.8	Moderate	0-12	0-1'
SAYBROOK	Glacial Till Plain	15"	SIL	SICL	L	>6'	0-35" 5.6-6.5 35-60" 7.4-8.4	Moderate	2-7	3-6
SEATON	Bluffs	9"	SIL	SIL	SIL	>6'	0-9" 5.6-7.3 9-70" 5.1-6.5 70-95" 5.6-8.4	Moderate	3-15	6'
SPARTA	Uplands, Stream Terraces, Outwash Plains	15"	LFS	LFS	FS	>6'	0-60" 5.6-6.0	Very Rapid	3-6	6'
STRONGHURST	Upland	11"	SIL	SICL	SIL	>6'	0-11" 5.1-7.3 11-47" 5.1-6.0 47-60" 5.6-7.3	Moderate to Mod. Slow	0-6	1-3'
SWYGERT	Uplands	12"	SICL to SIL	SIC	SIC	>6'	0-12" 5.6-6.6 12-31" 6.1-7.8 31-52" 7.9-8.4	0-12" Mod. Slow 12-52" Slow	0-12	1-3'

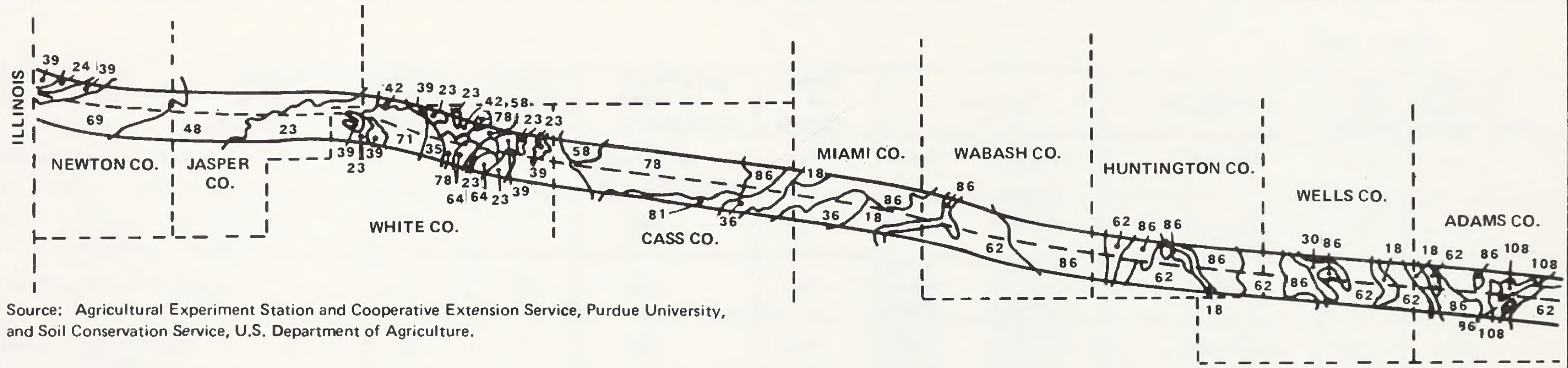
Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
TAMA	Upland	14"	SIL	SICL	SIL	>6'	0-14" 5.6-6.0 14-45" 5.1-5.6 45-60" 5.6-6.0	Moderate	12-18	3-6'

This Table Developed From: National Cooperative Soil Survey Reports, Soil Conservation Service

C - Clay
L - Loam
CL - Clay Loam
SL - Sandy Loam

FS - Fine Sand
SIL - Silty Loam
SIC - Silty Clay
FSL - Fine Sandy Loam

LFS - Loamy Fine Sand
SCL - Sandy Clay Loam
SICL - Silty Clay Loam



Source: Agricultural Experiment Station and Cooperative Extension Service, Purdue University, and Soil Conservation Service, U.S. Department of Agriculture.

SOIL ASSOCIATIONS

18. *Fox-Martinsville-Alluvial soils:* Sloping and nearly level, well drained, loamy Fox on outwash sand and gravel, and loamy Martinsville on outwash sand and silt and associated soils in alluvial deposits.

23. *Maumee-Gilford-Rensselaer:* Nearly level, very poorly drained, sandy Maumee and loamy Gilford and Rensselaer in outwash or lake-deposited sand and silt.

24. *Maumee-Newton:* Nearly level, very poorly drained, sandy soils in outwash or lake-deposited sands.

30. *Milford-Montgomery-Rensselaer:* Nearly level, very poorly drained, clayey Milford and Montgomery and loamy Rensselaer on lake deposits.

35. *Oshtemo-Fox:* Nearly level and sloping, well drained, loamy soils on outwash sand and gravel.

36. *Ockley-Westland:* Nearly level, well drained, loamy Ockley on outwash sand and gravel.

39. *Plainfield-Brems-Morocco:* Sloping, excessively drained, sandy Plainfield, nearly level, moderately well drained, sandy Brems, and nearly level, somewhat poorly drained, sandy Morocco in wind-blown or outwash sands.

42. *Plainfield-Chelsea:* Sloping, excessively drained, sandy soils in wind-blown sands.

48. *Rensselaer-Darroch:* Nearly level, very poorly drained, loamy Rensselaer and somewhat poorly drained, loamy Darroch on outwash or lake-deposited sand and silt.

58. *Crosier-Brookston:* Nearly level, somewhat poorly drained, loamy Crosier and very poorly drained, loamy Brookston in glacial till.

62. *Blount-Pewamo:* Nearly level, somewhat poorly drained, clayey Blount and very poorly drained, clayey Pewamo in glacial till.

64. *Crosby-Brookston:* Nearly level, somewhat poorly drained, clayey Crosby and very poorly drained, loamy Brookston in glacial till.

69. *Parr-Miami:* Sloping, well drained, loamy soils in glacial till.

71. *Randolph-Millsdale:* Nearly level, somewhat poorly drained, clayey Randolph and very poorly drained, clayed Millsdale in thin glacial till over limestone.

78. *Miami-Metca-Celina:* Sloping, well drained, loamy Miami and moderately well drained, loamy Celina soils in glacial till, and well drained, loamy Metea in sandy deposits and till.

81. *Miami-Russell-Fincastle:* Sloping, well drained, loamy Miami in glacial till and silty Russell in wind-blown silts and glacial till and nearly level somewhat poorly drained, silty Fincastle in wind-blown silts and glacial till.

86. *Morley-Blount:* Sloping, well drained, clayey Morley and nearly level, somewhat poorly drained, clayey Blount in glacial till.

108. *Mucks and peats:* Nearly level, very poorly drained soils developed in organic materials.

Figure 2.1.3.4-7 General soil map of Indiana

Table 2.1.3.4-7 Estimated properties of major soils along the proposed route in Indiana

Sheet 1 of 3

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH		Permeability		Slope Group Percent	Depth of Seasonal Water Table
ADRIAN	Organic Basins	30"	Muck	LFS	LFS	>15'	Variable		0-30" 30-60"	Moderate Rapid	0-2	0-1 or Ponded
BLOUNT	Upland Till Plains	7"	SIL	SIC	SCL	>15'	0-7" 7-29" 29-60"	6.1-6.5 5.6-6.0 7.9-8.4	0-7" 7-29" 29-60"	Moderate Slow Mod. Slow	0-5	Perched 1-3
BREMS	Outwash Plains	9"	LS	S	S	>15'	0-10" 10-60"	5.6-6.0 5.1-6.0	0-10" 10-60"	Mod. Rapid Rapid	0-6	2-3
BROOKSTON	Depressional on Till Plains	14"	SCL	CL	L	>15'	0-46" 46-60"	6.6-7.3 7.9-8.4	0-46" 46-60"	Moderate Mod. Slow	0-2	0-1 or Ponded
CELINA	Upland Till Plains	12"	SIL	SCL	L	>15'	0-12" 12-36" 36-60"	5.6-6.0 5.1-6.6 7.9-8.4	0-12 12-36" 36-60"	Moderate Mod. Slow Mod. Slow	0-6	3-6
CHELSEA	Sand Dunes on Outwash Plains	36"	LFS	Layered S & LFS	S	>15'	0-60"	4.5-6.0	0-60"	Rapid	0-12	>6'
CROSBY	Upland Till Plains	11"	SIL	CL	L	>15'	0-11" 11-36" 36-60"	6.1-6.6 5.1-6.6 7.9-8.4	0-11" 11-36" 36-60"	Moderate Slow Mod. Slow	0-6	1-3
CROSIER	Upland Till Plains	11"	SIL	Light CL	L	>15'	0-11" 11-38" 38-60"	6.1-6.6 5.1-6.6 7.9-8.4	0-11" 11-38" 38-60"	Moderate Mod. Slow Mod. Slow	1-4	1-3
DARROCH	Glacial Lake Plains	22"	L	CL	Stratified FSL, S, & SIL	>15'	0-22" 22-38" 38-60"	5.1-6.5 6.1-6.5 7.9-8.4	0-22" 22-38" 38-60"	Moderate Slow Moderate	0-2	1-3
FINCASTLE	Loess Mantled Uplands	16"	SIL	SICL over CL	L	>15'	0-16" 16-55" 55-60"	5.1-6.5 5.1-6.0 7.9-8.4	0-16" 16-55" 55-60"	Moderate Mod. Slow Mod. Slow	0-6	1-3
FOX	Outwash Plains	11"	SIL	SICL over CL	Stratified Sand & Gravel	>15'	0-11" 11-29" 29-60"	5.6-6.5 5.1-6.0 7.4-8.4	0-11" 11-29" 29-60"	Moderate Moderate Rapid	1-30	>6'
GILFORD	Outwash or Lake Plains	12"	FSL	SL	S	>15'	0-12" 12-34" 34-60"	5.1-6.5 5.6-6.0 7.4-8.4	0-12" 12-34" 34-60"	Mod. Rapid Mod. Rapid Rapid	0-2	0-1 Ponded
HOUGHTON	Organic Basins	42"	Muck	Muck	Muck	>15'	0-60"	5.5-7.3	0-60"	Mod. Rapid	0-2	0-1 or Ponded

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
MARTINSVILLE	Outwash Terraces	12"	SIL	SICL Grading to SL	Stratified SL, SCL, S, & SI	>15'	0-12" 5.6-7.3 12-43" 5.1-6.5 43-60" 7.4-8.4	0-12" Moderate 12-43" Moderate 43-60" Moderate	0-18	>6'
MAUMEE	Outwash Plains and Lake Plains	21"	LFS	S	S	>15'	0-21" 6.6-7.3 21-60" 6.6-7.3	0-21" Mod. Rapid 21-60" Rapid	0-2	0-1 or Ponded
METEA	Sandy Material over Upland Till Plains	10"	LS	LS Over CL	L	>15'	0-10" 5.6-6.5 10-42" 5.6-6.5 42-60" 7.4-8.4	0-10" Very Rapid 10-42" Moderate 42-60" Moderate	0-18	>6'
MIAMI	Upland Till Plains	10"	SIL	CL	L	>15'	0-10" 6.1-6.5 10-32" 5.6-6.0 32-60" 7.9-8.4	0-10" Moderate 10-32" Moderate 32-60" Moderate	0-12	>6'
MILFORD	Lake Plains	17"	SICL	SIC	SICL	>15'	0-17" 6.1-6.5 17-37" 5.6-6.0 37-60" 7.4-8.4	0-17" Mod. Slow 17-37" Mod. Slow 37-60" Mod. Slow	0-2	0-1 or Ponded
MILLSDALE	Uplands	7"	SICL	CL	SIC	20 to 40 Inches	0-7" 6.1-7.3 7-23" 6.6-8.4 23-30" 6.6-8.4	0-7" Mod. Slow 7-23" Mod. Slow 23-30" Mod. Slow	0-2	0-1 or Ponded
MONTGOMERY	Slack Water Terraces	15"	SICL Grading to SIC	SIC Grading to SICL	SICL	>15'	0-15" 6.6-7.3 15-38" 6.6-7.8 38-60 6.6-8.4	0-15" Slow 15-38" Very Slow 38-60" Very Slow	0-2	0-1 or Ponded
MORLEY	Upland Till Plains	6"	SIL	SIC	SICL	>15'	0-6" 5.6-6.0 6-30" 5.6-6.0 30-60" 7.9-8.4	0-6" Moderate 6-30" Slow 30-60" Slow	2-18	3-6
MOROCCO	Sandy Outwash Plains	14"	LS	FS	S	>15'	0-14" 5.6-6.0 14-30" 5.1-6.0 30-60" 5.1-6.0	0-14" Rapid 14-30" Very Rapid 30-60" Very Rapid	0-2	1-3
NEWTON	Sandy Outwash and Plains	16"	LFS	S	S	>15'	0-16" 5.1-6.0 16-60" 5.1-5.5	0-16" Rapid 16-60" Rapid	0-2	0-1 or Ponded
OCKLEY	Loess over Outwash	10"	SIL	SICL over Gravelly CL	S and Gravelly S	>15'	0-10" 5.1-6.0 10-55" 5.6-6.5 55-60"+ 7.4-8.4	0-10 Moderate 10-55" Moderate 55-60"+ Rapid	0-18	>6'
OSHTEMO	Outwash Plains	14"	SL	L Grading to LS	Stratified Coarse Sand & Fine Gravel	>15'	0-14" 5.6-6.0 14-60" 5.1-6.0 60"+ 7.4-8.4	0-14" Mod. Rapid 14-60" Mod. Rapid 60"+ Mod. Rapid	0-40	>6'
PALMS	Organic Basins	42"	Muck	L	L	>15'	0-42" 5.5-7.3 42-60" 7.4-8.4	0-42" Mod. Rapid 42-60" Moderate	0-2	0-1 or Ponded

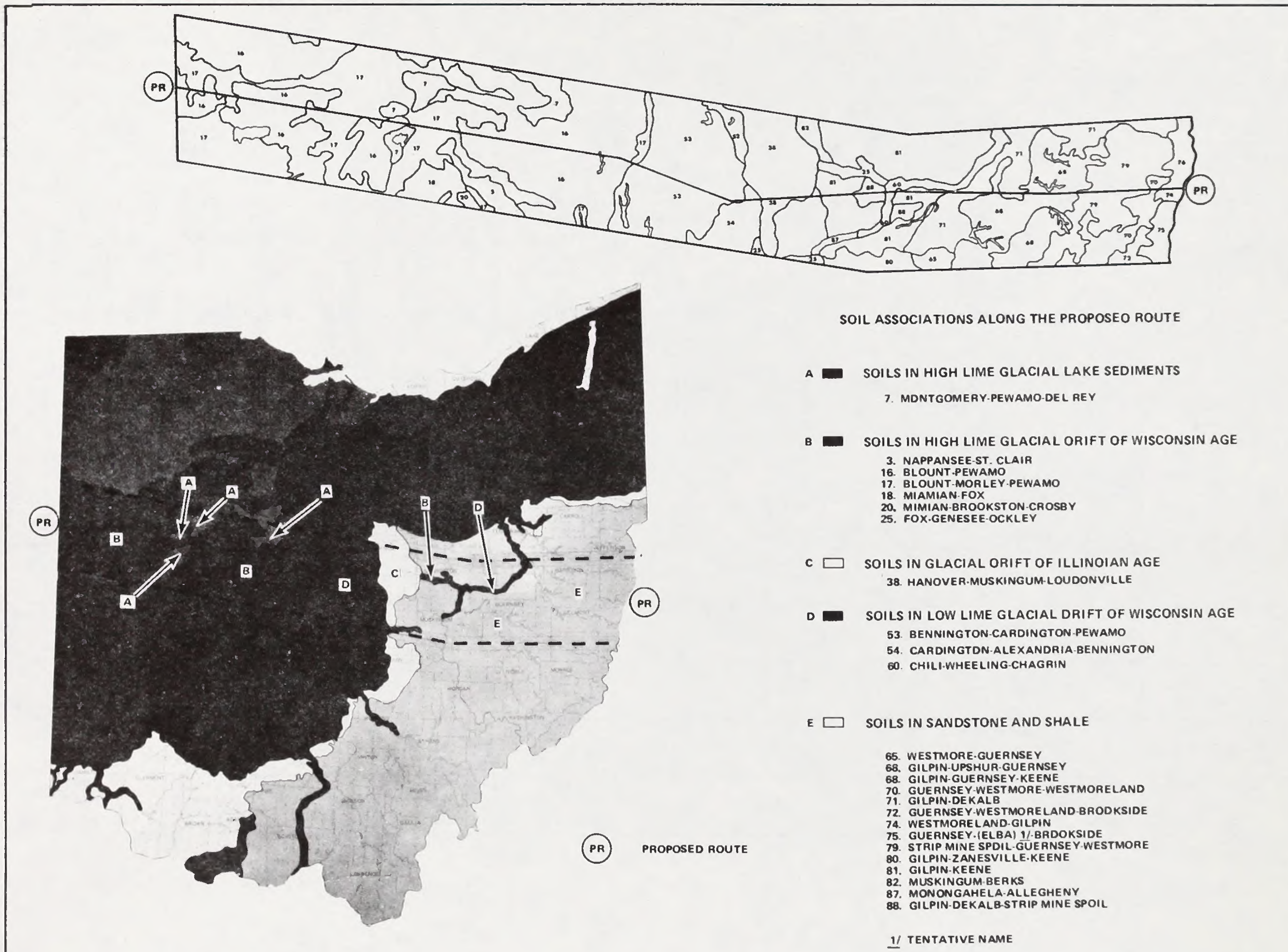
Sheet 3 of 3

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
PARR	Upland Till Plain	11"	SIL	CL	L	>15'	0-11" 5.6-6.0 11-31" 5.6-6.5 31-60" 7.4-8.4	0-11" Moderate 11-31" Moderate 31-60" Slow to Mod.	2-18	>6'
PEWAMO	Depressional Areas on Till Plain	12"	CL	CL	CL	>15'	0-12" 6.6-7.3 12-43" 6.6-7.3 43-60" 7.4-8.4	0-12" Mod. Slow 12-43" Mod. Slow 43-60" Mod. Slow	0-2	0-1 or Ponded
PLAINFIELD	Wind Deposited Sand and Sandy Outwash	8"	LS	S	S	>15'	0-8" 5.1-6.0 8-20" 5.1-6.0 20-60" 5.1-6.0	0-8" Very Rapid 8-20" Very Rapid 20-60" Very Rapid	0-12	>6'
RANDOLPH	Uplands	8"	SIL	SIC	Gravelly CL	20 to 40 Inches	0-8" 6.1-7.3 8-29" 6.1-6.5 29-34" 6.1-6.5	0.8" Moderate 8-29" Mod. Slow 29-34" Mod. Slow	0-6	1-3'
RENSSELAER	Outwash Plains & Lake Plains	15"	SIL	CL grading to SCL	Stratified FSL, CL, SI, & FS	>15'	0-15" 6.6-7.3 15-40" 6.6-7.3 40-60" 7.4-8.4	0-15" Moderate 15-40" Slow 40-60" Moderate	0-2	0-1 or Ponded
RUSSELL	Loess over Till on Uplands	10"	SIL	SICL grading to CL	L	>15'	0-10" 6.1-6.5 10-50" 5.6-6.6 50-60" 7.4-8.4	0-10" Moderate 10-50" Moderate 50-60" Moderate	2-12	>6'
WESTLAND	Loamy Outwash Plains	11"	CL	CL over gravelly CL	S and Gravelly S		0-11" 5.6-7.3 11-50" 5.6-7.3 50-60" 7.4-8.4	0-11" Moderate 11-50" Slow 50-60" Rapid	0-2	0-1 or Ponded

This table developed from: National Cooperative Soil Survey Reports, and Soil Series Description, Soil Conservation Service

LFS - Loamy Fine Sand
LS - Loamy Sand
FS - Fine Sand
S - Sand
SIC - Silty Clay
SI - Silt
SICL - Silty Clay Loam

SL - Sandy Loam
SCL - Sandy Clay Loam
CL - Clay Loam
L - Loam
FSL - Fine Sandy Loam
SIL - Silt Loam



Source: Adapted from Know Ohio's Soil Region, Ohio Division of Lands and Soil, 1973.

Figure 2.1.3.4-8 General soil map of Ohio

Table 2.1.3.4-8 Estimated properties of major soils along the proposed route in Ohio

Sheet 1 of 2

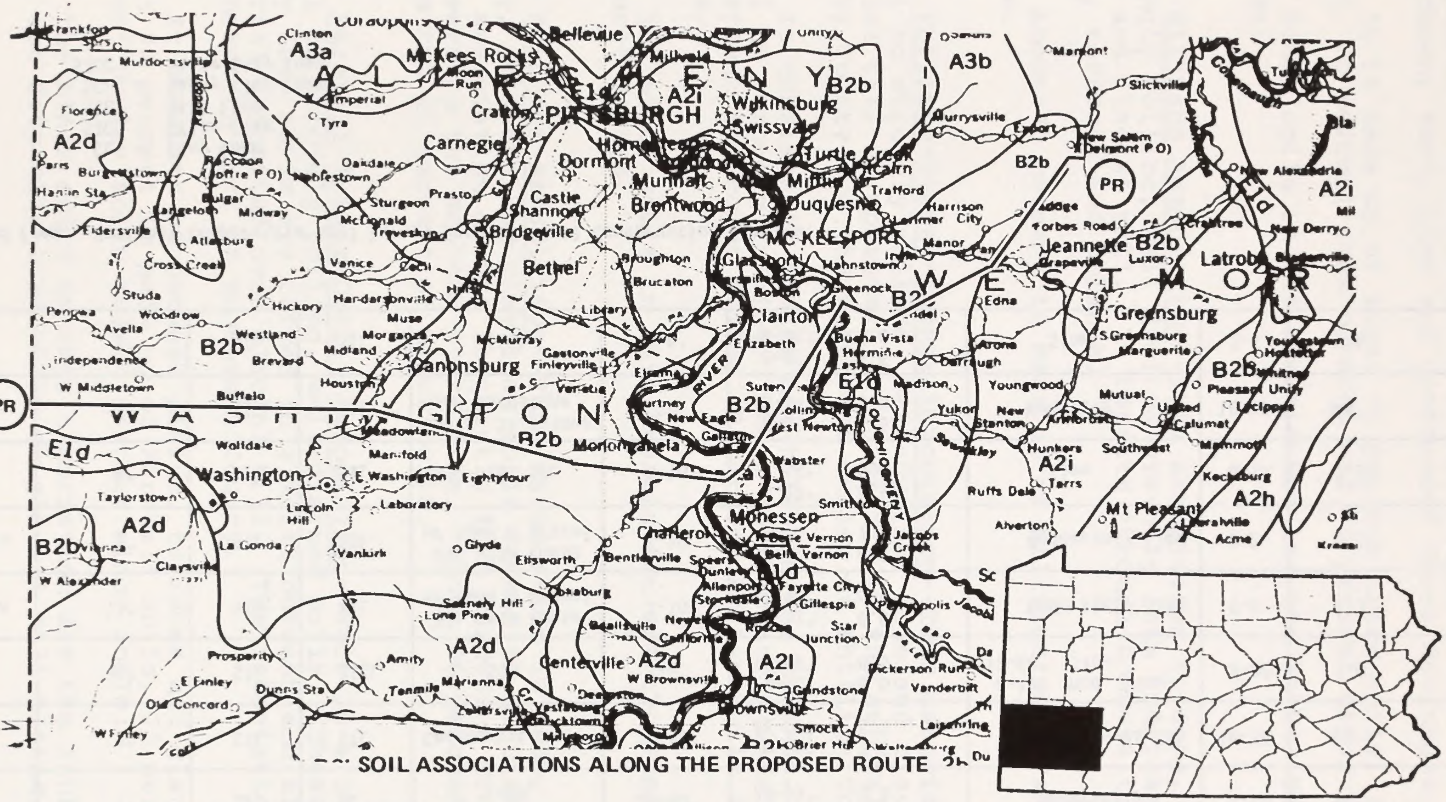
Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH		Permeability		Slope Group Percent	Depth of Seasonal Water Table
ALEXAN-DRIA	Till Plains	10"	SIL	CL & SICL	CL Till	>6'	0-10" 10-30" 30-60"	5.1-6.0 5.1-5.5 7.4-8.4	9-10" 10-60"	Moderate Mod. Slow	4-25	>6'
BENNING-TON	Till Plains	10"	SIL	SICL	CL Till	>6'	0-10" 10-30" 30-60"	5.1-6.0 5.1-5.5 7.4-8.4	0-10" 10-60"	Moderate Slow	0-3	1-3'
BERKS	Uplands on Siltstone Shale, & Sandstone	7"	SIL	Shaly SIL	Siltstone & Shale	20-40"	0-7" 7-24" 24"+	5.1-5.5 4.5-5.5	0-24" 24"+	Moderate Mod. Rapid	6-35	>6'
BLOUNT	Nearly Level Till Plains	10"	SIL	SICL	CL Till	>6'	0-10" 10-28" 28-60"	5.1-6.0 5.1-6.0 7.9-8.4	0-10" 10-28" 28-60"	Moderate Slow Very Slow	1-4	1-3'
CARDING-TON	Undulating Till Plains	11"	SIL	SICL	CL Till	>6'	0-11" 11-30" 30-60"	5.1-6.0 4.5-5.5 7.4-8.4	0-11" 11-60"	Moderate Mod. Slow	2-6	3-6'
CHAGRIN	FLoodplains	8"	SIL	SIL	SIL	>6'	0-8" 8-60"	5.6-6.0 5.6-6.5	0-60"	Moderate	0-2	>6'
CHILI	Stream Terra-ces & Out-wash Plains	10"	L	SL to CL	Sand & Gravel	>6'	0-10" 10-42" 42-60"	4.5-5.5 4.5-5.5	0-42" 42-60"	Moderate Rapid	1-15	>6'
DEKALB	Sandstone Uplands	7"	FSL	FSL	Sandstone Bedrock	20-40"	0-7" 7-30"	5.1-5.5 4.5-5.0	0-30"	Mod. Rapid	6-35	1-3'
DEL REY	Glacial Lake Plains	8"	SIL		SICL	>6'	0-8" 8-38" 38-60"	4.5-5.0 4.5-6.0 7.4-8.4	0-8" 8-38" 38-60"	Moderate Slow Slow	1-4	1-3'
GILPIN	Siltstone & Shale Uplands	7"	SIL	SICL	Siltstone & Shale Bedrock	20-40"	0-7" 7-29"	5.1-5.5 4.5-5.0	0-29"	Moderate	5-40	>6'
GUERNSEY	Sloping Ridgetops	11"	SIL	SIC	C Residuum from Shales	55-72"	0-11" 11-51" 51-69"	4.5-5.5 4.5-5.0 5.6-6.0	0-11" 11-51" 51-69"	Moderate Slow Slow	5-12	3-6'
HANOVER	Undulating to Steep Uplands	10"	SIL	SIL	L Till	>6'	0-10" 10-60" 60"+	5.1-5.5 4.5-5.0 5.6-6.5	0-60" 60"+	Moderate Slow	5-30	>6'
KEENE	Shale Uplands	10"	SIL	SICL	Clay Shale	20-40"	0-10" 10-30" 30"+	4.5-5.0 <4.5-5.0	0-10" 10-30" 30"+	Moderate Slow Very Slow	5-15	3-6'

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
LOUDON-VILLE	Sloping Uplands	8"	SIL	CL	Sandstone Bedrock	20-40"	0-8" 5.6-6.0 8-36" 4.5-5.5	0-36" Moderate	2-18	>6'
MONT-GOMERY	Old Lake Beds	12"	SICL	SIC	SIC to C	> 6'	0-12" 6.6-7.3 12-40" 6.6-7.3 40-60" 7.4-8.4	0-12" Mod. Slow 12-60" Very Slow	0-1	0-1 or Ponded
MORLEY	Upland Till Plains	8"	SIL	SIC	CL to SIC Till	> 6'	0-8" 5.6-6.0 8-24" 5.6-6.0 24-60" 7.4-8.4	0-8" Moderate 8-24" Mod. Slow 24-60" Slow	3-18	3-6'
MUSK-INGUM	Steep Uplands	8"	SIL	SIL	Siltstone & Shale Bedrock	20-40"	0-8" 5.1-6.0 8-22" 5.1-6.0	0-8" Mod. Rapid 8.22" Moderate	12-60	>6'
PEWAMO	Depressed Areas of Till Plains	10"	CL	SICL	SICL Till	> 6'	0-10" 6.1-7.3 10-40" 6.6-7.3 40-60" 7.4-8.4	0-60" Mod. Slow	0-1	0-1 or Ponded
WESTMORE	Sloping Uplands	7"	SIL	SICL	Channery SICL	4-6'	0-7" 5.1-6.5 7-40" 5.1-5.5 40-55" 5.6-7.3	0-7" Moderate 7-40" Slow 40-55" Slow	2-15	> 6'
WEST-MORELAND	Sloping to Steep Uplands	10"	SIL	SICL	Sandstone, Shale & Limestone Bedrock	20-40"	0-10" 5.1-6.0 10-35" 5.1-5.5	0-10" Moderate 10-35" Mod. Slow	10-60	> 6'
WHEELING	Stream Terraces	10"	SIL	SICL Grading to FSL	Stratified Sand, Gravel & Silt	> 6'	0-10" 5.1-6.0 10-48" 5.1-5.5 48-60"	0-48" Moderate 48-60" Rapid	1-10	>6'

This table developed from: National Cooperative Soil Survey, Soil Conservation Service

C - Clay
L - Loam
CL - Clay Loam
SL - Sandy Loam

SIC - Silty Clay
SIL - Silt Loam
FSL - Fine Sandy Loam
SICL - Silty Clay Loam



SOIL ASSOCIATIONS ALONG THE PROPOSED ROUTE

SOILS FROM NONCARBONATE SEDIMENTARY ROCKS

A2d CULLEOKA-WEIKERT

A2h GILPIN-HAZELTON-CALVIN

A2i GILPIN-ERNEST-WHARTON

A2l HAZELTON-GILPIN- ERNEST

A3a CAVODE-WHARTON-GILPIN

A3b UPSHUR-GILPIN- CLARKSBURG

SOILS FROM CARBONATE SEDIMENTARY ROCKS

B2b GUERNSEY-CULLEOKA

SOILS FORM WATER SORTED MATERIALS (ALLUVIAL)

E1d MONONGAHELA-PHILO-MELVIN

(PR) PROPOSED ROUTE

Source: Adapted from Pennsylvania General Soil Map, 1972.

Figure 2.1.3.4-9 General soil map of southwestern Pennsylvania

Table 2.1.3.4-9 Estimated properties of major soils along the proposed route in West Virginia/Pennsylvania

Sheet 1 of 1

Soil Series	Land Position	Thickness of Surface Layer	Dominant Surface Texture	Subsoil Texture	Underlying Material (Substrata)	Depth to Bedrock	Soil pH	Permeability	Slope Group Percent	Depth of Seasonal Water Table
CAVODE	Upland	6"	SIL	SICL	Stratified Clay Shale	3-6'	0-30" 5.0	Slow	0-6	1-3'
CULLEOKA	Upland	7"	SIL	CL	Channery Clay Loam	20-40"	0-23" 5.5 23-51" 6.5	Moderately	6-12	>6'
GILPIN	Uplands	7"	SIL	SIL	Channery Loam	20-40"	0-26" 5.5 26-36" 5.0	Moderately Rapid	18-35	>6'
GUERNSEY	Uplands	12"	SIL	SICL	SIC	3-6'	0-12" 6.0 12-42" 6.5	0-12" Mod. Slow 12-60" Slow	3-30	3-6'
LINDSIDE	Floodplain	11"	SIL	SIL	SIL with Lense of Sand & Gravel	3-10'	0-11" 6.0 11-48" 6.4	Moderately Slow	0-2	1-3'
MELVIN	Floodplain	8"	SIL	SIL	SIL with Lense of Sand & Gravel	3-10'	0-8" 6.5 8-45" 7.0	Moderately Slow	0-2	0-1'
RAINS-BORO	Stream Terrace	9"	SIL	SIL	SIL to SCL	4-10'	0-37" 5.5 37-55" 5.0	Slow	0-15	1-3'
WEIKERT	Uplands	7"	SICL	SIL	Shale, Siltstone and Sandstone	< 20"	0-6" 5.5 6-14" 5.0	Moderate	18-35	>6'
WHARTON	Drainage Divide	8"	SIL	SIL	SICL	3-6'	0-8" 5.5 8-48" 5.0	Slow	2-6	3-6'

This table developed from: National Cooperative Soil Survey Reports, Soil Conservation Service.

CL - Clay Loam
SIC - Silty Clay
SIL - Silt Loam
SCL - Sandy Clay Loam
SICL - Silty Clay Loam

on uplands. It consists of hills, ridges and stream dissected uplands of Frenchman, Rock, Lime and Cottonwood Creek drainages.

It is made up of about 35 percent Lisam soils, 35 percent Cabbart soils, 20 percent rock outcrop and 10 percent minor soils.

Minor soils in the association are the Thebo, Delphill and Evanston series.

Williams Association--This association is deep, nearly level to strongly rolling, well drained gravelly loam and loam soils formed in alluvium and glacial till. It repeats through Roosevelt and Valley counties on fans, terraces and uplands.

About 70 percent is made up of Williams soils and 30 percent minor soils.

Phillips-Socbey-Absher Association--This association is deep, nearly level to strongly rolling, well-drained loam and clay loam soils formed in glacial till on uplands. It is mainly in the central and northern part of Valley County and the northeast corner of Phillips County.

It consists of plains and hills in the uplands. Slopes are nearly level to strongly rolling. About 50 percent is made up of Phillips soils, 20 percent is Scobey soils, 10 percent Absher soils and 20 percent minor soils.

The minor soils in this association are the Thoeny, Telstad and Sunburst series.

Sunburst Association--This association is deep, strongly rolling to hilly, well drained clay loam soils formed in glacial till on uplands. The soil association occurs frequently from Porcupine Creek in Valley County eastward to the Montana state line. About 80 percent is made up of Sunburst soils and 20 percent of minor soils.

Parshall-Turner-Dooley Association--This is a grouping of deep, nearly level to strongly rolling, well-drained soils. These fine sandy loam and sandy loam soils are formed in glacial outwash and alluvial or eolian sandy material deposited over glacial till. The association is found in the east-northeastern part of Roosevelt County.

It consists of outwash plains, terraces and glacial till uplands. About 40 percent is made up of Parshall soils, 25 percent Turner soils, 25 percent Dooley soils and 10 percent minor soils.

The minor soils in this association are the Zahill and Williams soils. Both are deep clay loam soils on glacial till plains.

North Dakota Soil Associations

Agar-Williams-Zahl Association--This association occurs adjacent to or near the Missouri River Valley. The areas are leeward of the places where the prevailing northerly winds had a sufficient sweep across the Missouri bottomlands to pick up large amounts of silts and deposit them on the adjoining uplands. The association has nearly level to undulating topography on the uplands with slopes of 2 to 5 percent and is hilly to steep on the side slopes of the Missouri River Valley with slopes of 10 to 25 percent. Runoff is into the channels and steep coulees leading into the Missouri River bottomlands. The loess mantle, which decreases in thickness from west to east, has modified the landscape. The windward (north and west facing) slopes have a thinner mantle of loess than the leeward (east and south facing) slopes. In most of the association the glacial till depth ranges from 2 to 5 feet.

Morton Association--The Morton association is west of the Missouri River. The areas of the Morton association are gently to strongly sloping with a fully developed drainage system. Concave slopes or swales extend nearly to the top of the hills and ridges. Dominant slopes are from 2 to 12 percent but slopes range from 2 to 20 percent.

Bainville, Vebar, Rhoades, Wade, and Farland soils also occur in this association.

Morton-Rhoades Association--The Morton-Rhoades association occupies areas west of the Missouri River. The topography of this association consists of smooth, rounded hills and ridges. Long plane slopes extend from the crest of the hills and ridges into the swales and drainageways. Between the hills and on the sides of ridges, swales extend into the uplands. In places the Rhoades soils are without vegetation and appear as "slick" or "gumbo" spots. The surface is often pitted with small circular depressions a few inches deep in areas of Rhoades soils. Morton soils are as described in Morton association.

Other soils in the association are Bainville, Farland, Savage and Wade.

Morton-Williams Association--This association occurs in Oliver, Morton, Emmons, McIntosh and Logan Counties. The topography is undulating to rolling. The areas of this association have been glaciated. Much of the glacial drift has been removed by erosion since glaciation, especially on the rolling areas. Hill crests and ridges often are strewn with stones and boulders. Glacial till mantles the gentler slopes. Two to 8 percent slopes are most common, but the range of slopes is from 2 to 12 percent. This association is used for cropland and pasture. On slopes steeper than 5 percent, water erosion is a moderate hazard. Morton soils are as described in Morton Association, and Williams soils are described in Agar-Williams-Zahl association.

Raber Association--This association occurs in southeast Emmons and southwest McIntosh Counties. The Raber association occurs on an undulating to rolling landscape with low hills and knolls and ridges. The Association is dominated by the Raber Series.

Savage-Wade-Farland Association--This association is in Morton, Burleigh and Sioux Counties. These soils are on the terraces of Apple Creek and former small Missouri River tributaries. Topography is generally nearly level but some abandoned channels are present.

Williams Association--The Williams association is in the central and northwest part of the state. This association occurs on undulating to rolling landscapes west of the Missouri Coteau on both sides of the Missouri River. Considerable surface runoff drains into the depressions and surface drainage is partially developed.

Other soils in the association are the Bowbells, Zahl, Tetonka, and Oahe. Moderate susceptibility to water erosion is the principal limitation.

Parshall-Lihen Association--The Parshall-Lihen association is in Mercer, Oliver, Burleigh and Emmons Counties. This association is on moderately coarse and coarse-textured outwash and alluvium. Much of the material has been blown about by wind since it was first deposited. Topography ranges from nearly level to undulating and rolling, with slopes ranging from 0 to 8 percent.

Vebar Association--The Vebar Association occurs west of the Missouri River. The soils in this association occur on nearly level to sloping topography and have a slope range of 0 to 12 percent with a common range of 2 to 5 percent.

Associated with the Vebar soils are Flasher, Parshall, Lihen, and Rhoades series.

Williams-Vebar Association--This association occurs in eastern Dunn County. The Vebar-Williams association was glaciated but post-glacial geologic erosion has removed the glacial till from much of the area. The Vebar soils have developed in material weathered from soft sandstone; the Williams soils in the glacial till. They are well-drained moderately coarse-textured A horizons and clay loam B horizons. They are on broad, nearly level to undulating hills and ridge tops. Other soils in the association are the Parshall, Morton, and Flasher series.

Susceptibility to wind erosion of the Vebar and Parshall soils is the major limitation.

Williams-Zahl Association--The Williams-Zahl association lies east and west of the Missouri River Valley from the south central to the northwest part of the state. This association occurs on rolling to hilly topography with numerous depressions. Surface drainage is poorly developed. Much of the runoff flows into the depressions. Slopes range from 0 to 15 percent with dominant slopes of 6 to 12 percent. Other soils in the association are the Oahe, Sioux, and Parshall series.

Moderate susceptibility to water erosion of the Williams soils is the main limitation in this association. Oahe soils have limited water-holding capacity and are somewhat drouthy. Parshall soils are susceptible to wind erosion.

Havre-Banks Association--The Havre-Banks association is on the bottomlands of the Missouri and Yellowstone Rivers. The soils occur on the nearly level stream bottomlands and are dissected in places by tributaries of the rivers and by abandoned channels.

Badlands-Bainville Association--The Badlands-Bainville association parallels the Little Missouri River on both sides through most of its course in North Dakota. This association has two segments. Along the eastward course of the Little Missouri River in the northern part of the area the side slopes are deeply scarred with gullies, ravines and canyons. The Havre soils on the bottomland and the Patent soils on the colluvial fans at the base of the barren slopes are the dominant soils in this stretch of the river. The part of the unit extending from south to north differs from the deeply entrenched valley of the east-west portion. The Badland part of this unit consists of the steep slopes and breaks that have little or no vegetation. Bainville soils occur on the convex crests and steep upper slopes of the divides between the tributary streams.

Other soils in this association are Harve, Patent, Banks, Farland, Parshall, Flasher, Morton and Rhodes Series. Of these the soils are fairly extensive.

Bainville-Flasher-Agar Association--The topography of this association ranges from nearly level to hilly and steep. Slopes range from 2 to 25 percent. Surface drainage is well developed. Adjacent to the Missouri River the areas are dissected by numerous deeply entrenched coulees. Other soils in this association are Morton, Verbar and Farland. Moderate susceptibility to water erosion is a hazard on cultivated soils with slopes steeper than 3 percent. Vebar soils in cropland or heavily overgrazed areas are highly susceptible to wind erosion.

Bainville-Morton Association--This association occurs extensively on hilly and steep areas with deeply entrenched streams and coulees. Dominant slopes are from 10 to 30 percent. On the steepest slopes there are occasional outcrops of sedimentary rock and small barren areas. Farland, Flasher, Verbar and Rhoades also occur in this association. On slopes of more than 3 percent, moderate susceptibility to water erosion is a hazard on the Morton soils. Vebar soils are highly susceptible to wind erosion.

Bainville-Rhoades Association--This association occurs in one area which borders the Cannonball River in Grant, Sioux and Morton counties. The topography of the area is dominantly hilly with numerous well-entrenched streams. Slopes range from 5 to 40 percent with dominant slopes between 10 to 30 percent. Small areas of barren, steep slopes occur in the association. Morton, Flasher, Verbar, Harve, Farland and Parshall soils are locally important. Moderate susceptibility to water erosion on the Vebar and Parshall and the poor tilth of the Rhoades soils are the main hazards or limitations when these soils are cultivated.

Bainville-Zahl Association--The Bainville-Zahl association consists of steep valley side slopes and coulees which extend from the valleys into the uplands for short distances. Slopes in this association range from 5 to 50 percent with dominant slopes of 10 to 30 percent.

Near the Missouri River Valley, barren areas with exposures of the sedimentary beds are common on the steep-sided, deeply entrenched coulees. Flasher and Williams soils occur locally. Flasher soils are in association with the Bainville soils in the areas where sandstone is near the surface. Williams soils are in assocation with the Zahl but are on plane to gently convex slopes of 2 to 8 percent.

South Dakota Soil Associations

Bearpaw Association--This association is an undulating and rolling landscape with low hills and knolls. Surface drainage is well established with an intergrated drainage system.

Williams Association--This association occurs in the James River Lowland, part of an undulating glacial till plain 600 to 700 feet lower than the highlands of Coteau du Missouri to the west. Many small closed depressions and scattered sloughs and ponds dot the landscape and collect most of the runoff from the high lying land.

Williams-Tonka Association--This soil association is located on the Coteau du Missouri, an undulating and gently rolling highland area. There is no established surface drainage pattern and countless numbers of small lakes and closed depressions typify the region.

Williams-Zahl Association--This association is located in central McPherson County and extends into North Dakota. The landscape is undulating to hilly with many lakes, sloughs and depressions. This is predominantly hay and pasture land.

Stady Association--A nearly level but undulating landscape with numerous depressions and large pothole lakes characterizes the area of this association. Drainage is weakly developed with much of the precipitation infiltrating the substratum or held in depressions.

Niobell-Noonan Association--Lying to the west of Aberdeen, this association occurs on the western edge of Brown County and the eastern portion of McPherson and Edmunds Counties and extends northward into North Dakota. As part of the James River Lowland, it includes the upper reaches of Snake, Foot and Willow Creeks. Although weakly developed, there is sufficient drainage pattern to effect a reduction in the number of ponds and sloughs.

Barnes-Williams Association--This association occurs on the west side of the James River in the James River Lowland and ranges from Aberdeen to the North Dakota boundary. This area is a level to gently undulating glacial till plain. With the exception of the lands adjoining the Elm River, the area has a weakly developed drainage pattern and numerous ponds and depressions dot the landscape.

Beotia-Great Bend-Harmony Association--This association occurs in Brown County within the Lake Dakota plain and encompasses the area between Aberdeen, Columbia and the James River. A narrow strip also parallels the east side of the James River between Aberdeen and Groton.

Kranzburg Association--This association is a part of the James River Lowland with its southern tip beginning a short distance north of Verdon in Brown County and ranging northeasterly as a strip through Day and Marshall Counties. The land is level to slightly sloping and crosses numerous intermittent drainages flowing westerly from the Coteau des Prairies highlands. The drainage pattern is sufficently defined that few lakes and sloughs occur in the area.

Kranzburg-Brookings-Vienna Association--This association generally lays between the Big Sioux River and the eastern edge of the Coteau des Prairies. Many small drainges flow from the highlands west to the Big Sioux River. The gently sloping and undulating landscape is well-drained and few lakes and potholes are to be found.

Poinsett-Waubay Association--This is a large soil association occupying the central portion of the Coteau des Prairies highlands. It is generally bounded on the east by the Big Sioux River and on the west by the uplands arising from the James River Lowlands. In this association are nearly level or gently undulating deep, silty dark-colored soils with short and irregular slopes. There is no well-defined stream pattern and runoff collects in sloughs, lakes and depressions.

Singsacs-Oak Lake Association--This is a small association located at the junction of Deuel and Brookings Counties with the Minnesota state line. This portion of the Prairie Coteau has a moderately well defined drainage pattern and there are fewer sloughs, lakes and depressions. The landscape is characterized by a swell-and-swale type of topography. This association differs from other upland soil associations in having soils with horizons that have been thoroughly mixed by earthworms.

Vienna-Lismore Association--This association occurs on the uplands of the intermittent tributary streams that flow westerly to the Big Sioux River. It consists of soils that have developed directly in loam glacial till. This association is found on broad ridgetops and side slopes that end in drainageways. This association is used for cropland.

Forman-Aasted-Parnell Association--This association occurs primarily on the stream dissected slopes of the west side, the falling lake dotted region of the north central portion and small areas near the Minnesota border of the Coteau des Prairies. Irregular slopes and many closed depressions make up the landscape.

Forman-Buse Association--This association delineates the side slopes of the eastern and the central portion of the western escarpments of the Coteau des Prairies. This area is hilly to rolling with many short intermittent streams draining to the Red River Valley on the east and the James River to the west.

Forman-Buse-Aastad-Parnell Association--This association follows the upper portions of the western escarpment of the Coteau des Prairies. A small portion is also located in northeastern Clark County. It occurs on strongly undulating to steep glacial moraines and steep sides of stream valleys. Many areas are stony and closed depressions and lakes are common.

Poinsett-Buse Association--This association occupies silty areas where many lakes, sloughs and closed depressions dot the landscape. It occurs on the west side of the Big Sioux River in Brookings, Hamlin and Codington

Counties. The topography ranges from undulating to steep. The more gently sloping areas are used for cropland.

Fordville-Estelline Association--This association is made up of nearly level or gently sloping soils on stream terraces and outwash plains. It occurs on both sides of the Big Sioux River in Brookings, Hamlin and Codington Counties.

Renshaw-Fordville Association--This association occurs in the north central Coteau des Prairies in the vicinity of Bitter Lake. Scattered areas occur down the Big Sioux River valley into Brookings County. This association contains nearly level soils on high and low terraces, and a few short steep escarpments.

Peever-Cavour Association--This association occurs on the eastern edge of the James River Lowland in southwest Brown and northeast Spink Counties. It occupies the plane and convex slopes adjoining the Coteau des Prairies. Small intermittent streams drain the area. The dominant Peever clay loams occupy the well-drained areas and are good cropland soils. The Cavour loams are saline claypan soils occurring in moderately well-drained areas. Areas of Cavour soil intermingled with Peever soils are cultivated, resulting in "gumbo" or "slick" spots in portions of the field.

Aberdeen-Exline Association--This association occurs in a narrow strip of lowland in western Spink and Brown Counties in the Lake Dakota Plain. It is located on nearly level glacial lake plains with some slight rises, shallow swales and a few poorly drained depressions. In cultivated fields, the more shallow claypan layer of the Exline soils is mixed with the surface forming "gumbo" or "slick" spots.

Harmony-Arberdeen-Exline Association--This association of claypan soils occurs in the Lake Dakota Plain on either side of the James River in Spink and Brown Counties. The general slope is level with very gentle rises and swales of 1 to 3 feet or less.

Lamoure Association--This association occurs on the stream bottoms of the James and Big Sioux Rivers and their larger tributaries and is made up primarily of Lamoure soils.

Minnesota Soil Associations

Barnes-Buse Association--Soils are located on gently rolling to hilly topography. The soils have developed from calcareous loam glacial till and in some locations from calcareous gravel. Barnes soils are well-drained and are located on the lesser slopes of the area. Buse soils have a shallow surface, which is exposed during plowing and excessive drainage.

Barnes-Aastad-Flom Association--On a nearly level to rolling area, formed from calcareous loam glacial till. This association is in the western one-half of the pipeline route in Minnesota. Barnes loam is well-drained and occurs on convex slopes; Aastad is moderately well-drained and occurs in nearly level areas; and Flom soils are poorly drained and are located on level areas.

Clarion-Nicollet-Webster Association--Developed on topography that is nearly level to gently sloping with some gentle to strongly sloping areas. Also present are saucer-like depressions and low knobs and ridges on the level plains. These soils are dominant from western Cottonwood County to the southern state line. The parent material of the upland soils is primarily a friable, calcareous, loamy glacial till with some sand, loamy materials over gravel, silty clay loam and silty clay outwash. Clarion soils are located on moderately sloping to steep, well-drained topography. Webster loam is poorly drained and occurs in level areas.

Clarion-Storden Association--These soils are in the southeastern part of the pipeline route. These are rolling to hilly areas. They formed from medium textured glacial till. The major management problem is erosion control.

Estherville-Wadena-Hubbard Association--These soils are just to the south of the proposed route near the Murray-Cottonwood County line. This is primarily a nearly level area, but some scattered areas are rolling to hilly. These dark colored soils are well to excessively-drained. The Estherville and Wadena soils formed from moderately coarse to medium textured material overlying calcareous outwash gravel. In Estherville the gravel is within 18 inches of the surface. Wadena is deeper. Hubbard is formed from leached coarse and medium sand outwash. Droughtiness and wind erosion are major management problems.

Iowa Soil Associations

Clarion-Nicollet-Webster Association--Described in Minnesota Soil Associations but extending into Iowa.

Dinsdale-Tama Association--These soils are along portions of the eastern three-fourths of the pipeline route.

The topography upon which the Dinsdale-Tama soil association is developed is dominantly undulating with some moderate slopes with good drainage. The parent materials are primarily glacial till covered with a layer of wind deposited silts (loess) of varying thickness. Tama soils are found where the loess is thicker than 40 inches, Dinsdale soils where the loess is 20 to 40 inches thick and Kenyon soils where the loess is absent.

Fayette Association--The Fayette soils are along the eastern onefourth of the pipeline route.

The Fayette soil association is developed upon topography that has gentle to steep sided slopes. The parent material consists of narrow ridges of wind deposited silt (loess) on glacial till that overlies limestone. In some places, the till is missing and the loess blankets the limestone bedrock.

Kenyon-Floyd-Clyde Association--The soils in this association are along the major portion, eastern three-fourths, of the pipeline route. The topography of the Kenyon-Floyd-Clyde association is nearly level to gently undulating. In some sections of the area a swell and swale topography exists. The parent material of many of the soils of this association formed from 20 to 30 inches of loam to gritty silt loam overlying glacial till.

Tama-Muscatine Association--The soils in this association are along the eastern portion of the pipeline route. The Tama-Muscatine soil association is developed on topography that is gently to strongly sloping. The parent material consists of thick loess which directly overlies the limestone bedrock.

Illinois Soil Associations

Joy-Tama-Muscatine-Ipava-Sable Association--This association occurs in the northwestern and west central parts of the state (western part of the pipeline route). The vast majority of the area is nearly level to moderately sloping and is on the broader upland divides where drainage systems are not well developed.

Joy, Muscatine, Ipava and Sable soils are nearly level to moderately sloping. Tama soils are on strongly sloping areas along shallow stream valleys and on knobs and ridges. The included Port Byron soils are also associated with the Tama soils.

All the major soils in this association are moderately permeable and have a high available water capacity.

Bolivia and Port Byron are minor soils in this association.

Dana-Catlin-Flanagan-Drummer Association--This association is in the east central and north central part of the state (central part of the pipeline route). This grassland soil is dark colored and occurs on nearly level to strongly sloping upland areas. All the major soils in this association have moderate permeability and high available water capacity.

La Rose-Saybrook-Lisbon Association--This association occurs in the northeastern part of the state (central and eastern part of pipeline route) on nearly level to strongly sloping uplands. These dark colored permeable soils developed from thin wind deposited silts on loam glacial till that is calcareous at depths of less than 3.5 feet. All of the major soils have moderate permeability and high water holding capacity.

Elliott-Ashkum-Andres Association--The soils in this association are on uplands in the northeastern part of the state (eastern part of pipeline route) on nearly level to strongly sloping uplands. Muck and Peat soils occur in some of the depressions. The upper part of this profile is usually moderately permeable, but where the lower part of the soil has developed from silty clay loam till, permeability is moderately slow. Roots of annual crops such as corn do not penetrate as deeply as in the more permeable loamy till derived soils.

Available water capacity is high in all of the major soils in this association.

Swygert-Bryce-Clarence Association--This association occurs in the northeastern part of the state and along the eastern part of the proposed pipeline route. It is on nearly level to strongly sloping uplands.

Swygert and Bryce soils developed from less than 2 feet of medium-textured material on silty clay glacial drift that is calcareous at less than a depth of 3 feet.

Wetness is a problem in this soil association.

Seaton-Fayette-Stronghurst Association--This association occurs in the northwestern and western part of the state (along the western part of the pipeline route). The soils in this association have developed from thick wind deposited silts under mixed prairie and forest vegetation. They range from nearly level on upland divides to very steep along drainageways. Some bottomland soils occur within this association. All the major soils in this association have high available water capacity.

Morley-Blount-Beecher-Nappanee Association--This association occurs on nearly level to very strongly sloping uplands in northeastern part of Illinois and mainly in the center section of the pipeline route as it crosses the state.

Littleton-Proctor-Plano-Camden Association--This soil association occurs in scattered areas throughout the pipeline route. The dark and light colored soils are grouped together on the general soil map because in many areas their pattern of occurrence is mixed and very complex.

These soils occur over a wide range of slope from nearly level to very steep, on upland and stream terrace areas. However, most areas are nearly level to moderately sloping and the steeper areas are usually short escarpment-like breaks to lower lying alluvial soils.

Sparta-Ridgeville-Bloomfield-Alvin Association--This soil association occurs mainly in the western one-fourth and eastern onefourth of the pipeline route in Illinois. Major problems on these sandy soils are drouthiness, low fertility and wind and water erosion. Because of their low clay content, the capacities of these sandy soils to hold moisture and plant nutrients are very low. Drainage may also be a problem with the associated poorly-drained soils.

Lawson-Beaucoup-Darwin-Haymond Association--This soil association, consisting of bottomland soils, occurs in stream valleys. The largest area along the pipeline route is on the extreme western side of the state. Many bottomlands too small or too narrow to show on the map occur in other soil associations. The bottomland soils are usually nearly level to gently sloping. The bottomland soils of Illinois vary in color from light to dark, in texture from silty to clayey and natural drainage from poorly-drained to well-drained.

Hesch-Calco-Millington Association--The soils in this association occur in the middle of the pipeline route within Illinois. These soils occur on nearly level bottomlands. They consist primarily of thin to moderately thick alluvial material over sandstone, limestone and shale bedrock.

Indiana Soil Association

Maumee-Newton Association--The soils in this association occur in western Newton County. They are deep, nearly level, very poorly-drained, sandy soils formed in outwash or lake-deposited sands. Soil erosion by wind and subsurface wetness are the major limitations in use and management of these soils.

Seasonal high water table is the major limitation for most nonfarm uses. The soil features that affect the engineering uses of these soils are potential frost action, seasonal high water table and erosion by wind during construction.

Plainfield-Brems-Morrocco Association--This soil association occurs in Newton, White and Cass Counties. It is composed of sloping, excessively-drained, sandy Plainfield soils; nearly level, moderately well-drained, sandy Brems; and nearly level, somewhat poorly-drained, sandy Morocco soils in wind-blown or outwash sands.

Droughtiness, steeper slope and seasonal high water table are the major limitations for most nonfarm uses.

Parr-Miami Association--This soil association is in eastern Newton and western Jasper Counties. It is composed of sloping, well-drained, loamy soils formed in glacial till.

Rensselaer-Darroch Association--The soil association is mainly in Jasper County along the pipeline route. These soils are nearly level formed on outwash or lake deposited sand and silt. Seasonal high water table is the major limitation for most nonfarm uses.

Maumee-Gilford-Rensselaer Association--This association is mainly in Jasper and White Counties. These soils are nearly level, and are very poorly drained. The Maumee soils are described in the Maumee-Newton association and the Rensselaer soils are described in the Rensselaer-Darroch association. Seasonal high water table is the major limitation for most nonfarm uses.

Randolph-Millsdale Association--This soil association occurs only in western White County. These soils are nearly level and formed in thin glacial till over limestone bedrock. Subsurface wetness is the major limitation in use and management of these soils.

The major limitations of these soils for most nonfarm uses are the seasonal high water table and bedrock.

Oshtemo-Fox Association--This association occurs in the mid-part of White County. These soils are nearly level to sloping and are welldrained loamy soils on outwash sand and gravel.

Miami-Metea-Celina Association--This soil association is near the Tippecanoe River in White County and central portion of Cass County. These soils are sloping and well to moderately well-drained. Celina and Miami soils formed in loamy glacial till and Metea soils formed in sandy deposits and till. Subsurface wetness is a major limitation in use and management of the included Crosier and Brookston soils. The major limitations of these soils for nonfarm uses are the steeper slopes, seasonal high water table, cobbles and stones.

Plainfield-Chelsea Association--Sloping excessively-drained sandy soils formed in windblown sands. These soils occur in White County on the north side of the pipeline route. Plainfield and Chelsea soils are drouthy. Subsurface wetness is a major limitation in use and management of the included Maumee soils. Drouthiness, steeper slopes and seasonal high water table are the major limitations for most nonfarm uses.

Crosby-Brookston Association--This soil association is in the east central portion of White County. These are the nearly level somewhat poorly-drained Crosby soils and the very poorly-drained Brookston soils both of which formed in glacial till. Subsurface wetness is the major limitation of these soils. Seasonal high water table, permeability, cobbles and stones are the major limitations for most nonfarm uses.

Crosier-Brookston Association--These soils are in the western part of Cass County. They are the nearly level, somewhat poorly-drained loamy Crosier soils and the very poorly-drained, loamy Brookston soils both of which formed in glacial till. Subsurface wetness is the major limitation in use and management of these soils. Seasonal high water table, cobbles and stones are the major limitations for most nonfarm uses.

Miami-Russell-Fincastle Association--The soils in this association are just north of the Wabash River in Cass County. These are well-drained soils and nearly level somewhat poorly-drained soils. The Miami soils formed mainly in loamy glacial till and the Russell and Fincastle soils formed in wind deposited silts over loamy till. Subsurface wetness is a major limitation in the use and management of the Fincastle soils.

The major limitations of these soils for nonfarm uses are the steeper slopes of Miami and Russell soils, and seasonal high water table of the Fincastle soils.

Morley-Blount Association--The soils in this association extend from eastern part of Cass County to the eastern state line and is one of the most extensive soil associations along the pipeline route. These soils are sloping to nearly level, are well to somewhat poorly-drained and formed in silty clay loam glacial till.

The major limitations of these soils for nonfarm uses are the steeper slopes, seasonal high water table, permeability, cobbles and stones.

Ockley-Westland Association--The soils in this association are in eastern Cass County and western and central Miami County. These soils are nearly level, and formed in outwash sand and gravel. The nearly level Ockley soils have none or slight hazard of erosion, drouthiness or wetness. Subsurface wetness is the major limitation in use and management of Westland and included Sleeth soils.

Fox-Martinsville-Alluvial Soil Association--These soils are along the Wabash River in Miami and Wabash Counties. They are sloping to nearly level and are well-drained except for some of the included bottomland soils. Fox soils are on outwash sand and gravel and Martinsville soils are on outwash sand and silts. Fox soils are drouthy. Subsurface wetness is the major limitation in use and management of the included Westland soils. Flooding is the major limitation in use and management of the alluvial soils.

Slopes, seasonal high water table or flooding are the major limitations for most nonfarm uses.

Blount-Pewamo Association--These soils occur from the eastern part of Wabash County to the eastern state line. This is one of the major soil associations along the pipeline route. This association extends into Ohio and is described below under Ohio Soil Associations.

Milford-Montgomery-Rensselear Association--These soils occur in central Wells County. They are nearly level and are very poorly-drained. The Milford and Montgomery soils formed in clayey lake deposits and Rensselaer soils formed in loamy lake deposits. Subsurface wetness is the major limitation in use and management of these soils. Seasonal high water table is the major limitation for most nonfarm use.

Mucks and Peats Association--These soils occur in Adams County and are in relatively small areas. They are nearly level, very poorly-drained soils developed in organic materials. The dominant series are Palnes, Houghton and Adrian.

Ohio Soil Associations

Blount-Pewamo Association--The soils in this association are nearly level to gently sloping. The light colored, somewhat poorly-drained Blount soils occur on slightly elevated rises and the dark colored, very poorly-drained Pewamo soils occur on nearly level areas. These soils formed in high lime silty clay loam glacial till. Soil wetness is the major management problem of this association.

Blount and Pewamo are associated soils.

Montgomery-Pewamo-Del Rey Association--The relief in this association is characterized by its flatness which is broken in places by small rises. Montgomery and Pewamo soils are dark colored, very poorly-drained and lie on level relief. The Del Rey soils are light colored and somewhat poorly-drained. They occur mostly on small rises. The Montgomery soils formed in clayey glacial lake sediments, Pewamo formed in glacial till and Del Rey soils formed in silty glacial lake sediments. Soil wetness is the major management problem of this association. The unit of this association in Huron County has an appreciable acreage of dark colored, poorly-drained Lenawee soils which formed in limey, clayey and loamy glacial lake sediments.

Associated soils are Markland, McGary, and Kings.

Bennington-Cardington-Pewamo Association--This association consists mainly of nearly level to gently sloping soils in broad areas, but a few small areas of very steep soils are along the breaks of the main streams. The Bennington soils are light colored, nearly level to gently sloping and somewhat poorly-drained. Cardington soils are light colored and moderately well-drained and Pewamo soils are dark colored, nearly level and very poorly-drained. The soils in this association formed in limey clay loam glacial till. Soil wetness is a management problem on Bennington and Pewamo soils and erosion is a management problem on Cardington soils.

Cardington-Alexandria-Bennington Association--This association consists of nearly level to sloping uplands. The Cardington soils are mostly gently sloping to steep and are moderately well-drained. The Alexandria soils are well-drained and sloping to strongly sloping. The Bennington soils are light colored, nearly level to gently sloping and somewhat poorly drained. The soils in this association formed in limey clay loam glacial till. Erosion is the major management problem on these soils. Soil wetness is a problem on Bennington soils.

Associated soils are Cardington, Bennington, Condit and Marengo.

Hanover-Muskingum-Loudonville Association--This soil association occupies hilly uplands. The well-drained Hanover soils are on ridgetops and benches and the well-drained Muskingum and Loudonville soils are on ridgetops and side slopes. Hanover soils developed in loam glacial till and Loudonville soils developed in loam glacial till that is shallow over siltstone and sandstone bedrock. The Muskingum soils formed in siltstone bedrock. Steepness of slope and erosion are the major management problems on the soils in this association.

Montevallo, Berks, Litz, Gilpin, Wellston and Tilsit are among the associated soils.

Muskingum-Berks Association--This association consists of well-drained, moderately deep Muskingum soils and well-drained, shallow Berks soils which are sloping to steep. Underlying these unglaciated soils is bedrock including siltstone, sandstone and shale. Erosion and steepness of slope are the major management problems on the soils of this association. Shallowness to bedrock is a problem on Berks soils. The soils in this association are dominantly forested.

Gilpin-Keene Association--This association consists of well-drained, moderately deep to deep upland soils that are sloping to steep. These unglaciated soils are underlain by siltstone and shale and a relatively small but significant amount of sandstone. Erosion and steepness of slope are the major management problems on the soils in this association.

Litz, Muskingum and Wellston are among the associated soils.

Gilpin-Dekalb-Strip Mine Spoil Association--This association consists of well-drained, moderately deep, upland soils and strip mine spoil on sloping to steep slopes. The soils in this association formed over interlayered siltstone and sandstone. The strip mine spoil is commonly loamy and extremely to medium acid in reaction. This association is mainly forested.

Ramsey and Hartsells are among the associated soils.

Chili-Wheeling-Chagrin Association--This association occurs on nearly level to gently sloping terraces and level flood plains along the major streams in the Muskingum River drainage basin. The light colored, well-drained Chili and Wheeling soils formed in loamy material over outwash sand and gravel and the light colored, well-drained Chagrin soils formed in stream sediments. Chili and Wheeling soils have only slight limitations for many uses. Chagrin soils have severe limitation for some uses because of the flooding hazard.

Gilpin-Dekalb Association--This association consists of well-drained, deep and shallow upland soils which are sloping to steep. These unglaciated soils are underlain by siltstone and sandstone. Steepness of slope and erosion are the major management problems.

Gilpin-Guernsey-Keene Association--These are well and moderately well-drained, moderately deep to deep upland soils which are unglaciated and underlain by siltstone and limey and nonlimey shale. The topography of the soils in this association is sloping to steep. Steepness of slope and erosion are the major management problems.

Surface Mine Spoil-Guernsey-Westmore Association--A major part of this association has been influenced by strip mining operations for coal. The remainder of the association consists of moderately deep to deep, well-drained soils on sloping to very steep uplands and footslopes. The strip mine spoil has mostly clayey textures and is mostly medium acid to alkaline in reaction. Soil erosion and steepness of slope are the major management problems on the soils in this association.

Guernsey-Westmore-Westmoreland Association--This association consists of well and moderately well-drained, moderately deep upland soils that are sloping to steep. Guernsey, Westmore and Westmoreland soils formed over limey and nonlimey shales interbedded with siltstone and small amounts of dolomitic limestone. Steepness of slope and erosion are the major management problems on soils in this association.

Westmoreland-Gilpin Association--These are well-drained moderately deep and shallow upland soils which are steep and very steep. Westmoreland and Gilpin soils are underlain by bedrock consisting of varying proportions of limey and nonlimey shale and siltstone. Steepness of slope and erosion are the major management problems.

West Virginia and Pennsylvania Soil Associations

Guernsey-Culleoka-Weikert Association--The soils in this association extend from the West Virginia portion to near the end of the piepline route. It is the most extensive association and is interrupted mainly by the alluvial and terrace soils along the major stream valleys.

Rainsboro-Lindside-Melvin Association--This soil association is located on the flood plains and terraces that border the larger streams of the county. The nearly level to sloping terraces that border the Monongahela River in places are on two benches. The lower bench is separated from the present flood plain with a short escarpment. The higher bench typically lies 200 or more feet above the river and has a steep cliff with many outcrops of bedrock separating it from the remainder of the association. Along the larger creeks however, the terraces range from a gradual sloping away from the flood plains to benches with escarpments that have elevations of 40 or 50 feet above the flood plains.

Gilpin-Wharton-Cavode Association--Deep and moderately deep, well-drained to somewhat poorly-drained soils over acid, gray shale and siltstone. This association is steep and hilly. It is generally at elevations below the Pittsburgh coal seam. About 40 percent of the association consists of moderately deep, well-drained Gilpin soils, which are gently sloping to very steep. About 30 percent of the association consists of moderately well-drained Wharton soils. These soils are sloping to moderately steep and occur on benches and drainage divides on the lower parts of rounded hills. About 20 percent consists of somewhat poorly-drained Cavode soils, which are nearly level to moderately steep. The rest of the association consists of Ernest soils and other soils that occur on benches and fans along drainageways.

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Note: This is an interim publication for inservice use. Copies are not available for purchase or free distribution.

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2.1.3.5 Water Resources

Introduction

Just as the midcontinent region is divided physiographically into three major provinces on the basis of the configuration of the land surface and the character and distribution of the bedrock formations and overlying surficial deposits, so the region is divisible into three great drainage basins (Figure 2.1.3.5-1).

The three basins are those of the upper Missouri River, the upper Mississippi River and the upper Ohio River.

Water resources along the proposed pipeline, as elsewhere, consist of two major categories which are equally important although the importance of one or the other may vary locally, depending on local conditions and human needs. One of the categories is surface water--water that is on the ground surface. The other category is groundwater--below the suface of the ground.

Surface Waters

Surface water occurs in streams, ponds and reservoirs within the corridor of the proposed pipeline. Many of the streams are intermittent, flowing only part of the year; the same is true of many of the surface depressions in the corridor--water is present only part of the year. This is particularly true for many of the "potholes" along the proposed route.

Upper Missouri River Basin

The Upper Missouri River Basin, as shown in Figure 2.1.3.5-1, includes the Great Plains States of Montana, North Dakota and South Dakota. The water resources of this area of the Upper Missouri Basin are limited because of the limited precipitation and high evaporation rates. See climate data Section 2.1.3.1.

Stream drainages within the plains area include very finely textured systems within the badlands, coarsely textured systems on the flat glacial areas and non-integrated systems within the glacial-pothole areas of the Coteau du Missouri and Prairies. Within the drift area, the drainage system is a mixture of non-integrated streams, as in the pothole area, and small-order streams draining the sloped areas leading to the Missouri River. The nonglaciated plains locally are deeply dissected by drainages, forming badland areas or steep-sided valleys. Headward erosion into the weak bed-rock formations creates very finely textured drainage systems, which cause badlands and these expand laterally into the intervalley beachlands.

The surface stream flow is highly variable over the course of the year, ranging from dry or nearly dry conditions from September through May to flood stages in the spring. To regulate the streamflow and store this valuable resource, an extensive reservoir system has been installed on the major streams. Since the hydrology of unregulated streams in the Upper Missouri River Basin is characterized by extremely high and low flows, peak

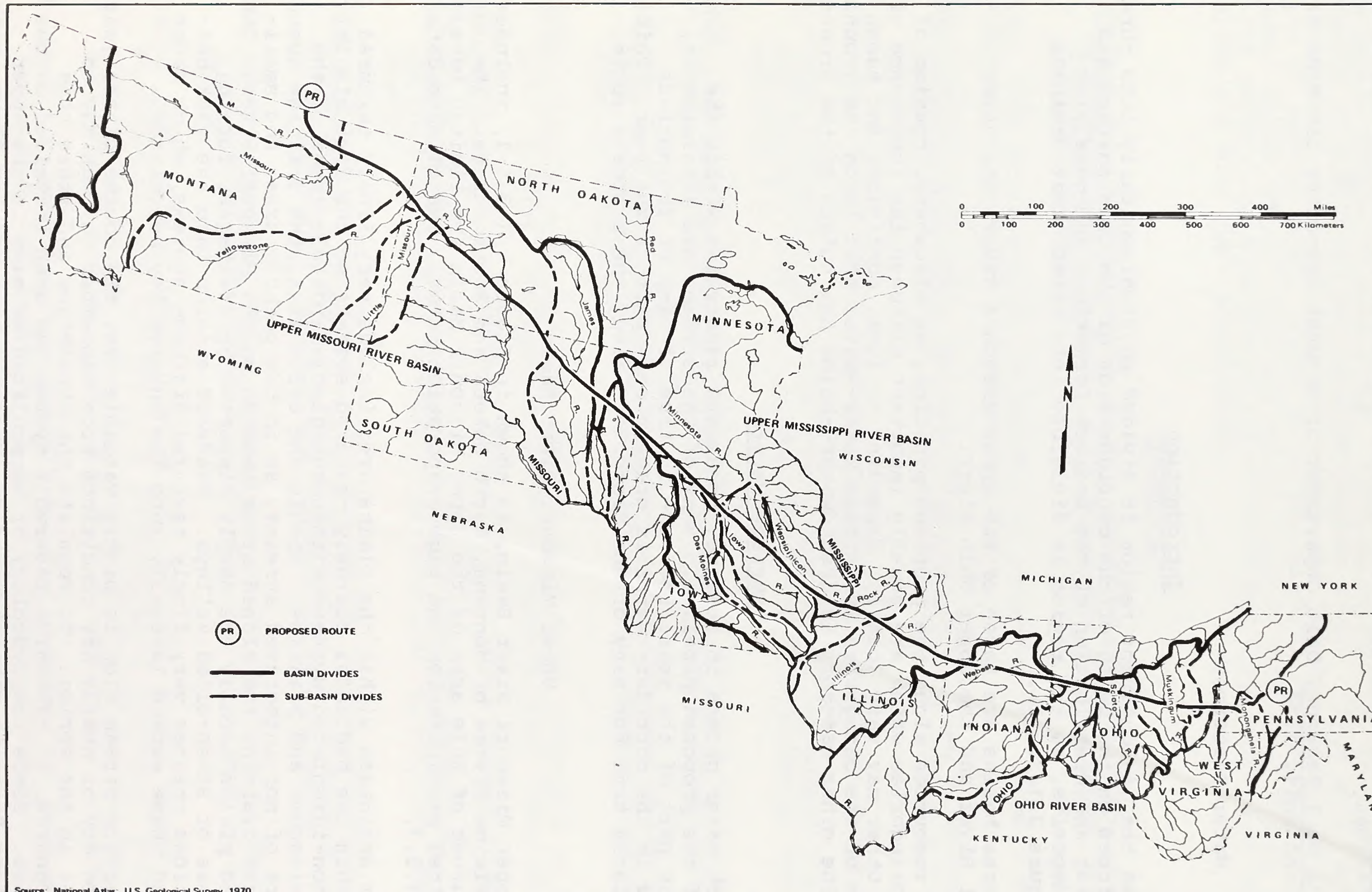


Figure 2.1.3.5-1 Major river basins and sub-basins of the 10-State Region

flow analysis is an important factor in the hydrology of the basin. On a seasonal basis the maximum streamflow occurs from May to July but in the larger river systems, which contain mountain runoff, this maximum occurs later because of the later mountain snowmelts and flow routing. Large regional summer rainstorms can also cause significant flows and excessive flooding and erosion. Annual sediment erosion within the plains over large expanses of land varies from less than 100 tons per square mile in the arid glacial areas to more than 2,000 tons per square mile for the extensive badlands drainages.

Most of the precipitation leaves the basin in the form of evapotranspiration. Annual surface runoff and groundwater recharge are very low. Runoff varies across the upper basin as illustrated in Figure 2.1.3.5-2. Runoff along the proposed route ranges from one-quarter inch per year from the glacial James River area to slightly over one inch per year from the steeper unglaciated basins of the Cannonball and Little Missouri Rivers.

The proposed route through the upper Missouri Basin makes three principal river crossings, those of the Missouri River at the extreme upstream end of Lake Sakakawea Reservoir, formed by the damming of that river near Garrison, North Dakota, the Little Missouri River and Lake Oahe Reservoir formed by damming the Missouri River at Pierre, South Dakota.

The glaciated areas of the Coteau du Missouri and the Coteau des Prairies are characterized by pothole lakes varying in size from a few acres to hundreds of acres. These water bodies are supplied from surface flow from the non-integrated drainage area surrounding the pothole. The glacial material of the potholes is extremely impermeable with water movements of less than 1 foot per year. Potholes tend to fill until an overflow ditch or saddle is reached or until evaporation balances the combined surface inflow and precipitation. The lakes become more permanent and larger to the southeast where more moisture is available.

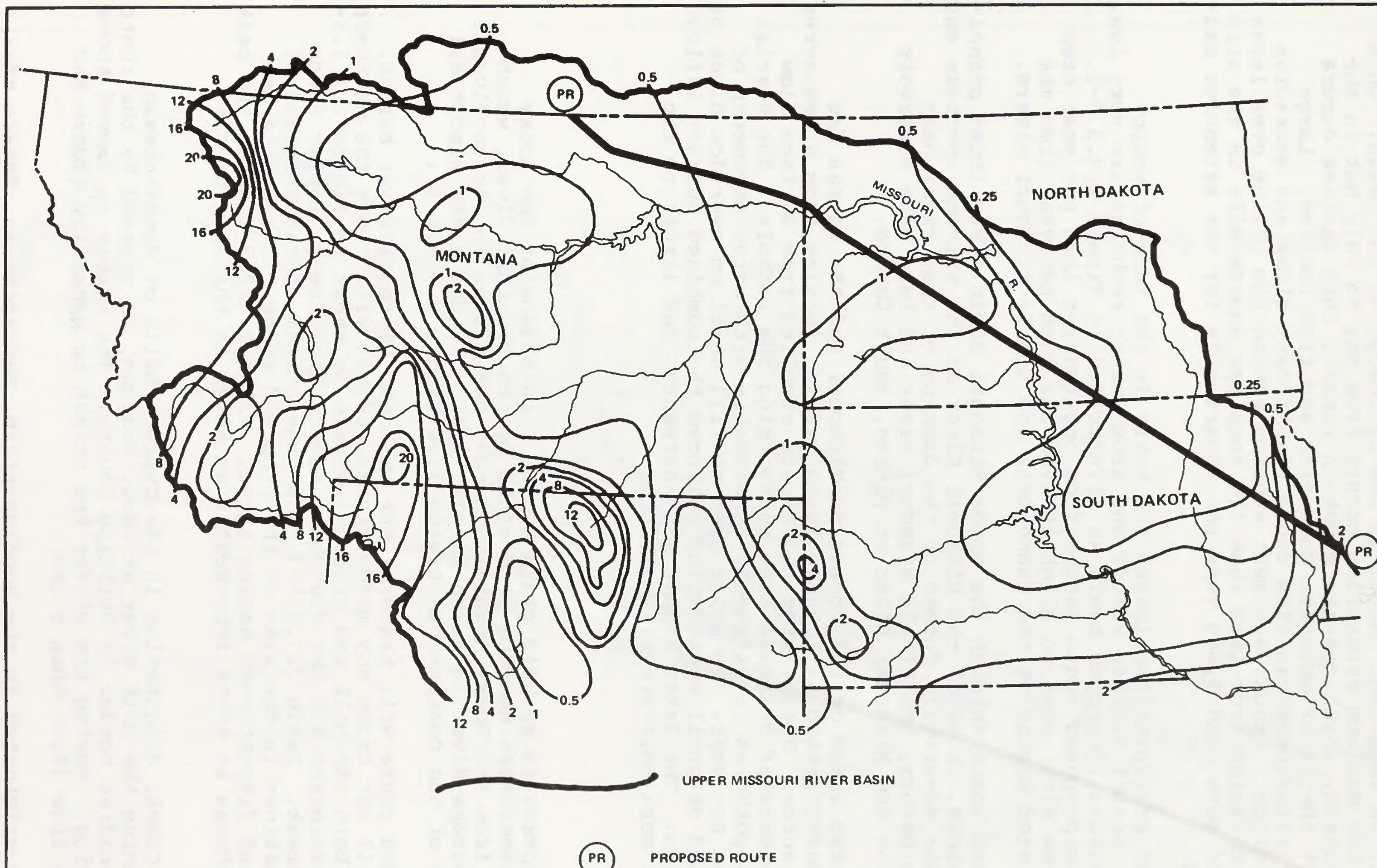
Montana

Eastern Montana is an arid plain in the rain shadow of the Rocky Mountains. Northeastern Montana is drained by the Missouri River, which flows eastward from the Rocky Mountains across the plains to its confluence with the Yellowstone River in North Dakota. Both streams drain almost all of Montana east of the Continental Divide (see Figure 2.1.3.5-1).

The proposed route will traverse the Milk and Missouri River basins. The pipeline will not cross any major rivers, but it will cross the northern tributaries of both the Milk and Missouri Rivers as shown in Figure 2.1.3.5-3. The major drainages are the Frenchman River, Rock Creek, Poplar River and Big Muddy Creek. Table 2.1.3.5-1 shows the stream characteristics of eight gaging stations in the area of the proposed route. These data are from existing and discontinued gaging sites. Table 2.1.3.5-2 shows the peak streamflow discharge at seven representative sites in the area of the proposed route.

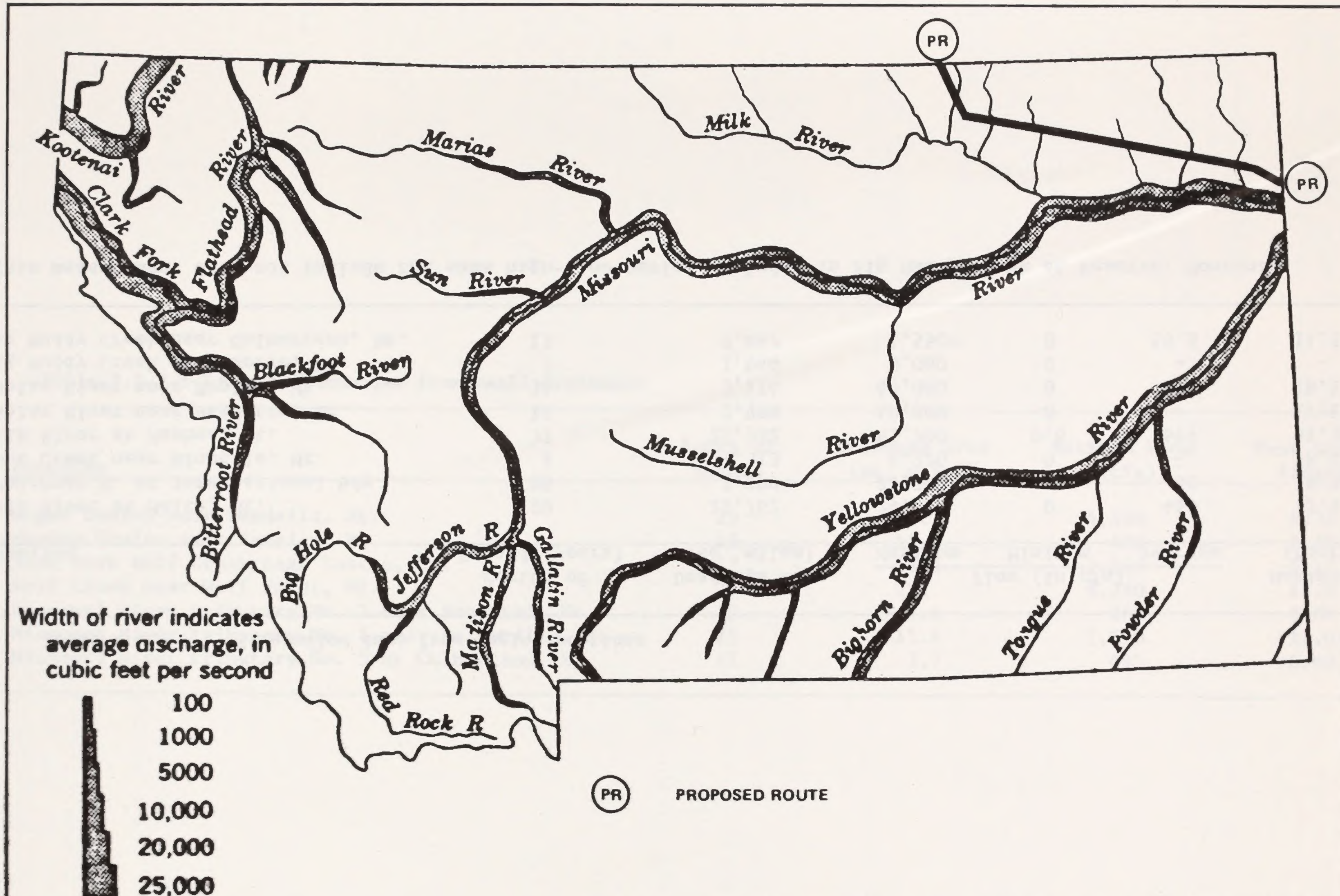
Frenchman Creek, originating in the Cypress Hills of Saskatchewan, Canada, and joining the Milk River at Saco, Montana, is crossed by the route south of the Canadian border in Phillips County. The stream is dammed above the route crossing. During the winter the stream is generally frozen and has very little flow (less than 5 cfs).

Rock Creek originates in the Wood Mountain, Saskatchewan, Canada area, flows southward, and joins the Milk River near Hinsdale. The proposed route crosses Rock Creek near the confluence of Rock and Snake Creeks.



Source: Missouri River Basin Comprehensive Study: Missouri Basin Inter-Agency Committee, 1969.

Figure 2.1.3.5-2 Mean annual runoff in the Missouri River Basin, in inches



Source: Modified from *Water Resources Investigations in Montana*, U.S. Department of Interior, 1959.

Figure 2.1.3.5-3 Average annual discharge of principal rivers in Montana

Table 2.1.3.5-1 Streamflow data from gaging stations

Location	Period of Record (years)	Drainage Area (sq. miles)	Flow (in cfs)			Maximum (feet)
			Maximum	Minimum	Average	
Milk River at Malta, Mt.	20	11,762	24,000	0	465	22.3
Frenchman R. at international bdy	56	2,299	22,700	0	82	19.90
Rock Creek near Hinsdale, Mt.	9	1,313	6,220	0	-	18.4
Milk River at Nashua, Mt.	37	22,332	45,300	0.6	699	31.38
Poplar River near Bredette, Mt.	13	2,990	40,000	0	-	17.18
Poplar River near Poplar, Mt.	34	3,174	40,000	0	129	18.1
Big Muddy Creek at Reserve, Mt.	7	1,044	8,000	0	-	-
Big Muddy Creek near Culbertson, Mt.	13	2,447	1,550*	0	58.5	11.2

*This measurement does not include the same high-flow period included in Big Muddy Creek at Reserve, Montana.

Table 2.1.3.5-2 Peak discharges from small drainages

Location	Years of Record	Drainage Area (sq. miles)	Maximum Flow (cfs)	Peak Stage (feet)
Unger Coulee near Vandalia, Mt.	15	11.1	4,460	6.31
Mooney Coulee near Tampico, Mt.	13	12.8	400	2.37
East Fork Wolf Creek near Lustre, Mt.	17	9.6	2,230	6.42
Wolf Creek near Wolf Point, Mt.	29	251	9,780	12.9
Missouri River tributary No. 2 near Brockton, Mt.	12	1.6	260	8.08
Missouri River tributary No. 4 near Bainsville, Mt.	11	11.6	1,670	12.02
Missouri River tributary No. 5 at Culbertson, Mt.	11	3.7	495	6.60

The Poplar River drains southward in a broad alluvial valley from the Wood Mountain area and joins the Missouri River at Poplar, Montana. The river is crossed by the route near the confluence of the Poplar River and Hay Creek in Roosevelt County.

Big Muddy Creek originates near Big Beaver, Saskatchewan, Canada, flows southward past Medicine Lake to the Missouri River near Culbertson, Montana. The proposed route crosses Big Muddy Creek about 5 miles upstream from Culbertson.

North Dakota

The arid, nonglaciated plains of southwestern North Dakota are dissected by steep-walled valleys which discharge into the Missouri River. North and east of the Missouri River, standing water occurs in surface potholes as a result of the increased precipitation patterns and glaciation, but the larger glacial lakes are drained dry by the James, Souris and Red Rivers.

Floods in North Dakota are common southwest of the Missouri River. In wet years stream discharges are above normal and heavy rainfall combined with saturated soils can cause flooding.

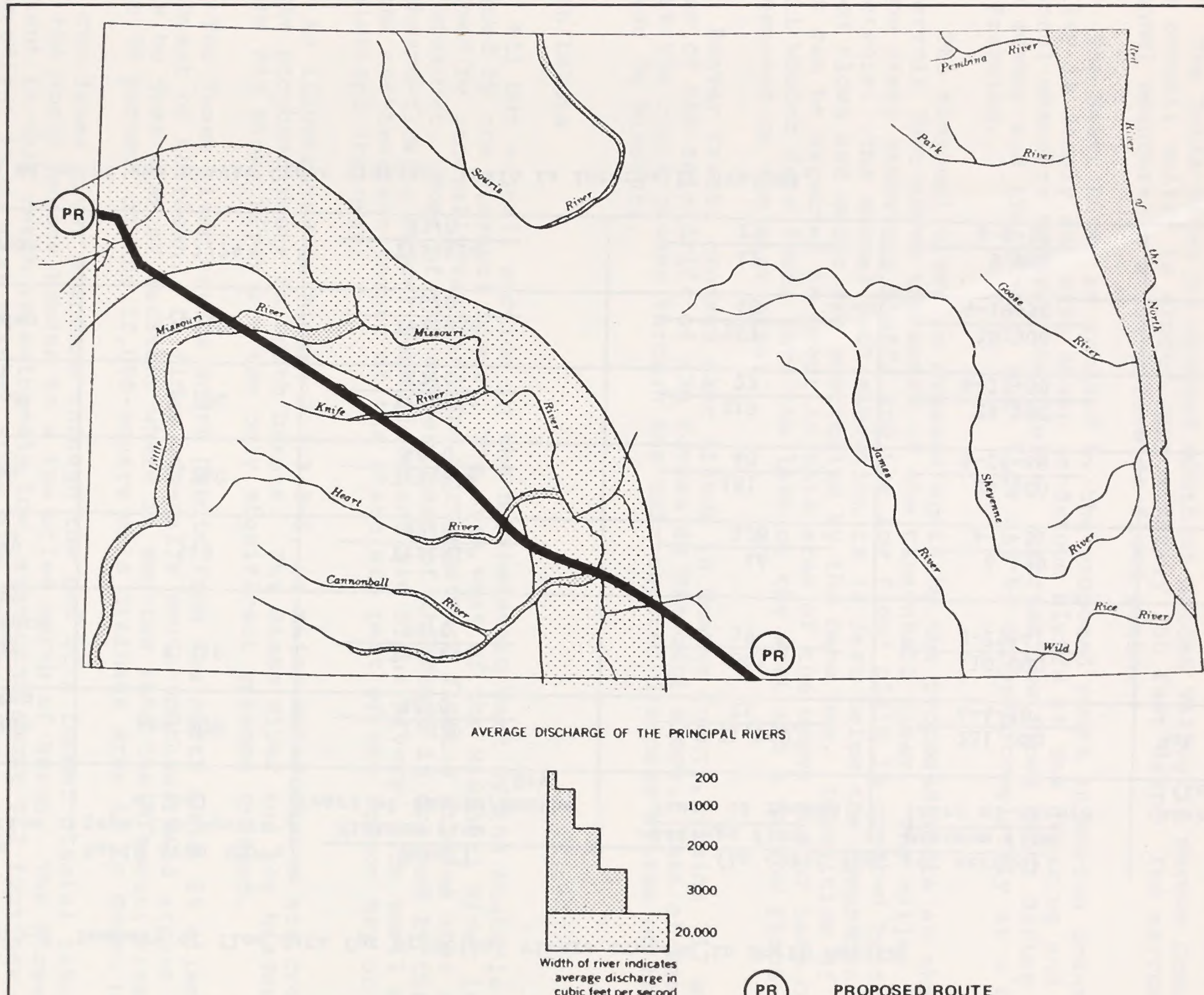
During the summer many streams flow only for a few hours after heavy rains, but small pools of water remain for several days. The water in streams that flow is turbid and sluggish even during dry spells. Most streams meander and are commonly entrenched 4 to 12 feet below narrow flood plains.

Severe summer thunderstorms, such as one experienced at Stanton, North Dakota, in which up to 13 inches of rain fell, most of which fell in 2.0 hours, can cause disastrous flash floods in the short, steep coulees along the Missouri River and its tributaries. The sharp margins of the Coteau du Missouri and the adjacent areas of impermeable lake clays lead to peak discharge rates as high as 1,000 cubic feet per second per square mile (cfsm) for an area of 1.4 square miles and 500 cfsm for an area of 50 square miles.

In addition to crossing the Missouri River twice, as illustrated in Figure 2.1.3.5-4, the proposed route crosses the Little Missouri River in its badlands area, the Knife and Heart Rivers, and the smaller Spring and Beaver Creeks. The flows of these streams have been gaged and flood conditions recorded as described in the paragraphs which follow. Flow tabulations are available for these streams in reports of the Geological Survey (see Table 2.1.3.5-3).

The first crossing of the Missouri River by the proposed route is west of Williston at the upper end of Garrison Reservoir and below the confluence of the Yellowstone River. At the crossing, the river forms a wide, 300-foot deep valley at the Williams-McKenzie County line. Scour during floods and deposition during extended low flow periods have presented some problems to local residents. The channel is straight under the bluffs with a 10-foot high wooded levee on the north side. The proposed route dissects an abandoned oxbow meander slough to avoid scattered farm buildings.

The Little Missouri Canyon, eroded to a depth of 500 feet, is crossed in Dunn County by the proposed route between Watford City and the Killdeer Mountains. At the crossing site the west bank is sandy with an open floodplain. The east bank is undercut slightly and wooded. The Little Missouri River carries a heavy sediment load, and considerable scour and fill can be expected.



Source: Water Resources Investigations in North Dakota: U.S. Department of Interior, 1972.

Figure 2.1.3.5-4 Average annual discharge of principal rivers in North Dakota

Table 2.1.3.5-3 Summary of flow data for principal rivers crossed in North Dakota

River	Gage Station	Basin area above gage (in square miles)	Runoff (In cubic feet per second) Minimum flow Years of record/Months Dry	Average flow Years of record	Maximum flow Years of Record	Bank height (in feet)
Missouri	Willi-ston	164,500	1,320 / 68/0	21,960 / 21	231,000 / 4-4-30	Not available
Little Missouri	near Watford City	8,310	Trickle / 39/0	605 / 39	110,000 / 3-25-47	20
Spring Creek	Zap	549	Trickle / 28/0	44 / 128	6,130 / 4-7-52	14
Knye	Hazen	2,240	Trickle / 40/0	181 / 40	25,300 / 6-24-66	21
Heart	N. of Lark	2,750	Trickle / 27/0	219 / 27	29,200 / 4-17-50	15
Heart	Mandan	3,310	Trickle / 40/0	257 / 40	30,500 / 4-19-50	17
Beaver Creeks	Linton	717*	Trickle / 23/0	42 / 23	9,800 / 4-8-52	13

* 100 square miles of the Beaver Creek drainage basin is internally drained.

Spring Creek, crossed by the proposed route near its headwaters in Dunn County, is a small stream draining the 545-square mile east side of the Killdeer Mountains into the Knife River at Zap, North Dakota. The shallow channel meanders within a mile-wide valley.

The Knife River is crossed south of Golden Valley in Mercer County. Its overall valley is eroded approximately 100 feet deep. Its narrow wooded channel meanders in a 1.5-mile-wide flood plain.

The Heart River is crossed by the proposed route in Morton County. Its valley is deeply cut with steep sandstone bluffs at the crossing and the channel meanders between the bluffs. Extreme low flows occur during both the summer and the winter, when flow may be stopped completely as a result of freezing.

The Missouri River is crossed again by the proposed route at the Oahe Reservoir just above the mouth of the Cannonball River. The valley lies below steep sandstone bluffs and the low flood plain is covered by the reservoir. The normal pool elevation is 12 feet below the reservoir limit. Flood flows and scour are controlled by the Oahe Dam. Deposition of sediment can be expected to occur in this area of the upper end of Lake Oahe. A small wooded draw leads into the lake on the west and a narrow flood plain is exposed on the east side.

Beaver Creek, crossed near Linton in Emmons County, drains 717 square miles of the thin drift of the Coteau du Missouri slope. East of Beaver Creek the route passes through the unintegrated drainage system of the Coteau du Missouri.

South Dakota

All but a small section in the northeastern part of the State is drained by the Missouri River. The area west of the Missouri River is drained by generally eastward and northeastward flowing streams that enter the Missouri. Most of the eastern part of the State is drained by the southward-flowing James, Vermillion and Big Sioux Rivers. The small areas in the northeastern corner of the State are part of the Hudson Bay or Upper Mississippi drainage.

As illustrated in Figure 2.1.3.5-5, no major watercourses are crossed by the proposed route in South Dakota. The James River and the headwaters of the Big Sioux River are the only significant streams crossed.

The James River enters South Dakota from the north about 35 miles northeast of Aberdeen. It flows generally south-southwestward across the State to just east of Yankton, where it empties into the Missouri River. About 70 percent of the 22,000-square mile drainage area is in South Dakota.

The James River meanders through the bed of a former glacial lake, from near the North Dakota border to a few miles north of Huron. The stream gradient in this reach is extremely low, averaging about 0.2 foot per mile. The gradient is so flat that at times high inflow from a tributary stream will cause the James River to flow upstream for a few miles above the mouth of that tributary. Flood flow from Elm River in April 1952, for example, caused a reverse flow of 1,860 cfs at the James River gaging station 3-1/2 miles upstream from the mouth of Elm River. The James River gradient increases to an average of about 0.4 foot per mile in the reach downstream from Huron. Reverse flow in this reach of river is uncommon, but not unknown.

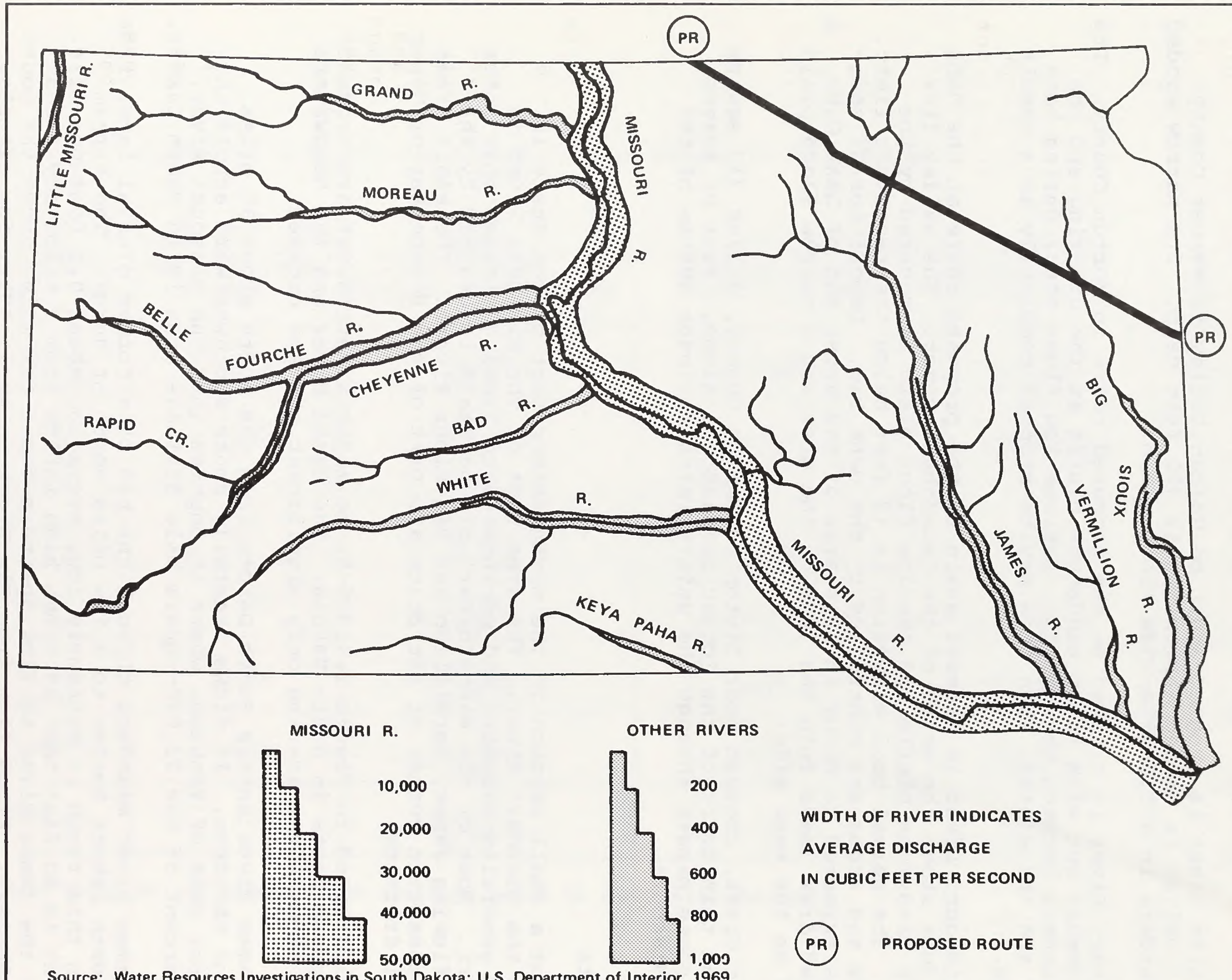


Figure 2.1.3.5-5 Average annual discharge of South Dakota rivers

Most floods from the larger drainage areas in the basin are caused by snowmelt. The flood plain of the James River is about a quarter to a half mile wide in South Dakota. The channel banks are low and the flood plain is very flat so that moderate floods cover nearly the entire width of the flood plain. Because of the low gradient of the stream, flood crests move slowly and the flood plain is inundated for as much as a month during major floods.

Several thousand square miles of the basin in both North Dakota and South Dakota that constitute the prairie pothole region do not contribute surface runoff.

The James River and its tributaries receive little or no sustained groundwater inflow; hence, most streams in the basin cease flowing for extended periods in most years. The mainstream and all tributaries except the Elm River, between the State line and the mouth of Turtle Creek, did not flow from August 1958 to March 1960. Low flow on the Elm River was sustained by releases from upstream storage during most of this drought.

Streamflow data from representative gaging stations in the basin are given in Table 2.1.3.5-4.

From its origin north of Watertown in the Coteau des Prairies of eastern South Dakota, the Big Sioux River flows generally southward to meet the northern border of Iowa southeast of Sioux Fall, South Dakota.

The upper half of the Big Sioux River Basin is broad and shallow; however, from Dell Rapids to the mouth the valley becomes well defined.

Streamflow records for selected stations are summarized in Table 2.1.3.5-5.

At Watertown the Big Sioux River normally does not flow for part of the fall and winter; near Brookings it has been at zero flow only a few times since 1953.

The Coteau des Prairies has numerous lakes, and drainage patterns are poorly defined. Several hundred square miles on the Coteau do not contribute surface runoff to the river. Some of the lakes are situated so that they provide natural off-stream storage for floodwaters from the river, and diversion channels have been constructed to others. This off-stream storage reduced flood peaks and also runoff because, in most instances, part of the floodwater does not return as the stream recedes.

Minnesota

The proposed route follows the divide between the Minnesota River of the Upper Mississippi River Basin to the northeast, and the West Fork, Des Moines River of the Missouri River Basin to the southwest, across the southwestern part of Minnesota (Figure 2.1.3.5-6). In this State the route is chiefly on the Minnesota River, or northeastern side of the divide, but in the southernmost part of the state crosses the headwaters of minor tributaries to the West Fork, Des Moines River. Because of its interbasin location, no large streams are crossed.

The Minnesota River lies about 35 miles northeast of and parallel to the proposed route. Its principal tributaries in the area of concern are Yellow Medicine River, Redwood River, Cottonwood River and Blue Earth River. The West Fork, Des Moines River lies just southwest of and in part parallel to the route; the river has no major tributaries crossed by the route.

Table 2.1.3.5-4 Streamflow data from gaging stations.

Station	Drainage area (square miles)	Years of record	Average discharge (cubic feet per second)	Extremes of discharge (cubic feet per second)	
				Maximum	Minimum
James River at Columbia, S.D.	7,050	28	103	5,420	1,860 [a]
Elm River at Westport, S.D.	1,680	28	47.1	12,600	0
James River at Ashton, S.D.	11,000	28	154	5,680	2,100 [a]
James River at Huron, S.D.	16,800	34	237	9,000	0

a Negative figures, indicates reverse flow.

Table 2.1.3.5-5 Streamflow data from gaging stations.

Station	Drainage area (square miles)	Years of record	Average discharge (cubic feet per second)	Extremes of discharge (cubic feet per second)	
				Maximum	Minimum
Big Sioux at Watertown, S.D.[a]	1,800	27	33.3	2,220	0
Big Sioux near Brookings, S.D.	4,420	20	169	33,900	0
Big Sioux near Dell Rapids, S.D.	5,060	25	275	41,300	0.20

a Discontinued station.

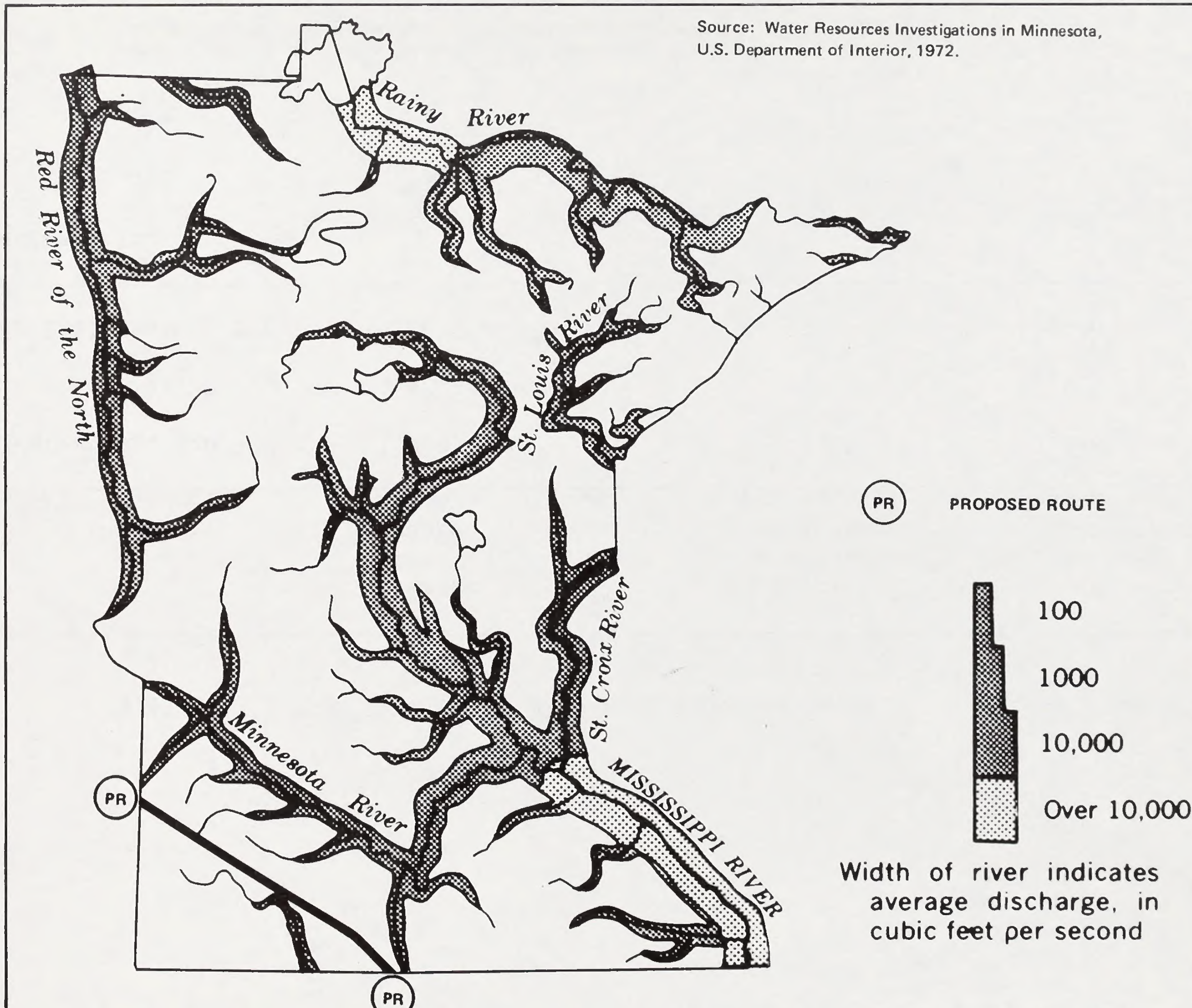


Figure 2.1.3.5-6 Average annual discharge of Minnesota rivers

Table 2.1.3.5-6 lists the gaging stations and streamflow data on these rivers.

High flows in the area usually occur in the spring because of snowmelt, augmented at times by spring and early summer rains. High flows of short duration, however, may occur at any time during the summer or fall as a result of intense storms. The area has a well-integrated drainage system which tends to cause rapid runoff and produce streamflows of short duration. The high flows in spring and early summer are followed by a recession through late summer, fall and winter months. Winter freezeup is the most common cause of extended periods of low flow.

Upper Mississippi River Basin

The Upper Mississippi River Basin in north-central United States drains the area upstream of the mouth of the Ohio River, excluding the Missouri River Basin. The basin encompasses the States of Minnesota, Wisconsin, Iowa and Illinois, and parts of South Dakota, Missouri and northwestern Indiana.

Iowa

As illustrated in Figure 2.1.3.5-7 central and eastern Iowa contain a series of major tributaries to the Mississippi River, all flowing in a southeasterly direction. Those transected by the proposed route include the Cedar and Wapsipinicon Rivers.

The Cedar River is the largest tributary of the Iowa River. It rises in the southeastern quarter of Minnesota and flows southeasterly to its confluence with the Iowa River near the town of Columbus Junction, Iowa. The major tributaries of the Cedar River join about 16 miles upstream from the city of Waterloo to form a main stem which traverses the cities of Cedar Falls, Waterloo, Evansdale and Cedar Rapids.

The drainage area of the Cedar River at the mouth is 7,819 square miles. Of this amount 1,024 square miles is in Minnesota.

From the confluence of the West Fork of the Cedar River with the Shell River to the mouth of the Cedar River the drainage area of the stream nearly doubles. However, there are only five tributaries exceeding 200 square miles in drainage area downstream from the confluence.

The following list shows the principal tributaries:

Cedar River below West Fork	4,315 square miles
Beaver Creek	319 square miles
Blackhawk Creek	344 square miles
Wolf Creek	328 square miles
Prairie Creek	216 square miles
Sugar Creek	222 square miles
Cedar River at the mouth	7,819 square miles

The Wapsipinicon River has a long narrow basin lying diagonally across the northeast quarter and a corner of the southeast quarter of Iowa. Of the 2,540 square miles total drainage area, all but about 13 square miles lies within the boundaries of the state. Tributary basins above Anamosa are long and narrow and are roughly parallel to the main stem. Those below Anamosa have the more normal dendritic pattern and are generally short by comparison with the upper tributaries. Land shapes range from flat in the upper basin

Table 2.1.3.5-6 Streamflow data at selected sites in southwestern Minnesota

	Drainage area (sq. mi.)	Years of record	Maximum discharge cfs	Minimum discharge cfs	Average discharge		Average annual runoff in
					yrs	cfs	
Minnesota River at Montevideo, Minn.	6,180	1909-71	35,100	no flow	50	659	1.44
South Branch Yellow Medicine River at Minneota, Minn.	111	1959-71	4,430	no flow	11	23.4	2.86
Yellow Medicine River near Granite Falls, Minn.	653	1931-38 1940-71	17,200	no flow	35	106	2.20
Redwood River near Marshall, Minn	307	1940-71	4,400	no flow	31	48.2	2.13
Minnesota River near New Ulm, Minn.	9,530	1967-71	58,000	42	--	--	--
Cottonwood River near New Ulm, Minn.	1,280	1911-13 1935-37 1938-71	28,700	0.5	37	281	2.98
East Branch Blue Earth River near Bricelyn, Minn.	132	1952-69	1,320	no flow	17	42.1	4.30
Blue Earth River near Rapidan, Minn.	2,430	1940-45 1950-71	43,100	6.9	28	1,206	4.69
Des Moines River at Jackson, Minn.	1,220	1909-13 1930-71	15,700	no flow	36	284	3.16

Data from Water Resources Data for Minnesota 1969 and 1971: U.S. Geological Survey, 1971 and 1973.

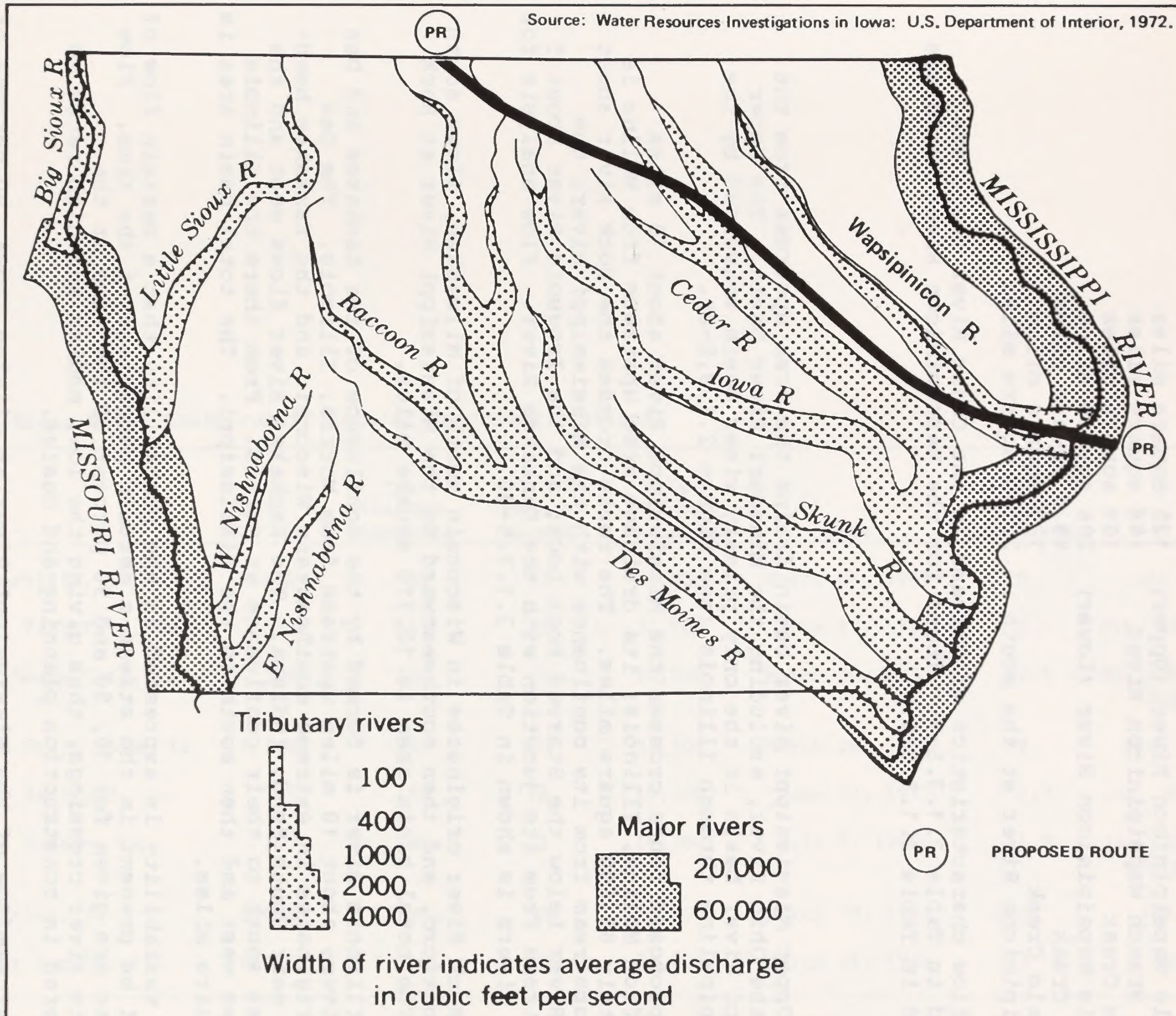


Figure 2.1.3.5-7 Average annual discharge of principal rivers in Iowa

to gently rolling in the lower basin. Floodplains are generally wide and flat, especially in the lower basin.

The following list shows the principal tributaries:

Little Wapsipinicon River (Upper)	125 square miles
East Branch Wapsipinicon River	148 square miles
Crane Creek	109 square miles
Little Wapsipinicon River (Lower)	206 square miles
Pine Creek	49.7 square miles
Buffalo Creek	732 square miles
Wapsipinicon River at the mouth	2,540 square miles

The flow characteristics of streams in the Cedar River basin are summarized in Table 2.1.3.5-7. Those for the Wapsipinicon River basin are summarized in Table 2.1.3.5-8.

Illinois

The Upper Mississippi River basin drains the area upstream from the mouth of the Ohio River, excluding the Missouri River basin. The Upper Mississippi River basin is the only primary river basin traversed by the proposed pipeline through Illinois (see Figure 2.1.3.5-8).

The proposed route crosses the Mississippi River about 10 miles upstream from Moline, Illinois; its drainage area upstream from Moline is approximately 85,600 square miles. The route crosses the Rock River about 40 miles upstream from its confluence with the Mississippi River; the Illinois River below the Starved Rock Lock; and the Iroquois River about 5 miles upstream from its junction with the Kankakee River. Flow analysis for the three rivers is shown in Table 2.1.3.5-9.

The Rock River originates in Wisconsin north of Milwaukee, flows south through Rockford, and then southwestward to the Mississippi River at Rock Island. The total basin area is 10,710 square miles.

The Illinois River is formed by the confluence of the Kankakee and Des Plaines Rivers about 10 miles upstream from Morris, Illinois. The Des Plaines originates in extreme southeastern Wisconsin and the Kankakee headwaters is near South Bend, Indiana. The Kankakee River flows west and the Des Plaines south to their confluence at Morris. From there the Illinois River flows west and then south to the Mississippi. The total basin area is 29,000 square miles.

Flow variability is expressed as the probability that a certain flow of water will be present in the stream a certain percentage of the time. Flow frequencies are given for 10, 50 and 90 percent of the time at the approximate river crossings, thus giving the low, median and high rates to be considered in construction planning and design.

The streamflow of the Mississippi River at Clinton, Iowa, 90 percent of the time, exceeds 17,120 cubic feet per second (cfs); the flow, 50 percent of the time, exceeds approximately 32,240 cfs and the flow, 10 percent of the time, exceeds 77,040 cfs.

The variability of flow at the Mississippi and the other three river crossings is presented in Table 2.1.3.5-9. The minimum, average and maximum flow rates can be read directly from the figure.

Table 2.1.3.5-7 Cedar River Basin runoff data at recording stations

Section Name	D.A. Sq. Mi.	Cfs Average Discharge	No. of Years of Record	Cfs Maximum Discharge	Date	Cfs Minimum Discharge	Date
Cedar River at Janesville, Ia.	1,661	764	53	37,000	March 28, 1961	28	Oct. 21, 1922
W.F. Cedar River at Finchford, Ia.	846	437	28	31,900	June 27, 1951	5.9	Feb. 26-27, 1959
Winnebago River at Mason City, Ia.	526	236	41	10,800	March 30, 1933	2.5	Dec. 29-31, 1933 Aug. 5, 1934
Shell Rock River at Shell Rock, Ia.	1,746	844	20	33,500	March 28, 1961	39	Feb. 4-9, 1959
Beaver Creek at New Hartford, Ia.	347	184	28	18,000	June 13, 1947	2.3	Jan. 20-24, 1956
Black Hawk Creek at Hudson, Ia.	303	156	21	19,300	July 9, 1969	1.9	Jan. 21-23, 1956 July 30, 1956
Cedar River at Waterloo, Ia	5,146	2,725	33	76,700	March 28, 1961	152	Jan. 28, 1959
Cedar River at Cedar Rapids, Ia.	6,510	3,216	71	73,000	March 31, 1961	53	Jan. 6, 1950

Table 2.1.3.5-8 Wapsipinicon River Basin runoff data at gaging stations

Station Name	D.A. Sq. Mi.	Average Discharge	No. of Years of Record	Maximum Discharge	Date	Minimum Discharge	Date
Wapsipinicon River at Independence	1,048	569.0	40	26,800	July 18, 1968	7.0	1933-1934
Wapsipinicon River near DeWitt	2,330	144.7	39	27,000	April 22, 1973	40.0	Jan. 17, 1940

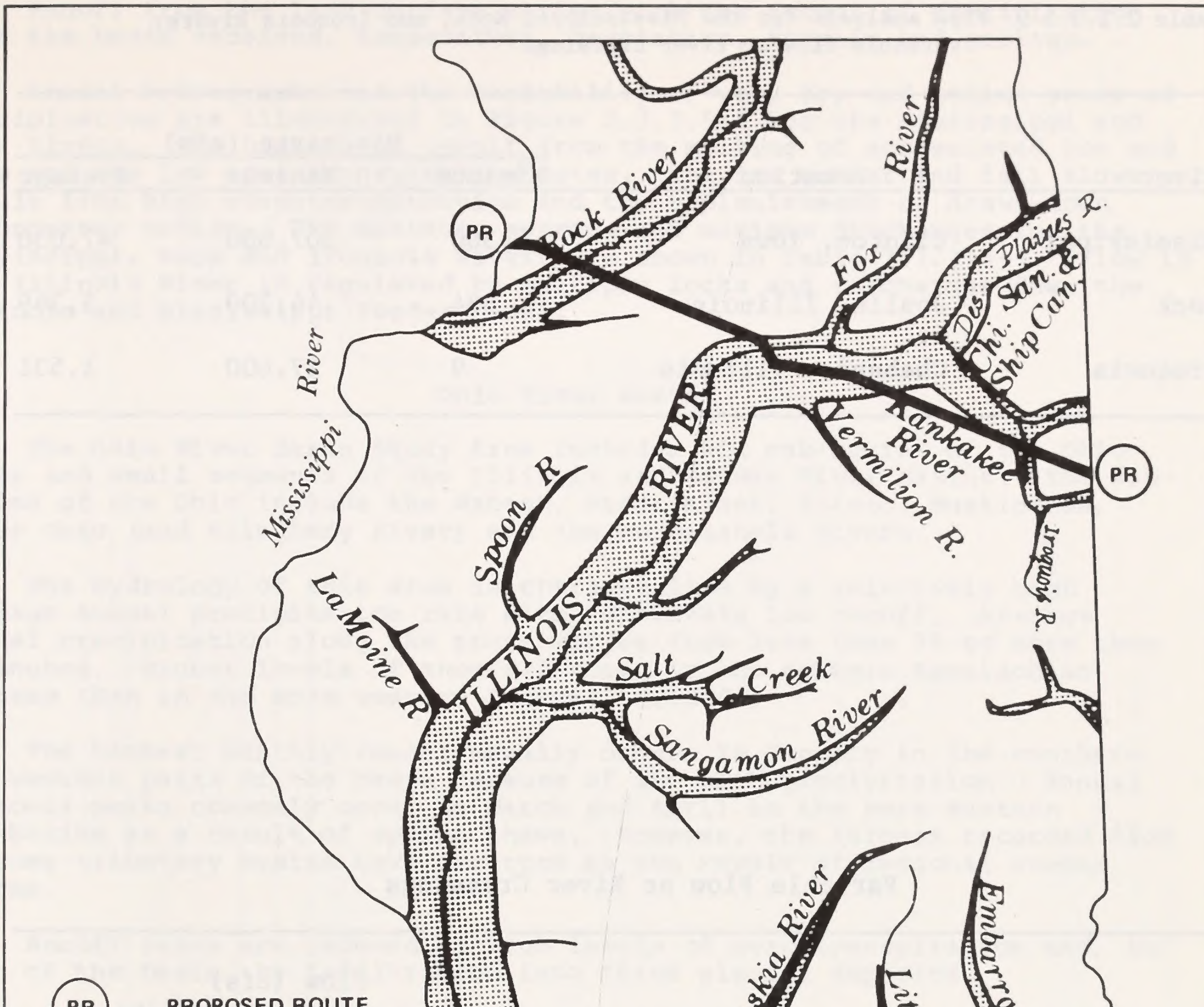


Figure 2.1.3.5-8 Average annual discharge of the principal rivers in Illinois

Table 2.1.3.5-9 Flow analysis for the Mississippi, Rock, and Iroquois Rivers; variable flow at river crossings

River	Location	Discharge (cfs) Minimum	Maximum	Average
Mississippi	Clinton, Iowa	6,500	307,000	47,030
Rock	Joslin, Illinois	834	46,200	5,369
Iroquois	Chebanse, Illinois	9	27,000	1,531

Variable Flow at River Crossings

River	Gage Location	Flow (cfs) in percent of time shown 10%	50%	90%
Mississippi	Clinton, Iowa*	77,040	34,240	17,120
Rock	Near Joslin**	13,300	3,800	1,710
Illinois	At Marseilles***	20,460	8,000	4,660
Iroquois	Near Chebanse****	4,130	593	66

*15 miles upstream of crossing

**Approximately at river crossing

***15 miles upstream of crossing and includes Fox River flow at Dayton

****Approximately at river crossing

Runoff from the land surface varies with the amount of precipitation that the basin receives, temperature, vegetation, terrain and geology.

Annual hydrographs and the variability of wet, dry and medium years of precipitation are illustrated in Figure 2.1.3.5-9 for the Mississippi and Rock Rivers. The high flows result from the melting of accumulated ice and snow and the low evapotranspiration rates. The low summer and fall flows result from high evapotranspiration and the replenishment of drawn-down groundwater tables. The minimum, average and maximum discharges for the Mississippi, Rock and Iroquois Rivers are shown in Table 2.1.3.5-9. Flow in the Illinois River is regulated by multiple locks and discharges down the Illinois and Mississippi Feeder Canal.

Ohio River Basin

The Ohio River Basin Study Area includes six sub-basins of the Ohio River and small segments of the Illinois and Maumee River Basins. The sub-basins of the Ohio include the Wabash, Great Miami, Scioto, Muskingham, Upper Ohio (and Allegheny River) and the Monongahela Rivers.

The hydrology of this area is characterized by a relatively high average annual precipitation rate with relatively low runoff. Average annual precipitation along the route varies from less than 36 to more than 44 inches. Higher levels of snowfall occur in the eastern Appalachian Plateau than in the more western Central Lowlands.

The highest monthly runoff usually occurs in January in the southern and western parts of the basin because of the high precipitation. Annual seasonal peaks commonly occur in March and April in the more eastern sub-basins as a result of spring thaws. However, the largest recorded flow of some tributary basins have occurred as the result of regional summer storms.

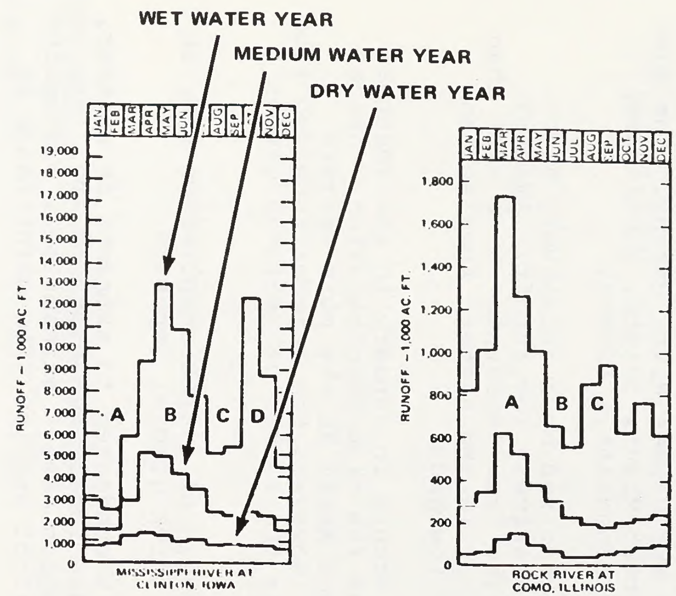
Runoff rates are reduced by high levels of evapotranspiration and, in part of the basin, by infiltration into thick glacial deposits.

The Ohio River Basin is occasionally subjected to extremes in weather, including extended regional rains, intense local thunderstorms and, less frequently, prolonged droughts, all of which affect streamflows. Extensive streamflow regulation provides flood control and low flow maintenance in some sub-basins.

Indiana

Most of Indiana's flat to rolling terrain is drained by the Wabash River, a major tributary of the Ohio River. The only exception within the study area is the Iroquois River which drains into the Illinois River. Indiana's climate and associated hydrology are beneficial to large-scale agricultural development, but have also caused flooding and high water table problems requiring extensive management and flood flow regulation.

As shown in Figure 2.1.3.5-10, the Wabash River is the only principal river crossed by the route in Indiana. Other rivers crossed from west to east are the Iroquois, Tippecanoe, Eel and Salamonie Rivers. With the exception of the Iroquois River, all drain into the Wabash system. Flow analyses of the major rivers crossed by the proposed route are given in Table 2.1.3.5-10.



A – LOW PRECIPITATION, GROUNDWATER RECHARGE, SNOW AND ICE STORAGE IN THE WATERSHED.

B – HIGH PRECIPITATION SNOW AND ICE MELT LOW EVAPORATION GROUND WATER STORAGE MAXIMUM.

C – LOWER PRECIPITATION, HIGH EVAPOTRANSPIRATION, GROUND WATER DRAWDOWN.

D – HIGHER FALL PRECIPITATION, GROUNDWATER RECHARGE LOW EVAPOTRANSPIRATION.

Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 2.1.3.5-9 High, medium, and low monthly discharge of selected Illinois rivers

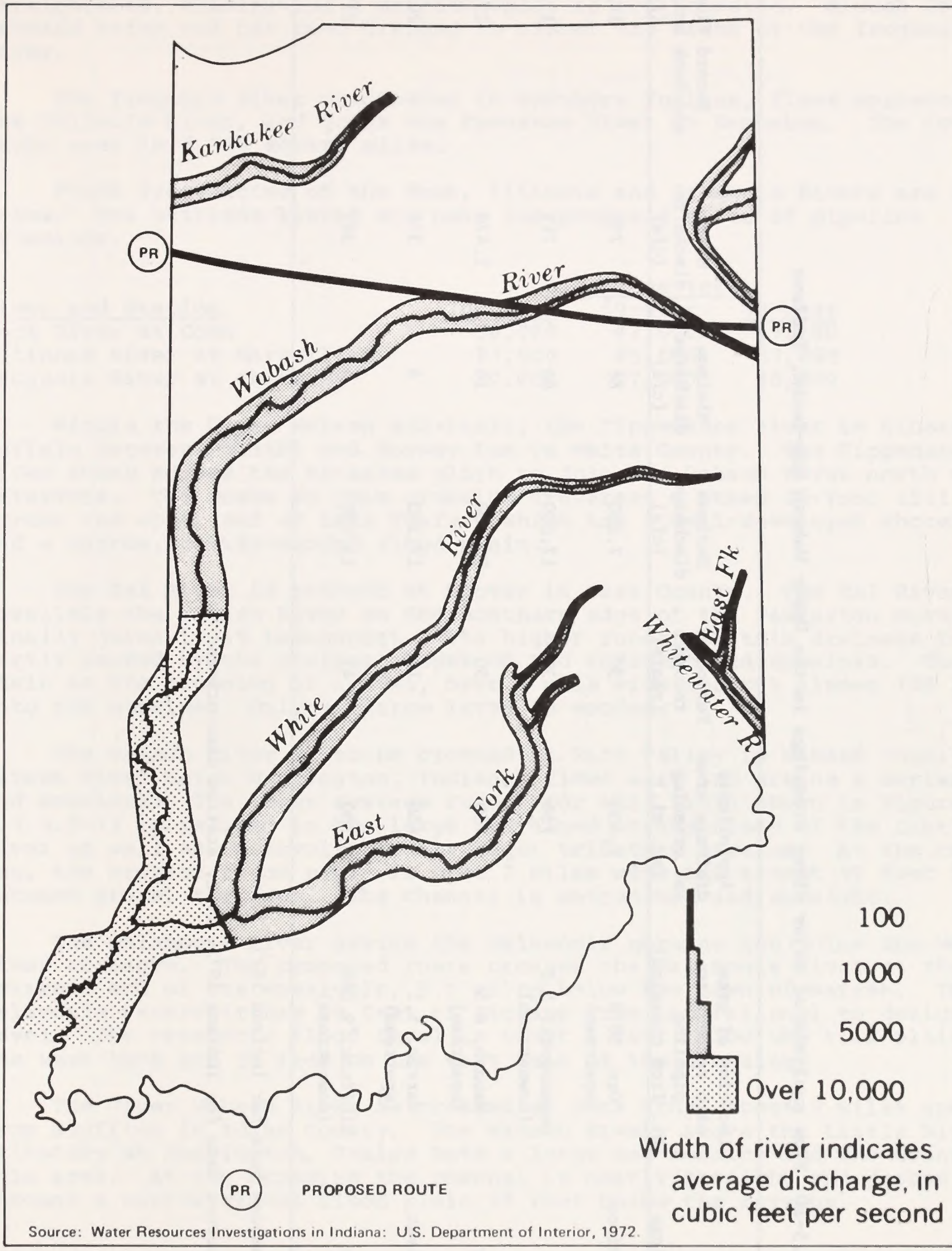


Figure 2.1.3.5-10 Average annual discharge of the principal rivers in Indiana

Table 2.1.3.5-10 Flow analysis of major river crossings in the Upper Wabash Sub-Basin, Indiana

River Crossings	Location of gage with respect to pipeline (Mi. from crossing)	Approximate drainage area at crossing (sq. mi.)	Period of record (years)	Maximum discharge (cfs)	Minimum discharge (cfs)	Mean discharge (cfs)	Record flood/ and bank height (ft.)
Tippecanoe River	Ora, 50.0 (upstream)	1,400	30	7,800	86	798	14/10
Eel River	Logansport, 5.5 (downstream)	750	30	17,000	65	719	13/11
Wabash River	Wabash, 6.5 (upstream)	1,750	50	90,000	19	1,470	29/12
Salamonie River	Warren, 5.5 (upstream)	450	16	13,200	6	378	20/17
Wabash River	Bluffton, 9.0** (downstream)	500	41	25,000	4	387	21/10

*Water Resources Data for Indiana 1973, 1974

**Water Resources Data for Indiana 1971, 1972; station discontinued

At the Iroquois River crossing, the channel has been dredged and straightened, eliminating a meander which is now forested. Slough Creek is crossed twice and has been dredged to almost the width of the Iroquois River.

The Iroquois River originates in northern Indiana, flows westward into the Illinois River, and joins the Kankakee River at Kankakee. The total basin area is 2,120 square miles.

Flood frequencies of the Rock, Illinois and Iroquois Rivers are given below. The stations listed are near the proposed sites of pipeline crossings.

	Discharge (cfs)		
River and Station	100-year	50-year	10-year
Rock River at Como	58,000	47,000	41,000
Illinois River at Marseilles	91,000	85,000	67,000
Iroquois River at Chebanse	30,000	27,000	20,000

Within the Upper Wabash sub-basin, the Tippecanoe River is crossed at Buffalo between Pulaski and Norway Dam in White County. The Tippecanoe flows south across the Kankakee plain to join the Wabash River north of Lafayette. The route at this crossing traverses a steep 25-foot till bluff, across the upper end of Lake Shafer, which has a well-developed shoreline and a narrow, partly-wooded flood plain.

The Eel River is crossed at Hoover in Cass County. The Eel River parallels the Wabash River on the southern edge of the Packerton moraine and finally joins it at Logansport. The higher runoff of this drainage basin is partly caused by the steeper slopes of two adjacent end moraines. The flood plain at the crossing is gravel, over a mile wide and cut almost 100 feet into the moraine. Only a narrow levee is wooded.

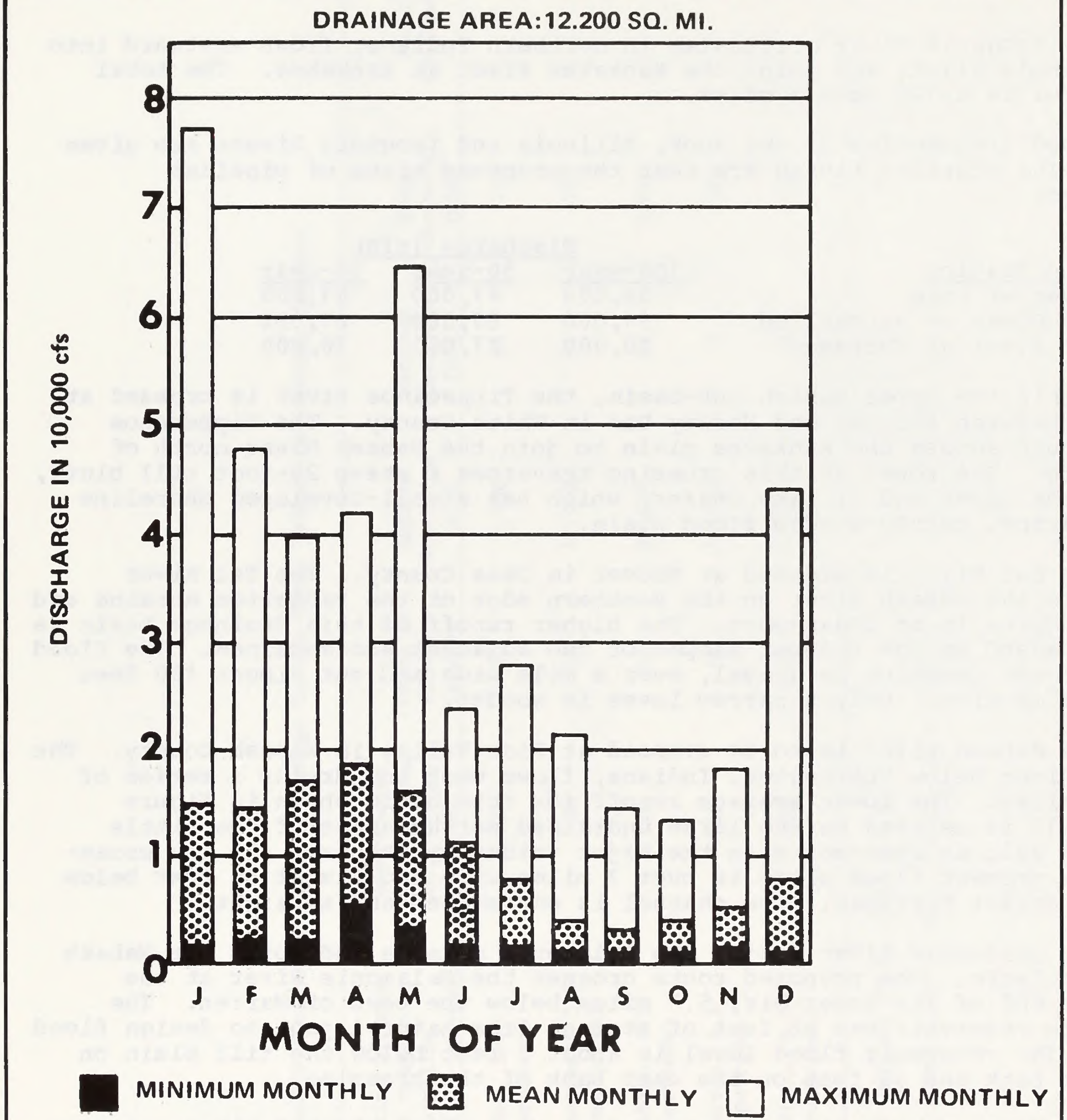
The Wabash River is to be crossed at Rich Valley in Wabash County. The Wabash River below Huntington, Indiana, flows west and drains a series of end moraines. The lower average runoff for this basin shown in Figure 2.1.3.5-11 is related to the large undrained marshy areas of the Little River as well as reservoirs on the major tributary streams. At the crossing, the present flood plain is over 2 miles wide and almost 50 feet below outwash gravel terraces. The channel is entrenched and straight.

The Salamonie River drains the Salamonie moraine and joins the Wabash River at Lagro. The proposed route crosses the Salamonie River at the upstream end of its reservoir, 5.5 miles below the town of Warren. The Salamonie reservoir has 38 feet of storage from natural pool to design flood level. The reservoir flood level is about 5 feet below the till plain on the west bank and 30 feet on the east bank of the crossing.

The Upper Wabash River is crossed at Vera Cruz, about 9 miles upstream from Bluffton in Adams County. The Wabash River, above the Little River tributary at Huntington, drains both a large end moraine and the Grand Lake, Ohio area. At the crossing the channel is nearly straight and passes through a narrow gravel flood plain 25 feet below the moraine.

Ohio

The streams of Ohio drain principally into the Ohio River and the Lake Erie Basin. Most of northern Ohio, including a 42-mile segment of the proposed route in eastern Indiana, drains into the latter. Five sub-basins are crossed by the route between the Indiana-Ohio border and the Ohio River.



Source: Adapted from Ohio River Basin Comprehensive Survey, Vol. IV, Hydrology: The Ohio River Basin Survey Coordinating Committee and U.S. Army Corps of Engineers, 1966.

Figure 2.1.3.5-11 Monthly mean discharge patterns for the Wabash River at Terre Haute, Indiana

These basins, shown in Figure 2.1.3.5-12 include the Maumee Basin; the Great Miami Basin; the Scioto Basin; the Muskingum Basin; and the Upper Ohio Tributary Basin. The small stretch of Maumee Basin which the route crosses remains relatively close to the Wabash-Maumee divide.

In the State of Ohio the proposed route will cross two major tributary basins of the Ohio River (the Scioto, Olentangy and Big Walnut Rivers of the Scioto River Basin; the Muskingum River and Stillwater Creek of the Muskingum River Basin) and the Ohio River itself. Basic data on all but the Big Walnut River are given in Table 2.1.3.5-11. This figure shows that only the Ohio and Muskingum Rivers have a large drainage area at the crossing site; the other rivers are crossed nearer to their headwaters where the flow is variable. The Scioto River is crossed about 15 miles upstream from the Columbus water-supply reservoir.

The Muskingum River is the only river within Ohio which is not crossed near its headwaters by the proposed route. The crossing is 3 miles below the confluence of the Walhonding and Tuscarawas Rivers. The Muskingum, where it is crossed, is only a few hundred feet wide and normally 3 to 4 feet deep, but its flood plain is 6,000 feet wide at the crossing site, wider than that of the Ohio River in some places. Floodwaters occasionally overflow the banks, cresting at times as much as 10 feet above normal, but 12 reservoirs located upstream have prevented serious flooding.

At the Coshocton gage site the drainage area is approximately 5,000 square miles of which only 30 percent is uncontrolled by dams. The Muskingum River at this site is shallow, and has a gradient of about 1 foot per mile.

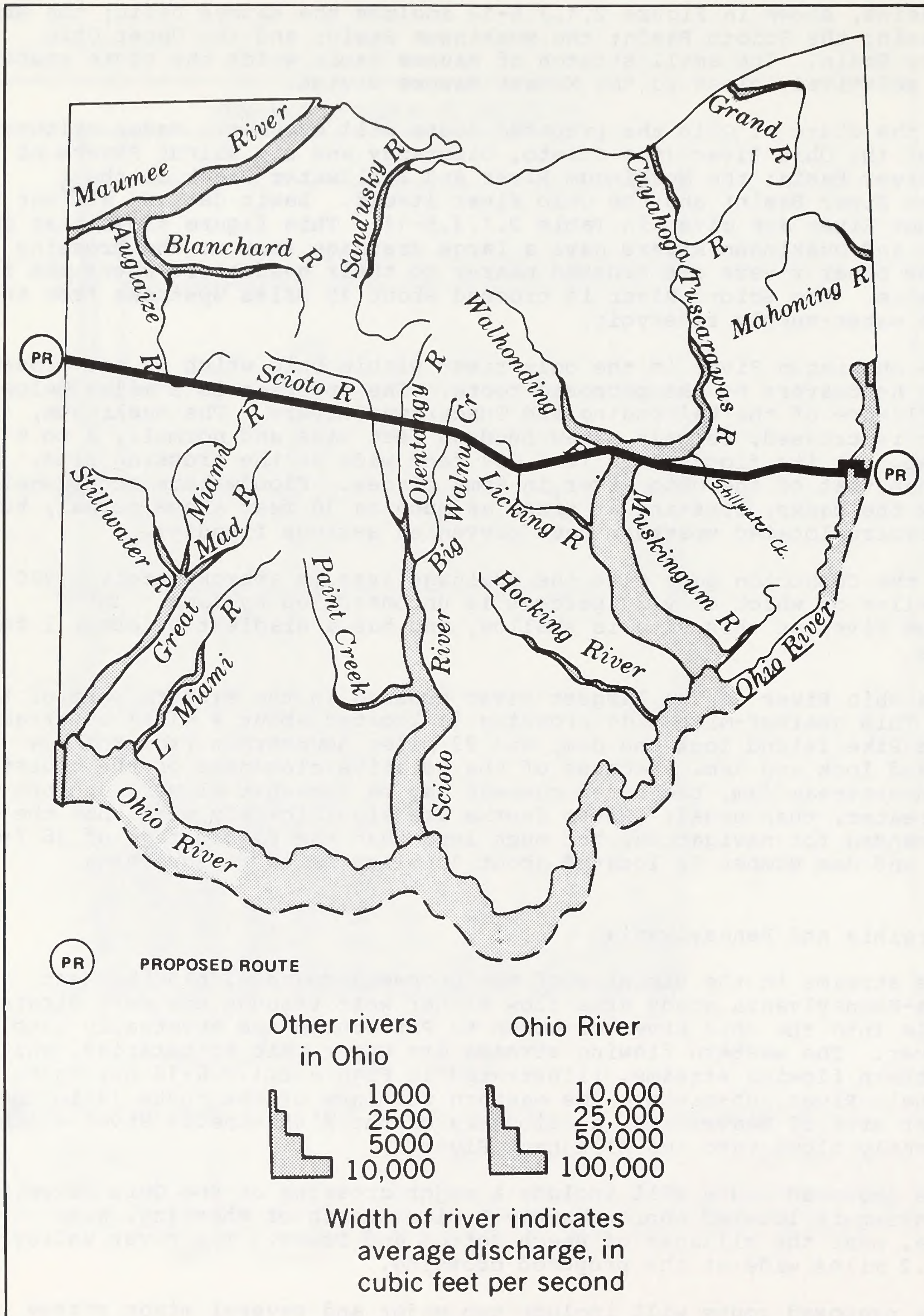
The Ohio River is the largest river crossed in the eastern part of the route. This quarter-mile wide crossing is located about 4 miles upstream from the Pike Island lock and dam, and 23 miles downstream from the New Cumberland lock and dam. Because of the relative closeness of the crossing to the downstream dam, the river current may be somewhat slower, and the depth greater, than usual. River depths are significantly more than the 12 feet demanded for navigation, but much less than the flood stage of 36 feet at lock and dam Number 12 located about 10 miles below the crossing.

West Virginia and Pennsylvania

The streams in the vicinity of the proposed route within the West Virginia-Pennsylvania study area flow either west through the West Virginia panhandle into the Ohio River or north to Pittsburgh and eventually into the Ohio River. The western flowing streams are Upper Ohio tributaries, while the northern flowing streams, illustrated in Figure 2.1.3.5-13 belong to the Monongahela River sub-basin. The eastern terminus of the route is in the headwater area of Beaver Run, a tributary of the Kiskiminetas River which subsequently flows into the Allegheny River.

The proposed route will include a major crossing of the Ohio River. The crossing is located approximately 8 miles north of Wheeling, West Virginia, near the villages of Beech Bottom and Power. The river valley is about 1.2 miles wide at the proposed crossing.

The proposed route will include two major and several minor stream crossings between the Ohio River and Delmont. These include: Buffalo Creek in West Virginia; Chartiers Creek, Little Chartiers Creek, Pigeon Creek, the Monogahela River and the Youghiogheny River in Pennsylvania. Summary data on the flows of the Monongahela and Youghiogheny Rivers are given in Table 2.1.3.5-12. Few flow data are available on the smaller western creeks, some



Source: Water Resources Investigations in Ohio, U.S. Department of Interior, 1968.

Figure 2.1.3.5-12 Average annual discharge of the principal rivers in Ohio

Table 2.1.3.5-11 Flow analysis of major river crossings in Ohio

River Crossing	Location of gage with respect to pipeline (mi. from crossing)	Drainage sub-basin	Drainage area (sq. mi.)	Period of record (years)	Max. daily discharge (cfs)	Min. daily discharge (cfs)	Mean daily discharge (cfs)
Scioto River	4.5 (downstream)	Scioto	567	33	27,000	4.5	416
Olentangy River	6.25 (downstream)	Scioto	393	38	41,600	3.9	348
Muskingum River	0.75 (upstream)	Muskingum	4,859	29	78,700	418	4,684 (2)
Stillwater Creek	6.5 (upstream)	Muskingum	122	27	1,470	0.1	137 (3)
Ohio River	7.0 (downstream)	Ohio	25,100	18	412,000	6,700 (4)	40,850

(1) Adapted from Cross, W.P., "Flow Duration of Ohio Streams", 1968.

(2) Flow partially regulated by 12 upstream flood control reservoirs.

(3) Gage located below reservoir.

(4) Baseflow at Wellsville, West Virginia (about 28 miles upstream).

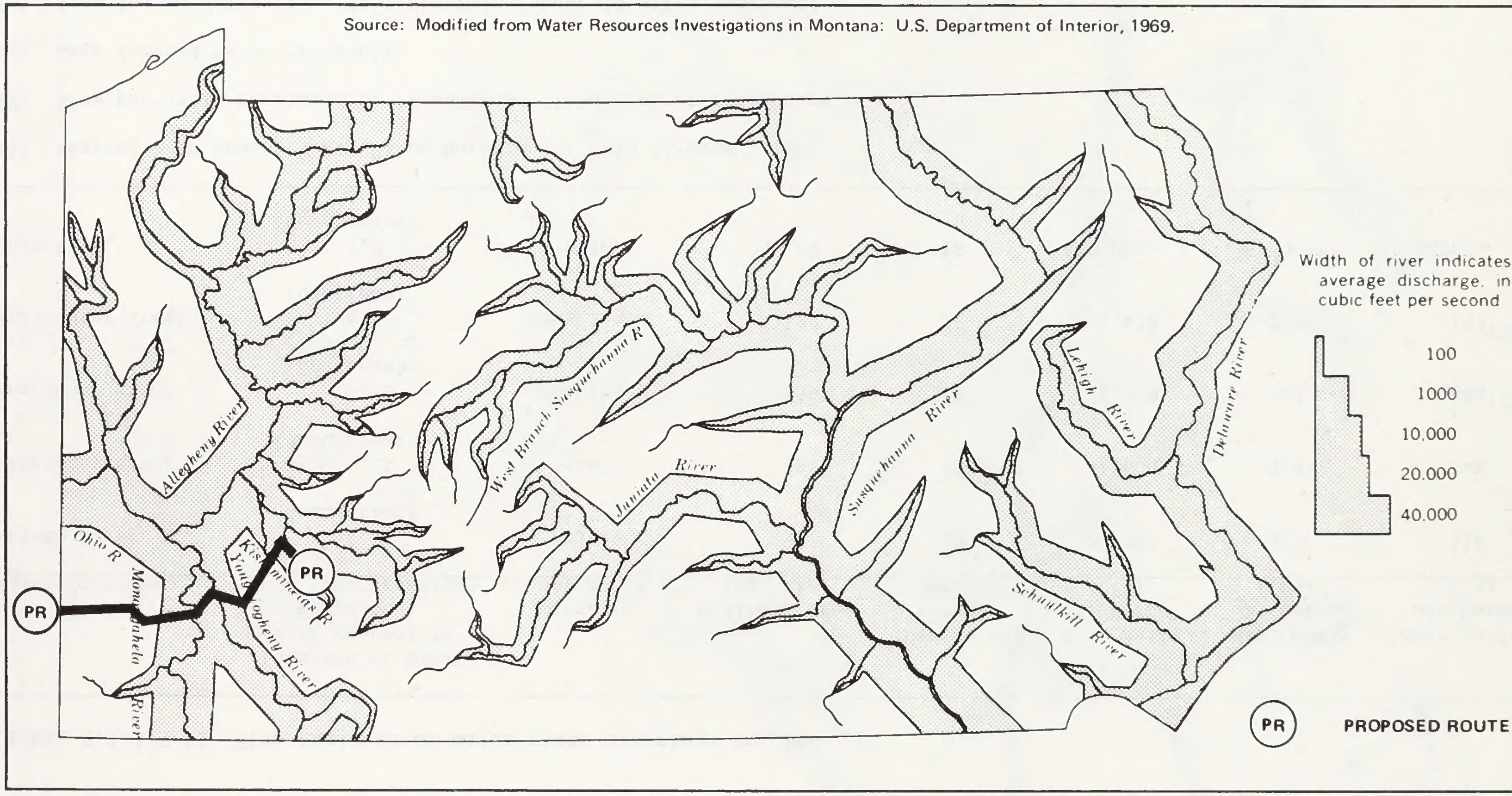


Figure 2.1.3.5-13 Average annual discharge of the principal rivers of Pennsylvania

Table 2.1.3.5-12 Summary of flow data for major Pennsylvania river crossings

Gage Location	Approximate Distance of Gage from Pipeline (miles)	Drainage Area (sq. mi.)	Period of Record (years) (thru 1973)	Maximum	Minimum	Mean
Monongahela						
Greensboro	51 Upstream	4,407	33	134,000	204	8,036
Charleroi	7 Upstream	5,213	40	158,000	--	8,914
Braddock (1)	24 Downstream	7,337	35	210,000	559	12,200
Youghiogheny						
Connellsville	34 Upstream	1,326	65	103,000	11	2,533
Sutersville	6 Upstream	1,715	53	108,000	57	2,969

*Adapted from U.S. Geological Survey, 1974, Water Resources Data for Pennsylvania, Part 1 and Surface-Water Records, 1973: Harrisburg, Pennsylvania; U.S. Geological Survey Report, p. Ref. J.

(1) Measurement includes Youghiogheny River flow.

of which are also summarized in that table. Clearly, Buffalo Creek, Chartiers Creek and a few other streams are relatively small at the pipeline crossings. The extent of flooding in these Ohio River tributaries is generally limited to narrow valley bottoms.

The worst flooding, in terms of impact to large numbers of people, occurs in Pittsburgh where the Monongahela and Allegheny Rivers meet. This area has the highest average annual flood damages in the Ohio Basin. Two upstream reservoirs control the outflow from 22 percent of the 7,384-square mile Monongahela drainage. Other reservoirs are in the planning stage.

The Monongahela drainage contributes about 40 percent of the Ohio flow at Pittsburgh and about 4 percent at Cairo, Illinois, where the Ohio meets the Mississippi River.

Groundwater

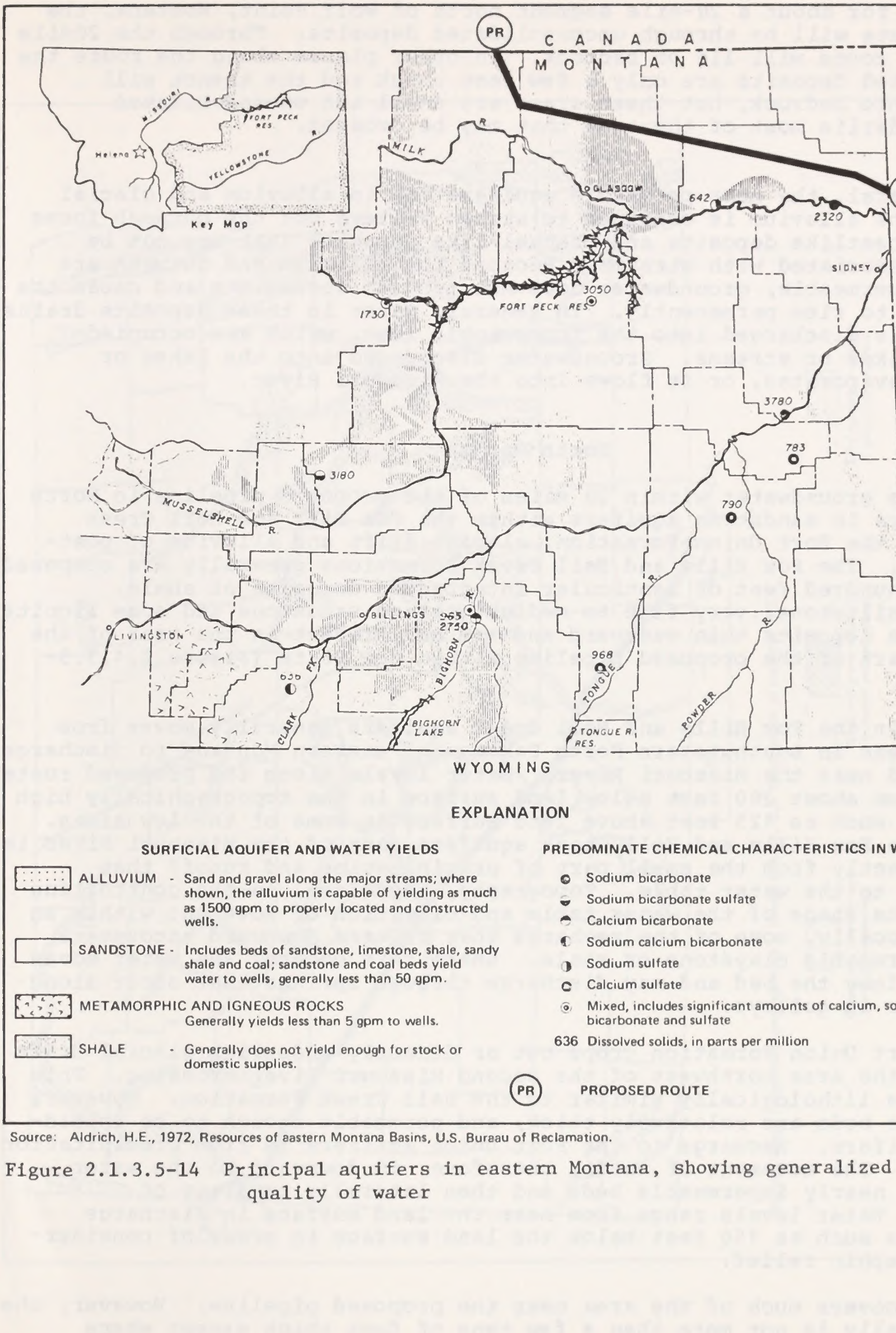
Groundwater is found in a variety of geologic formations. The units that contain water differ in lithology and geologic age from one part of the region to another, and they are commonly given names for convenience in reference. The name of a single formation is commonly a geographic place name, but multiple or complex units may be referred to by their geologic age. Whether the geologic unit that contains water is a bedrock formation or part of the overlying surficial materials, it is generally called an aquifer.

Aquifers are geologic units that contain water. They may be permeable, consolidated, layered, bedrock formations such as sandstone, limestone, coal or other materials that are porous or fractured. They also may be permeable but unconsolidated materials, perhaps nonlayered materials overlying the bedrock--surficial deposits such as glacial deposits and alluvium. Aquifers are sometimes classified as to whether they are shallow or deep, but there is no generally accepted definition of these terms; both 100 and 500 feet are used as a dividing point. For the purposes of this report, "shallow" aquifers are those in surficial materials, whatever their depth, or the thickness of the surficial deposits. "Deep" aquifers are those in bedrock formations, even though the formation locally may be close to, or even at, the surface of the ground.

It is important that an aquifer crop out either at the ground surface, or beneath permeable surficial materials. If it does not there is little opportunity for recharge--the replacement of groundwater in the aquifer that has been lost to the formation either by leakage or human consumption. Aquifers that have little or no source area for recharge may contain little water, and replacement of loss is slow. Such units are of reduced value as water suppliers.

Montana

Several aquifers will be crossed by the proposed route through Montana. Most of the route will traverse deposits of till which were laid down many thousands of years ago by continental ice sheets. Other important aquifers that will be crossed include deposits of sand and gravel (outwash) laid down by streams flowing from the melting ice; and sand and gravel (alluvium) laid down by modern streams. Bedrock aquifers include beds of sandstone in the Judith River Formation, Fox Hills Sandstone, Hell Creek and Fort Union Formations and sand or gravel in the Flaxville Gravel. In most places, deposits of till, outwash and alluvium cover the bedrock to a depth ranging from a few feet to as much as 300 feet (see Figure 2.1.3.5-14).



Source: Aldrich, H.E., 1972, Resources of eastern Montana Basins, U.S. Bureau of Reclamation.

Figure 2.1.3.5-14 Principal aquifers in eastern Montana, showing generalized quality of water

Except for about a 20-mile segment north of Wolf Point, Montana, the proposed route will be through unconsolidated deposits. Through the 20mile segment the route will lie on bedrock. In other places along the route the unconsolidated deposits are only a few feet thick and the trench will penetrate into bedrock, but these areas are small and unconsolidated deposits underlie most of the area that may be crossed.

In general, the most permeable aquifers are in alluvium and glacial outwash. The alluvium is confined to stream valleys but the outwash forms extensive sheetlike deposits and channel-like deposits that may not be presently associated with streams. Because the alluvium and outwash are relatively permeable, groundwater does not tend to accumulate and cause the water level to rise permanently. In general, water in these deposits drains toward and is discharged into the topographic lows, which are occupied either by lakes or streams. Groundwater discharged into the lakes or streams is evaporated, or it flows into the Missouri River.

North Dakota

Potable groundwater within 20 miles of the proposed pipeline in North Dakota occurs in sandstone aquifers within the Fox Hill and Hell Creek Formations, the Fort Union Formation, glacial drift and alluvium of post-glacial age. The Fox Hills and Hell Creek Formations generally are composed of several hundred feet of lenticular interbedded deposits of shale, claystone, siltstone, very fine to medium-grained sandstone and some lignite beds. These deposits thin eastward and are not present in the area of the southeast part of the proposed pipeline within the State (Figure 2.1.3.5-15).

Water in the Fox Hills and Hell Creek aquifers generally moves from recharge areas in southwestern North Dakota and eastern Montana to discharge areas in and near the Missouri River. Water levels along the proposed route may vary from about 200 feet below land surface in the topographically high areas to as much as 125 feet above land surface in some of the low areas. Water in the Fox Hills and Hell Creek aquifers east of the Missouri River is derived directly from the small part of precipitation and runoff that infiltrates to the water table. Topography, therefore, is the controlling factor in the shape of the water table and direction of movement within an aquifer. Locally, some of the recharge that filters downward encounters nearly impermeable claystone or shale. Where this occurs, the water moves laterally along the bed and may discharge through springs that occur along hillsides or in gulleys.

The Fort Union Formation crops out or directly underlies glacial drift in most of the area northwest of the second Missouri River crossing. This formation is lithologically similar to the Hell Creek Formation. However, some lignite beds are relatively thick, and permeable enough to be considered as aquifers. Recharge to the Fort Union aquifers is from precipitation and runoff. The movement of water, therefore, is downward to the water table or to nearly impermeable beds and then laterally to areas of discharge. Water levels range from near the land surface in discharge areas, to as much as 150 feet below the land surface in areas of considerable topographic relief.

Drift covers much of the area near the proposed pipeline. However, the drift generally is not more than a few tens of feet thick except where ancient valleys have been filled and in areas in Williams, Emmons, Logan and McIntosh Counties. The largest and most important glacial aquifers in the area are those in valley fills. They are outlined in Figure 2.1.3.5-15.

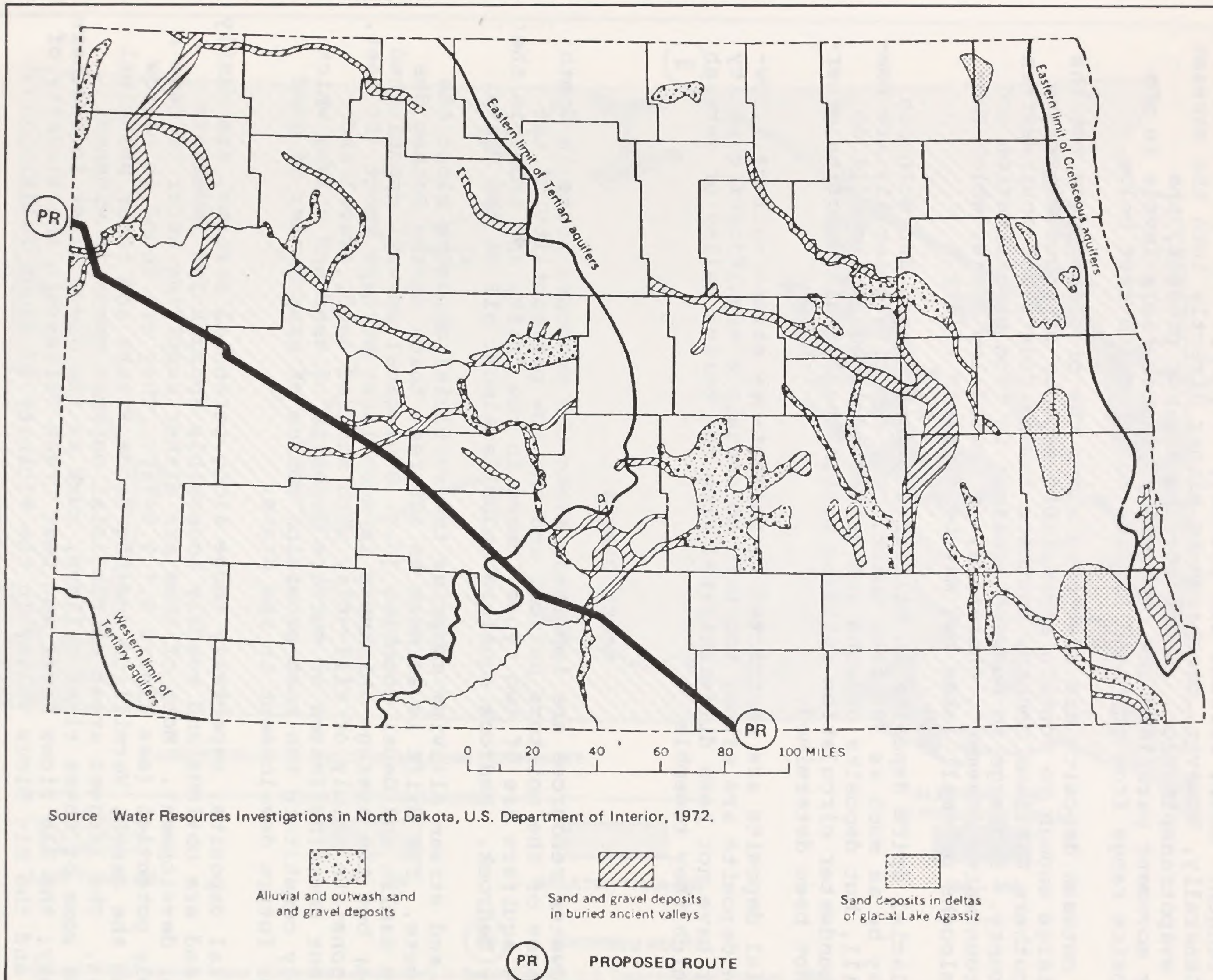


Figure 2.1.3.5-15 Principal aquifers in North Dakota

These aquifers are situated in topographically low areas and are recharged with water from the adjacent Fort Union or Fox Hills and Hell Creek aquifers as well as from precipitation and runoff. Water generally moves toward the lowest part of the valleys, which may be occupied by a stream for part or all of its length. Where streams are present, they may locally recharge the aquifer. Generally, however, discharge is either directly into the streams or lost by evapotranspiration. Where streams are not present, the groundwater movement parallels the topography. Water table levels in the valley deposits range from the land surface to about 100 feet below.

A few outwash deposits are scattered along the proposed route but the only ones large enough to contain appreciable amounts of groundwater are those in southern Williams County, southern Emmons County and southwestern McIntosh County. Recharge to outwash aquifers is from precipitation and runoff. Groundwater movement, therefore, is toward low areas, which commonly are sloughs or small lakes but may be a stream valley.

The glacial drift deposits in Williams, Emmons, Logan and McIntosh Counties may be as much as 300 feet thick. The deposits generally are composed of till, but deposits of sand and gravel enclosed in the till do exist. Groundwater circulation patterns within these small deposits generally have not been determined.

Alluvial deposits are restricted to present-day stream valleys. However, these deposits are either too thin to contain a significant quantity of water or have not been differentiated from the buried valley or outwash deposits which they resemble.

South Dakota

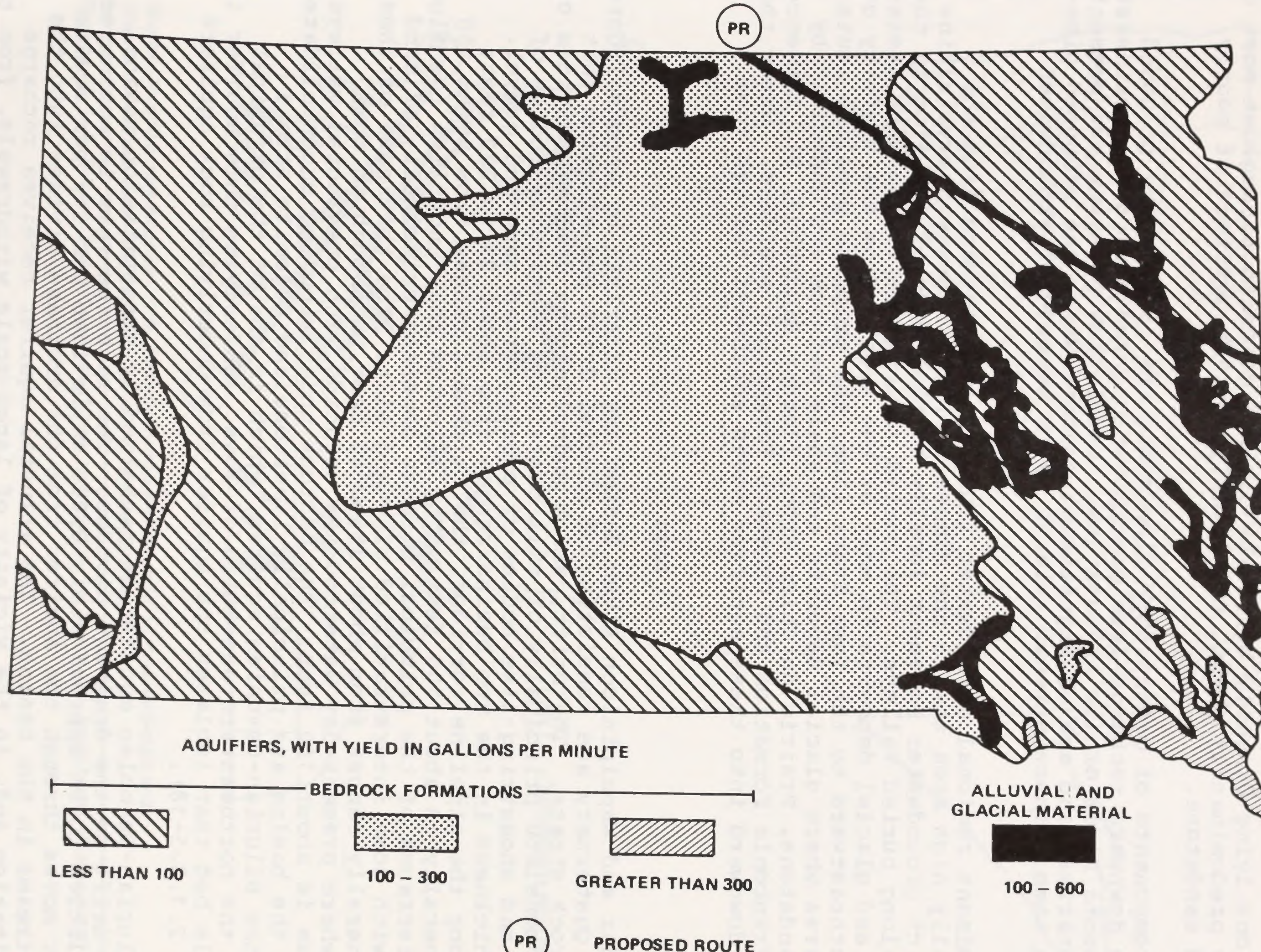
Groundwater resources are important along the proposed route in South Dakota because of the moisture deficit and the low permeability of the soils. The aquifers are of two types, those in the drift, and those in the sedimentary bedrock. Bedrock aquifers underlie almost all of the State.

Drift and stream alluvium comprise the surficial deposits along the proposed route. The drift is as much as 800 feet thick on the Coteau des Prairies in Hamlin and Deuel Counties (U.S. Geological Survey, unpublished information) but the average thickness is much less; perhaps about 150 feet. The drift consists mainly of till--clay with admixed sand, gravel and boulders, but contains lenses or surface deposits of sand and gravel which collectively constitute the most promising source of groundwater of good quality for future development in the State.

Alluvial deposits, especially those along perennial streams, are easily recharged and are obvious and readily accessible sources for immediate groundwater development. Most of them are either supplying water or have a water-supply potential (see Figure 2.1.3.5-16). They are found in narrow bands along the James, Vermillion and Big Sioux Rivers and their principal tributaries. The largest areas of surficial outwash occur in widened portions of some of these river valleys, such as the James River in southern Spink County; the Big Sioux River and Deer Creek Valleys in the vicinity of Brookings and the Big Sioux Valley in the vicinity of Sioux Falls.

Minnesota

Glacial deposits cover most of the southwestern part of Minnesota, and contain widely used aquifers. The glacial deposits are predominantly till. Beds of sand and gravel within the till are the most widely accessible and



Source: Modified from Water Resources Investigations in South Dakota, U.S. Department of Interior, 1969.

Figure 2.1.3.5-16 Principal aquifers in South Dakota most widely used aquifers in the areas of the proposed pipeline. These buried sand and gravel lenses are commonly thin and discontinuous, but provide water supplies adequate for most uses. Generally, water supplies can be obtained from glacial outwash where it is present (see Figure 2.1.3.5-17).

Formations lying directly below the glacial deposits throughout most of the area are predominantly shale, but locally contain aquifers of poorly consolidated sandstone.

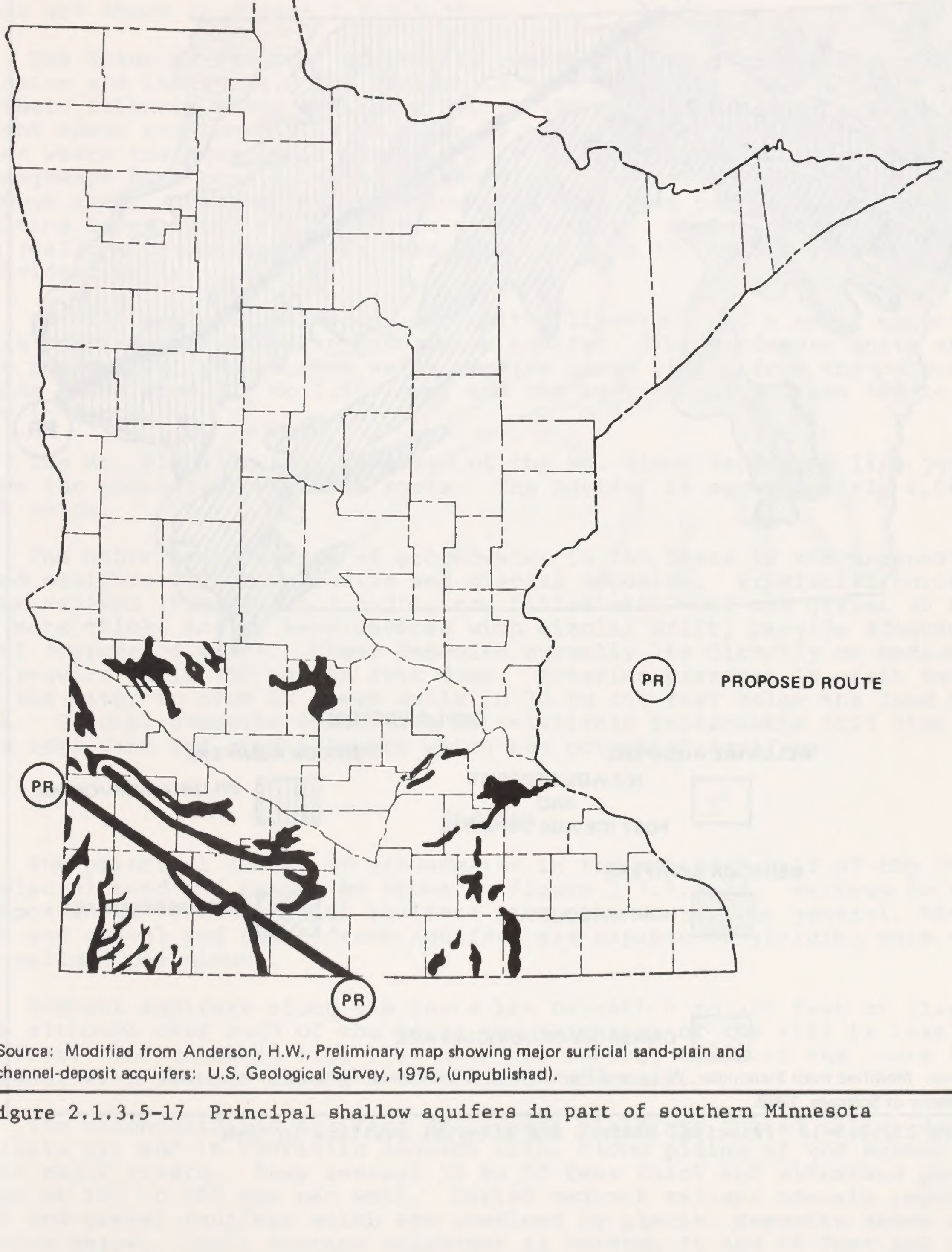
Major components of groundwater flow along the line of the proposed pipeline are downward recharge from precipitation, and toward the northeast to the Minnesota River or its tributaries. Local flow patterns are present at the tributaries, and are of significant concern where the proposed pipeline crosses them. These streams receive water because of groundwater discharge.

The dominant regional groundwater flow is northeastward from the topographically high area toward the Minnesota River. Ancient crystalline rocks restrict groundwater movement locally so that much of the flow in the bedrock is along buried valleys. The buried valleys are filled with Cretaceous rocks and glacial deposits in most of the area. From the vicinity of Fairmont southeastward to the Iowa State line, the proposed pipeline route crosses an area where glacial deposits and shale bedrock are underlain by St. Peter Sandstone, Prairie du Chien Group (Jordan Sandstone, St. Lawrence Formation, Franconia Formation and Dresbach Formation) aquifers. Water that infiltrates downward into these aquifers moves southward through them.

Iowa

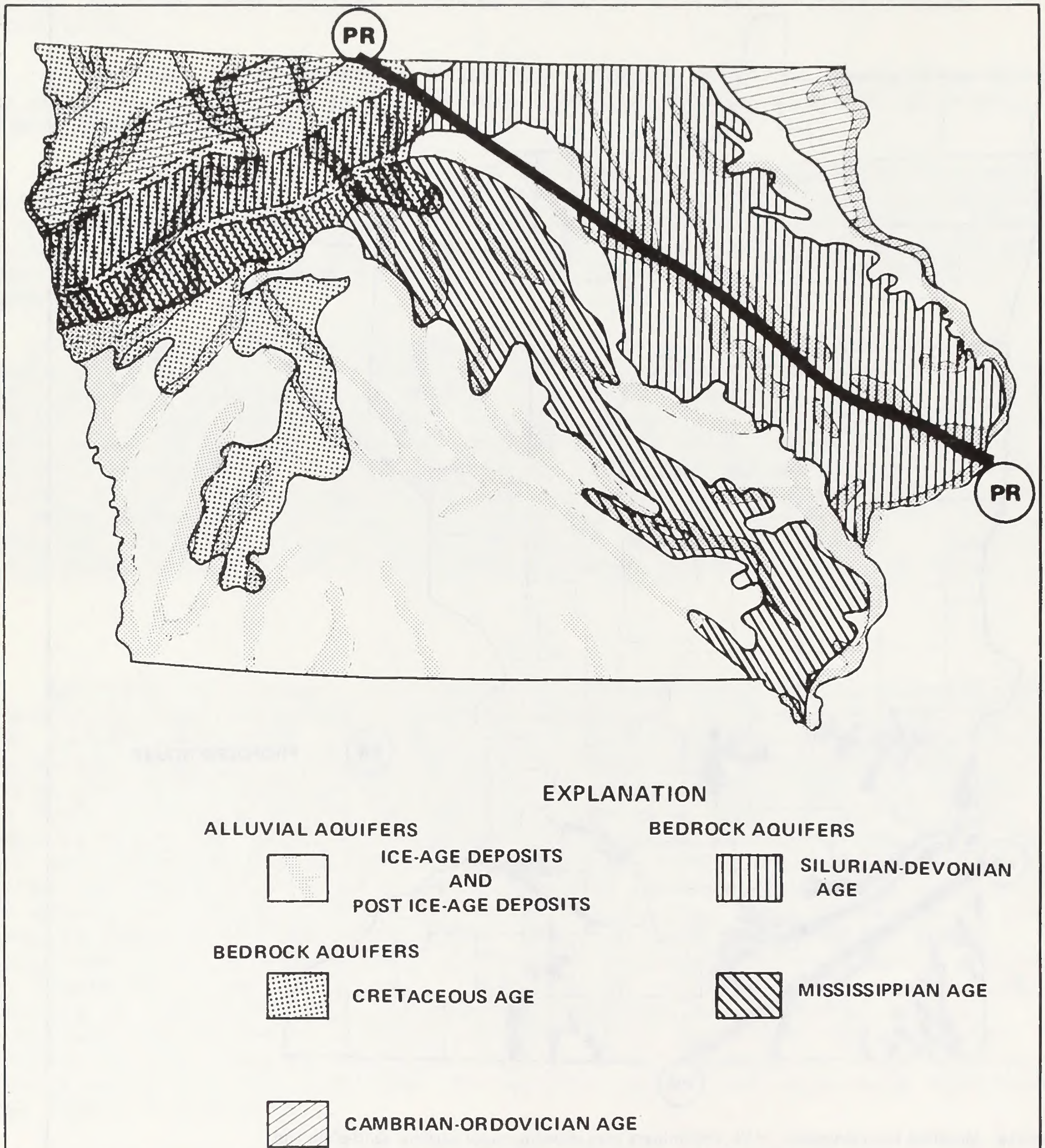
The Cedar and Wapsipinicon River Basins are underlain by unconsolidated deposits of Quaternary age consisting of glacial drift and alluvium that rest on bedrock strata. The drift, which underlies the drainage divides of the basins, consists principally of till containing lenticular bodies of sorted sand and shoestring-like bodies of poorly sorted sand and gravel. The drift thickness in the two basins ranges from about 25 to 200 feet; however, along the pipeline corridor, the thickness ranges from 50 to 150 feet and generally is about 100 feet. The alluvium that underlies the flood plains and terraces of the principal streams consists principally of sand and gravel with some interstratified clay and silt. The thickness of these deposits generally ranges from about 35 to 60 feet, although in some localities where present-day watercourses coincide with preglacial valleys the thickness is about 100 feet. The bedrock underlying the unconsolidated deposits in the basins are principally limestone and dolomite strata constitute the Silurian-Devonian aquifer, which is one of the principal aquifers in the northeastern one-third of Iowa. Underlying this aquifer is a thick shale bed that isolates the aquifer from underlying rock aquifers (see Figure 2.1.3.5-18).

The Silurian-Devonian aquifer is recharged by precipitation moving through the drift on the drainage divides. The recharge rate is estimated at two localities to be approximately 8,000 cubic feet per day per square mile. Water moves through the aquifer from the drainage divides into the principal streams in the basins. The alluvial aquifer receives recharge from precipitation and, in the vicinity of large-scale withdrawals, from the river by induced infiltration.



Source: Modified from Anderson, H.W., Preliminary map showing major surficial sand-plain and channel-deposit acquifers: U.S. Geological Survey, 1975, (unpublished).

Figure 2.1.3.5-17 Principal shallow aquifers in part of southern Minnesota



Source: Modified from Steinhilder, W. L., and Horick, P. J., Ground-water resources of Iowa; Iowa Academy of Sciences, 1969.

Figure 2.1.3.5-18 Principal bedrock and alluvial aquifers in Iowa

Illinois

The three major bedrock aquifers in Illinois are the Silurian-Devonian, the Cambrian-Ordovician and the Cambrian-Precambrian Mt. Simon-Hinckley beds. The useful limits of these aquifers in the northern third of the State are shown in Figure 2.1.3.5-19.

The Silurian-Devonian aquifer is composed of fractured and creviced dolomite and limestone. The aquifer is just below the glacial drift in northern Illinois where wells are 100 to 400 feet deep. This aquifer dips to the south and locally is overlain by younger bedrock strata. In those areas where the aquifer is overlain only by glacial drift, interconnecting passageways have been enlarged by the dissolving action of water passing through them. These openings narrow with depth and become fine cracks, limiting large water yields to the upper layers. Yields as great as 1,500 gpm (gallons per minute) have been reported with 150 to 300 gpm common from individual wells.

Several units of sandstone, dolomite, limestone and a small amount of shale comprise the Cambrian-Ordovician aquifer. The sandstone units are the most productive, though some wells receive large yields from the dolomite. Yields range from 300 to 1,500 gpm, and the aquifer ranges from 600 to 2,200 feet in depth.

The Mt. Simon aquifer composed of the Mt. Simon sandstone lies just above the ancient crystalline rocks. The Aquifer is approximately 2,000 feet thick.

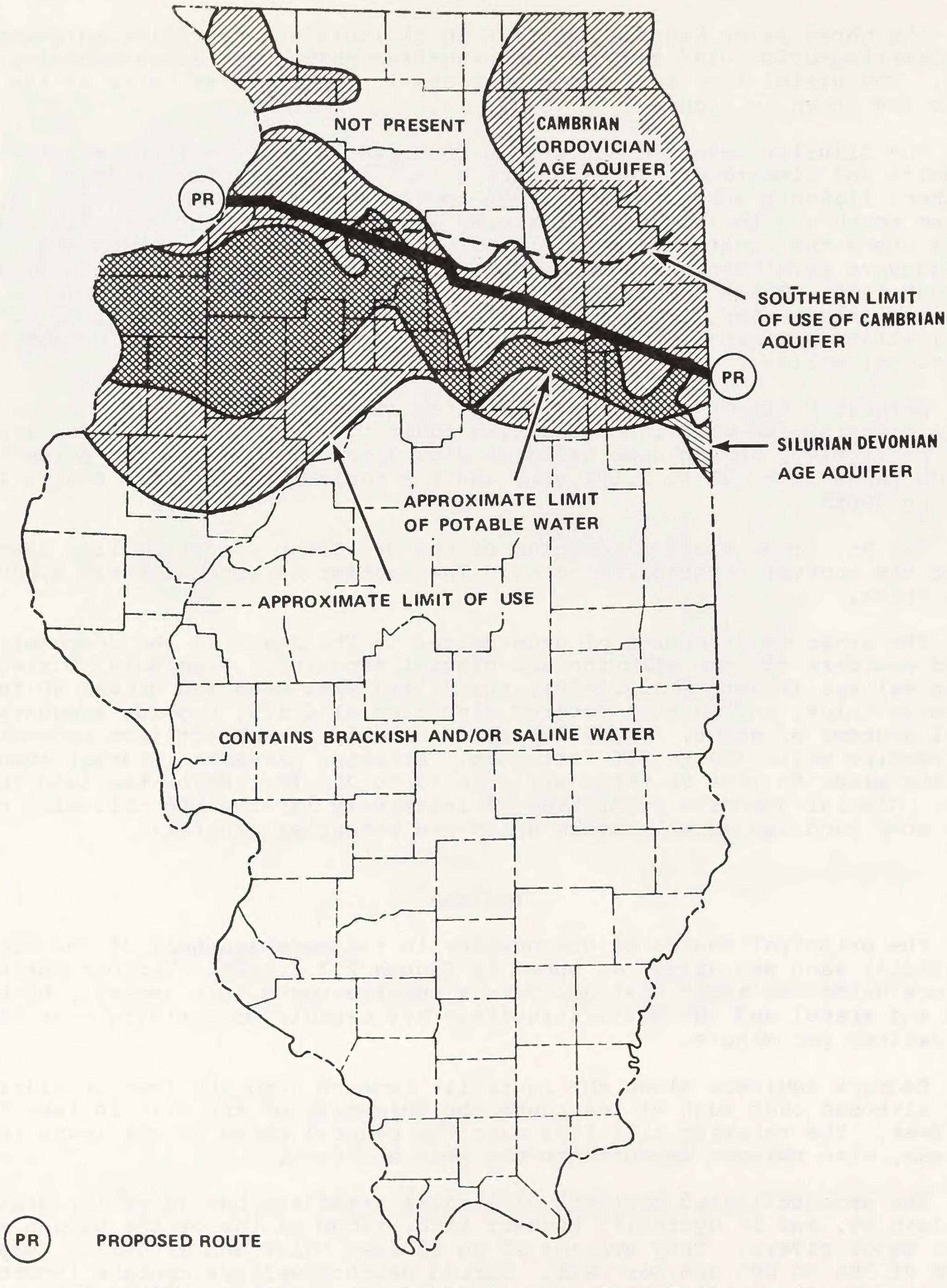
The other major source of groundwater in the State is the unconsolidated aquifers of both alluvium and glacial deposits. Preglacial buried river valleys (Figure 2.1.3.5-20), now filled with sand and gravel 40 feet and more thick, and in turn covered with glacial drift, provide adequate local sources of water. These deposits normally lie directly on bedrock, and require wells 150 to 400 feet deep. Artesian pressure is great enough for the water to rise in these wells to 30 to 200 feet below the land surface. Glacial deposits consisting of relatively impermeable till also contain some sand and gravel layers which are potential aquifers.

Indiana

The principal source of groundwater in the northern half of the State is glacial sand and gravel as shown in Figure 2.1.3.5-21. Various buried bedrock units are additional aquifers along the route. In general, both the sand and gravel and the bedrock aquifers are capable of yielding more than 100 gallons per minute.

Bedrock aquifers along the route lie beneath 0 to 400 feet of glacial till although over much of the route the thickness of the till is less than 100 feet. The thickest till lies over the central third of the route in Indiana, with thinner deposits to the west and east.

The unconsolidated aquifers of largest yield are buried valley deposits overlain by, and in hydraulic contact with, flood plains of the Wabash and other major rivers. They average 20 to 80 feet thick and withstand pumping rates of 500 to 800 gpm per well. Buried bedrock valleys contain important sand and gravel aquifers which are confined by glacial deposits above and bedrock below. Their average thickness is between 10 and 50 feet and yields are 200 to 700 gpm. Other sources of groundwater are discontinuous sand and gravel lenses in till or glacial lake sediments. The yields from these deposits vary with deposit thickness and extent and the source of recharge.



Source: Modified from Peterson, H.C. (ed.), Waters for Illinois, 1967, and, Environmental Assessment, Northern Border Pipeline Co., 1974.

Figure 2.1.3.5-19 Principal bedrock aquifers in Illinois

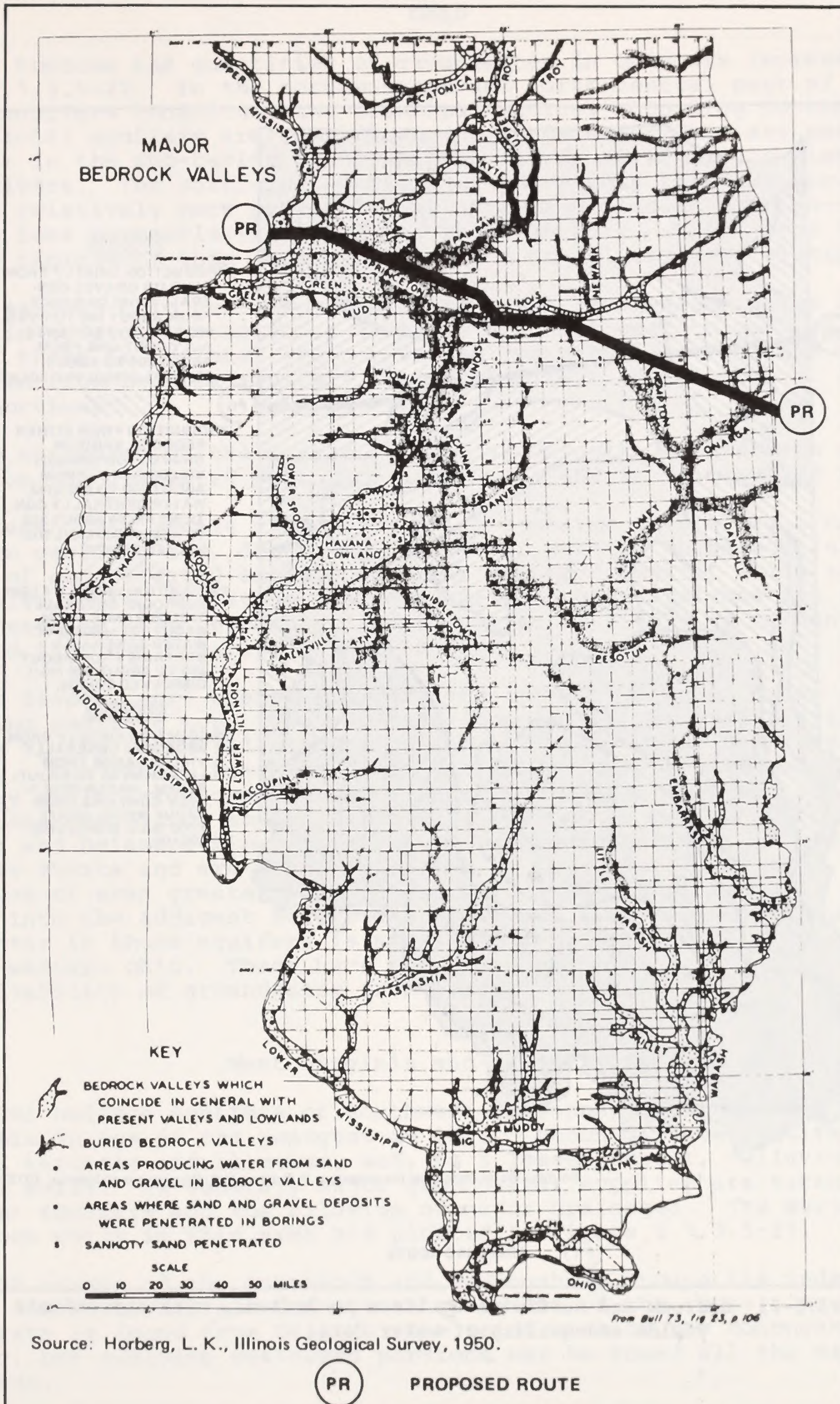


Figure 2.1.3.5-20 Principal surficial aquifers in Illinois

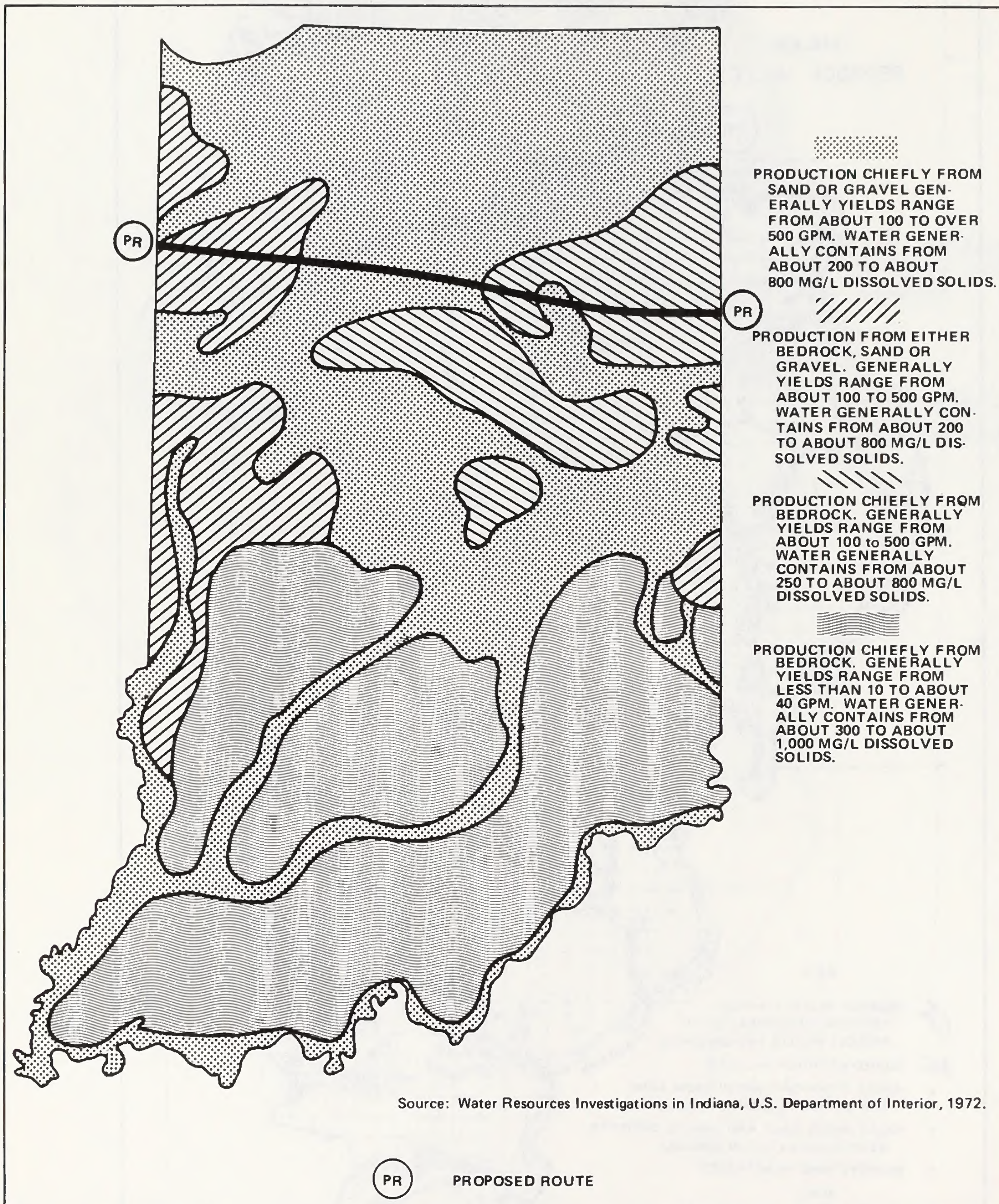


Figure 2.1.3.5-21 Bedrock and surficial aquifers in Indiana, with approximate yields and quality-of-water data

Ohio

The sources and quantities of groundwater in Ohio are represented in Figure 2.1.3.5-22. In the northwestern and north-central part of the State bedrock aquifers constitute the principal sources according to that figure, but surficial aquifers are significant nevertheless. They are particularly important in the sub-basins of the Wabash, Great Miami-Little Miami and Scioto Rivers. The surficial aquifers are divisible into two groups, those that are relatively more permeable--alluvium and glacial outwash--and those that are less permeable--till and glacial-lake clay. Yield from the till probably represents thin lenses of sand and gravel enclosed within it.

In eastern Ohio most groundwater is taken from valley fills that are similar in general character to those in the northwestern part of the State. However, those in the east are not buried beneath till. In this area water production from bedrock aquifers is minor, a reverse relation to that found in the northwest.

The thickness of the mantle of glacial deposits ranges from about 20 to 60 feet on the glaciated upland to as much as 400 feet in buried valleys.

Beneath this mantle is bedrock which contains several aquifers that differ in geologic age, depth and quality of water. These aquifers mainly consist of consolidated sandstone, limestone or dolomite, which are interbedded with shale, siltstone and some coal. Other water-bearing strata above these are less permeable, and any water is likely to be contaminated with acid from coal-bearing formations.

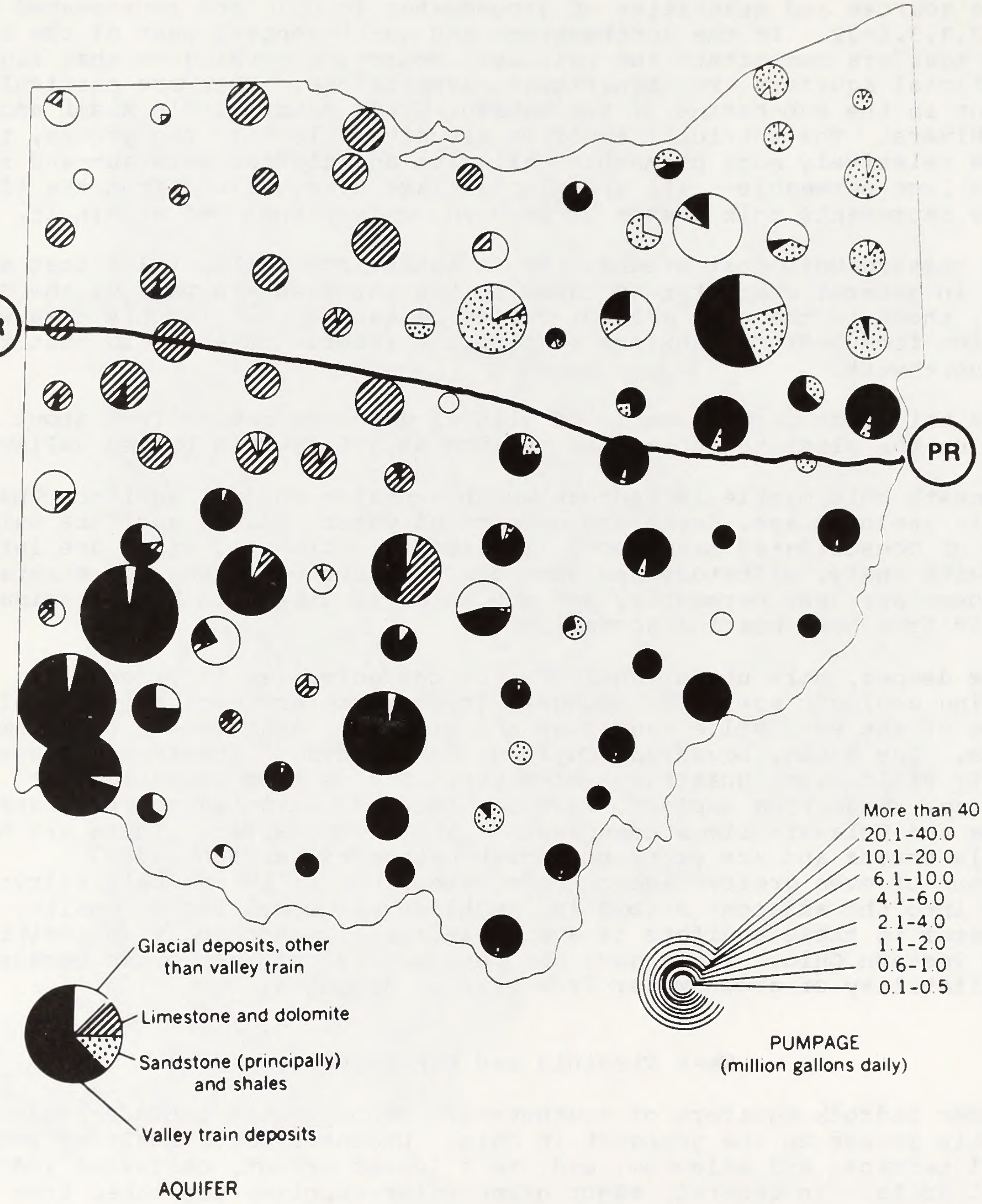
The deeper, more useful aquifers are characterized in order of increasing geologic age. The youngest (uppermost) are variable in yield, but beds of the Pottsville Sandstone and Allegheny Sandstone provide ample supplies. The Berea, Logan and Cuyahoga Sandstones of intermediate age generally yield large quantities of water. Yields from formations of greater age range from ample to lacking; the best Devonian aquifers are the Columbus and Delaware Limestones west of the Scioto River. These are highly permeable strata and are prone to contamination by surface water. Formations of even greater age contain water, but it is commonly salty; some escapes into the adjacent Scioto and Muskingum Rivers. Better quality groundwater in these aquifers is available from limestones and dolomitic beds in western Ohio. These have not been extensively exploited because of the availability of groundwater from glacial deposits.

West Virginia and Pennsylvania

Older bedrock aquifers of southwestern Pennsylvania include strata comparable in age to the youngest in Ohio. Unconsolidated aquifers include alluvial terraces and alluvium, and, to a lesser extent, colluvium and residual soils. In general, major groundwater supplies are taken from older sandstone aquifers and the alluvium of major drainages. The maximum yields of bedrock wells in this area are plotted in Figure 2.1.3.5-23.

Rock strata of the Conemaugh and Monongahela Groups lie under about half of the West Virginia-Pennsylvania segment of the route. Most of the rock strata is found from Delmont to a point west of the Monongahela River crossing, but outlying scattered portions may be found all the way to the Ohio River.

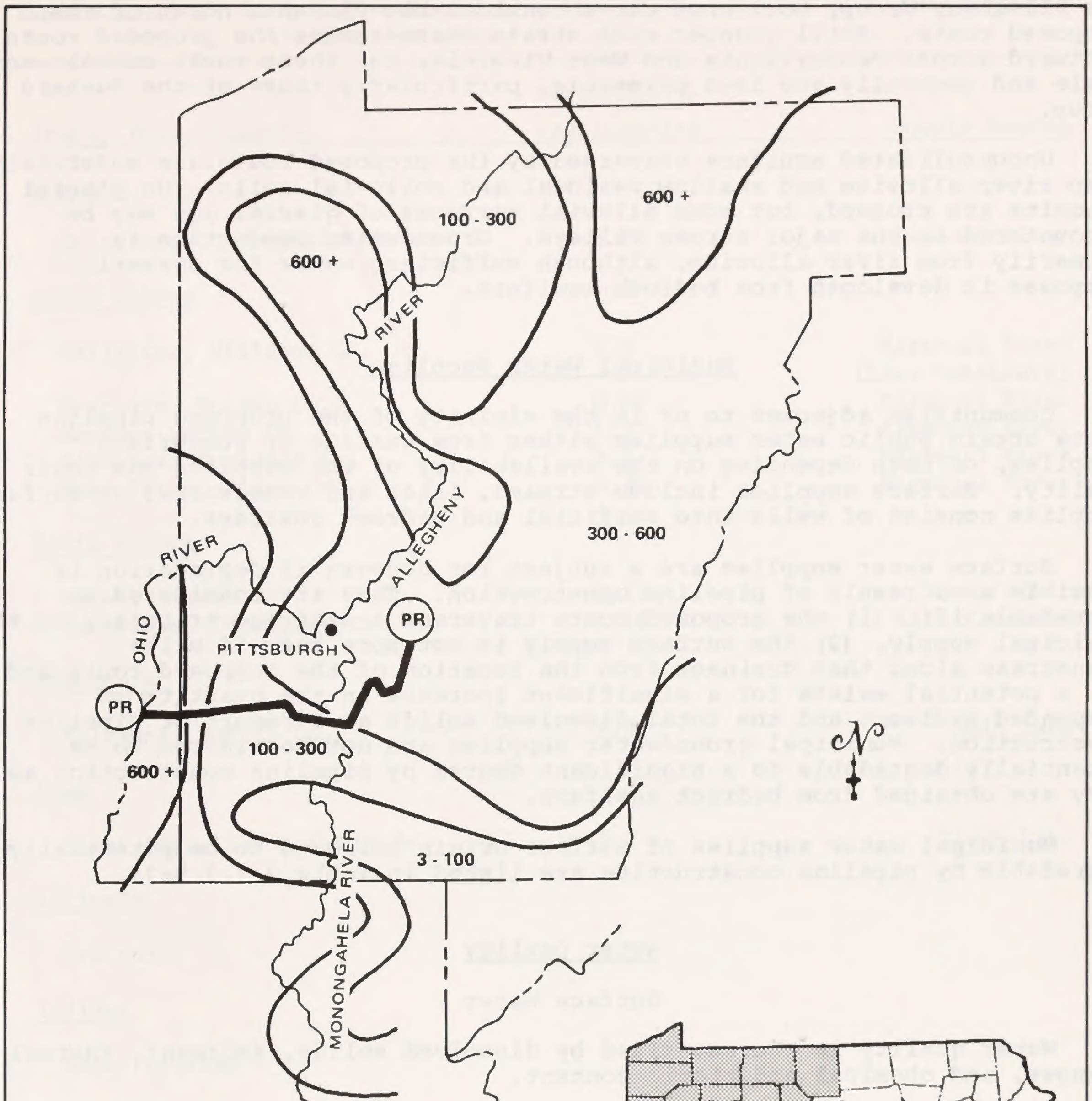
These bedrock aquifers are not noted as water holders although small to moderate supplies can be developed from the Conemaugh beds. Better yielding sandstones are found within the Pottsville Group, and to a lesser extent,



Source: Adapted from Water Resource Investigations in Ohio, U.S. Geological Survey, 1968.

PR PROPOSED ROUTE

Figure 2.1.3.5-22 Source and quantity of groundwater in Ohio



Source: Adapted from Development of Water Resources in Appalachia, Subregional Plans, 1969.

Figure 2.1.3.5-23 Maximum well yields in western Pennsylvania and the West Virginia Panhandle the Allegheny Group, both crop out a considerable distance north of the proposed route. Still younger rock strata characterize the proposed route westward across Pennsylvania and West Virginia, but these rocks contain more shale and generally are less permeable, particularly those of the Dunkard Group.

Unconsolidated aquifers traversed by the proposed route are moderately deep river alluvium and shallow residual and colluvial soils. No glacial deposits are crossed, but some alluvial terraces of glacial age may be encountered in the major stream valleys. Groundwater production is primarily from river alluvium, although sufficient water for domestic purposes is developed from bedrock aquifers.

Municipal Water Supplies

Communities adjacent to or in the vicinity of the proposed pipeline route obtain public water supplies either from surface or subsurface supplies, or both depending on the availability of the supplies and their quality. Surface supplies include streams, lakes and reservoirs; subsurface supplies consist of wells into surficial and bedrock aquifers.

Surface water supplies are a subject for concern if degradation is possible as a result of pipeline construction. They are considered as degradable if: (1) the proposed route traverses a drainage tributary to the municipal supply, (2) the surface supply is not more than 50 miles downstream along that drainage from the location of the proposed route and (3) a potential exists for a significant increase in the quantity of suspended sediment and the total dissolved solids as a result of pipeline construction. Municipal groundwater supplies are not considered to be potentially degradable to a significant degree by pipeline construction as they are obtained from bedrock aquifers.

Municipal water supplies of surface origin believed to be potentially degradable by pipeline construction are listed in Table 2.1.3.5-13.

Water Quality

Surface Water

Water quality is characterized by dissolved solids, sediment, thermal changes, and chemical and biotic content.

In the Great Plains states through which the proposed route passes, water quality is generally good. Most of the streams of Montana and the Dakotas have dissolved-solids levels of less than 500 mg/l at medium and high flows, which means that they are suitable for domestic use. There is no thermal pollution along the route severe enough to affect water quality, but numerous municipal sewage plants along the route discharge to rivers and streams and thus contribute to their microorganism content.

As the proposed route proceeds east, water quality tends to degenerate as more pollution sources are encountered.

The quality of the water of the Missouri River is relatively good when compared with other surface waters in the United States. The dissolved solids concentration near Williston, North Dakota averages about 420 mg/l, and has a range of about 300 to 600 mg/l. The range of concentration is reduced by mixing in Lake Sakakawea, and the concentration from Garrison Dam to Bismarck is about the same as the average at Williston. The water has a

Table 2.1.3.5-13 Municipal water supplies from surface sources in the vicinity of the proposed route

State, Town, County	Millions of gallons/day	Supply Source
Montana		
Cultertson, Roosevelt Co.	0.15	Missouri River
North Dakota		
Williston, Williams Co.	2.0	Missouri River (Lake Sakakawea)
Washburn, McLean Co.	0.09	Missouri River
Mandan, Morton Co.	1.3	Missouri River
Bismarck, Burleigh Co.	5.5	Missouri River
Fort Yates, Sioux Co.	0.22	Missouri River
South Dakota		
Huron, Beadle Co.	2.27	James River
Watertown, Codington Co.	1.16	Lake Kampeska
Minnesota		
Fairmont, Martin Co.	1.5	Budd Lake
Iowa		
Clear Lake, Cerro Gordo Co.	1.0	Clear Lake
Illinois		
See text		
Indiana		
None reported		
Ohio		
Columbus Metropolitan Area	35.0	Scioto River
	58.0	Big Walnut Creek
Delaware, Delaware Co.	1.9	Olentangy River
Newark, Licking Co.	11.0	Licking River
West Virginia and Pennsylvania		
Western Pennsylvania Water Co. (Monongahela and Pittsburgh Districts)	64.0	Monongahela River
Herminie Water District, Westmoreland Co.	0.1	Springs
Municipal Authority of Westmoreland County, Westmoreland Co.	28.0	Beaver Run Reservoir

hardness of 200 to 300 mg/l, which is relatively low compared to other waters in North Dakota.

The quality of water in the James River is closely related to the amount of water discharge of that stream, and is affected somewhat by regulation of Sand Lake near the North Dakota state boundary. When fairly large amounts of water are being released from the lake or are entering the river from tributaries downstream from the lake, the dissolved-solids content of the water varies between about 200 and 300 mg/l.

Because of the large amount of storage capacity in the channel of the James River, the quality of the water remains fairly constant for a few days after flow ceases entirely. However, if the period of no flow is long, the dissolved-solids content of the water in channel storage increases gradually because of evaporation, at times to more than 1,500 mg/l. Hardness expressed as $CaCO_3$ content of the water also increases, at times to more than 500 mg/l. The quality of the water during periods of no flow is of considerable importance to users such as the citizens of Huron, who depend on the River for their water supply.

The dissolved-solids content of water in the Big Sioux River and most of its tributaries fluctuates between 100 and about 900 mg/l.

Sediment records during the period 1957-1962 for the Iowa River near Rowan, Iowa, with a drainage area of 429 square miles which is in the upper reaches of the basin show a maximum daily sediment concentration of 760 mg/l.

Sediment records during the period 1967-1970 for the Wapsipinicon River at Independence, Iowa, with a drainage area upstream of 1,048 square miles, show a maximum daily sediment concentration of 840 mg/l. Specific conductance varies from 180 to 490 micromhos (a measure of total dissolved solids).

Records of specific conductance collected monthly on the Little Cedar River at Janesville, Iowa, and Shell Rock River at Shell Rock, Iowa, both sites near the pipeline crossing, show a range of 280-880 micromhos. Those collected on the Wapsipinicon River near De Witt, Iowa, a site near the mouth, show a range of 230-590 micromhos.

Chemical analyses made since February 1974 of samples from the Cedar River upstream from Waterloo, Iowa, show ranges of values for alkalinity (126-211 mg/l, pH (7.2-8.7 units), turbidity (7-180 JTU--Johnson Turbidity Unit), dissolved oxygen (8.1-12.4 mg/l), and fecal coliform (180-4,200 colonies/100 ml). Analyses for the same period of samples from the Cedar River downstream from Cedar Rapids, Iowa, show a respective range of values of 112-182 mg/l, 6.9-8.6 units, 8-210 JTU, 6.9-12.0 mg/l and 300-600,000 colonies/100 ml.

In Illinois water quality data are available from the Rock River at Como and for the Illinois River at Peoria. Turbidities for the Rock River samples were not less than 6 JTU (1956-1961) or 5 JTU (1961-1966), nor more than 70 JTU (1956-1961) or 85 JTU (1961-1966) for the central 80 percent of the time. Median values were 30 JTU (1956-1961) and 35 JTU (1961-1966).

Water quality analyses for the Rock River are shown on page 329.

		Concentration (mg/l) not exceeded for indicated percent of time		
		10%	50%	90%
Alkalinity (as CaCO3)	(1956-1961)	175	240	280
	(1961-1966)	175	234	280
Hardness (as CaCO3)	(1956-1961)	225	290	340
	(1961-1966)	230	290	355
Total Dissolved Minerals	(1956-1961)	285	340	390
	(1961-1966)	295	340	425
Nitrate	(1956-1961)	2.2	6.4	12
	(1961-1966)	4.6	9.6	17.8
Manganese	(1956-1961)	T	0.2	0.3
	(1961-1966)	0.1	0.2	0.3

The best sampling of the Illinois River is at Peoria, several miles downstream from the proposed crossing of the pipeline. The tabulation of water quality data is for the period from October 3, 1966 to September 2, 1971. For 80 percent of the time, in the interval between 10 and 90 percent, the daily mean discharge did not exceed 2.56 cfs/square mile, nor fall below 0.44 cfs/square mile. The median flow was 0.93 cfs/square mile and the mean was 1.2 cfs/square mile.

The turbidity was not less than 34 JTU nor more than 87 JTU for the central 80 percent of the time. The median value was 50 JTU for the central 80 percent of the time. The median value was 50 JTU and the mean 56 JTU.

Water quality analyses for the Illinois River are shown below.

	Concentration (mg/l) not exceeded for indicated percent of time (means in parentheses)		
	10%	50%	90%
Alkalinity (as $CaCO_3$)	140	172	212
Hardness (as $CaCO_3$)	236	282	342
Total dissolved minerals	362	419	497
Nitrate (NO_3)	9.3	15.5 (16.2)	23.8
Total inorganic phosphate (PO_4)	1.1	2.35 (2.48)	5.0
Soluble inorganic phosphate (PO_4)	0.8	1.06 (1.91)	3.6
Manganese (Mn)	0.04	0.12	0.19

In Indiana the pollution problems of the Wabash River are indicative of most streams within the Ohio River Basin. Downstream from Huntington, Logansport, Bluffton and Wabash there are high concentrations of organic pollutants originating mainly from sewage treatment plants and various industries, such as food processing plants and paper mills which discharge organic material. The metal-finishing industry adds deleterious concentrations of heavy metals such as cadmium, chromium, copper, nickel, lead and zinc to receiving waterways, while electric generating plants are a source of thermal pollution to short stream stretches in the Wabash River sub-basin. There are three generating plants in the area, two of which are on the Wabash River near the route at Logansport and Peru. At these two towns, water temperatures have been recorded slightly above the allowable State maximum of 90 degrees F. Both high water temperatures and organic pollutants can lead to a reduction of dissolved oxygen concentrations. In Huntington and Logansport the dissolved oxygen levels have periodically dropped to a 3.0 mg/l. The waters of the Wabash and Salmonie Rivers where they are crossed by the route may be degraded from municipal organic wastes and other wastes discharged several miles upstream from the crossing sites.

In Ohio the Muskingum River and Ohio River Main Stem watersheds suffer from agricultural pollution problems. Water quality problems resulting from industrial and municipal discharges are also present in some areas. A major pollution problem in the unglaciated section is associated with acid mine drainage, which is extremely toxic to aquatic biota.

In West Virginia and Pennsylvania surface water varies in quality although a relatively high degree of mineralization is a common characteristic. Sulfate is a dominant ion particularly in the small streams tributary to the main rivers in the vicinity of the proposed route. Significant bicarbonate concentrations west of the Monongahela River were found in a recent stream-quality reconnaissance.

In the Ohio River Main Stream watershed stream water quality has been degraded by thermal pollution, industrial inorganic discharges, acid mine drainage, and organic waste discharges from municipal sewage treatment plants. The major single source of organic waste discharges in this area is the Allegheny County Sanitary Authority, whose treatment plant's effluent is discharged into the Ohio River at a point just below the confluence of the Allegheny and Monongahela Rivers. The effluent from treatment plants in small communities has also resulted in the degradation of receiving streams.

Thermal power plants are major sources of heat release to the main stem of the Ohio River. Heated effluents have resulted in deleteriously high water temperatures in Hancock, Brooke, Marshall, Wetzel, Pleasants and Wood Counties in West Virginia. Inorganic discharges from the basic steel and metal finishing industries in this region include iron, phenols and plating wastes.

Groundwater

The quality of groundwater is generally evaluated on the basis of its chemical properties. This is determined to a large degree by the soluble materials present in the aquifer which holds or carries the water. Subsurface water quality may also be affected by toxic materials filtering down from surface sources. The amount of dissolved solids present is the primary criteria for determining groundwater quality and is used below to discuss the quality of groundwater along the proposed route.

In Montana, water from the oldest of the shallow bedrock aquifers (Judith River Formation) is used for a few domestic and stock wells. The quality of water is poor, however, and wells are drilled to this aquifer only as a last resort. Dissolved solids are usually greater than 1,500 mg/l and the principal constituents are sodium and bicarbonate. Other bedrock aquifers (Fox Hills Sandstone, Hell Creek and Fort Union Formations) are tapped by more wells than is the Judith River Formation, but these aquifers, too, contain water of marginal quality for domestic or stock use. Dissolved solids are usually 1,000 mg/l or greater, the principal constituents being sodium, calcium, magnesium, bicarbonate and sulfate.

The Flaxville gravel contains water of relatively good quality; however, the formation is limited in extent and few wells have been drilled into it.

The quality of water in the unconsolidated deposits ranges widely. The best quality water is found in relatively thick alluvial or outwash deposits where dissolved solids range from 500 mg/l to 2,000 mg/l. Principal constituents are calcium, magnesium and sulfate. Water from the glacial till contains from 5,000 mg/l to 50,000 mg/l and dissolved solids, averages about 20,000 mg/l. The water contains measurable amounts of many elements but the principal constituents are calcium, magnesium, sodium, bicarbonate, nitrate, sulfate and chloride. Trace elements such as lead, zinc, tin and selenium appear in measurable amounts.

In North Dakota the water in the Fox Hills and Hell Creek aquifers generally is a soft, sodium-bicarbonate type with a dissolved-solids content that ranges from 1,200 to 2,000 mg/l. The pH generally ranges from 7.5 to 8.6. East of the downstream crossing the water in Fox Hills aquifer generally is a somewhat non-acidic soft, sodium-bicarbonate type with a dissolved-solids content that ranges from 183 to 1,500 mg/l. However, either calcium or sulfate may be the dominant cation and anion locally. Also, where there is at least 70 feet of glacial drift overlying the Fox Hills aquifer, the dissolved-solids content locally may be as high as 3,660 mg/l.

Analyses of water from the drift aquifers show a wide range of water quality. The water generally is hard to very hard, and of either a calcium-bicarbonate or calcium-sulfate type. Locally, however, sodium or magnesium may be present in significant quantities, and either may be the dominant cation.

Generally, the best quality water is in surficial outwash deposits that are in the topographically higher areas or have sufficient discharge for adequate flushing action to take place. Water from these ideally situated aquifers generally contains less than 1,000 mg/l dissolved-solids and commonly less than 500 mg/l. The poorest quality water generally is in small till-enclosed sand and gravel deposits, or in surface outwash deposits in topographically low areas with high water tables where much of the discharge is through evaporation and transpiration. Locally some of the small aquifers, which are scattered across the area, contain water with concentrations of dissolved solids in excess of 5,000 mg/l.

The quality of water in the partly buried or buried-valley aquifers is extremely varied from place to place. Most of these aquifers have water with dissolved-solids concentrations that generally range from about 400 to 2,500 mg/l.

In South Dakota the range in chemical quality of water within many of the individual aquifers in the State is greater than the range between aquifers. The water from glacial drift probably has a greater range in quality than has the water from any of the other major aquifers. For example, the specific conductance, a measure of the total dissolved solids, of water from the glacial aquifers in Edmunds, McPherson and Faulk Counties ranges from about 400 to 4,000 micromhos per centimeter and averages about 1,800. Hardness ranges from about 36 to 2,300 per litre. In Brown County specific conductance ranges from about 250 to 5,900 micromhos per centimeter, and hardness from 80 to 3,300 per litre. Quality variations in individual aquifers are caused by local differences in factors such as rate of recharge, chemical and physical properties of the materials that compose the aquifer, and the nature of the material through which water infiltrates to the aquifer.

In Minnesota the dissolved solids in aquifers (less than 100 feet deep) in surficial materials depend on minerals composing the glacial sediments, groundwater movement and leaching of soluble minerals. End moraines have quantities of dissolved solids (1,000 mg/l and greater) that are of calcium-magnesium-sulfate type. Water from deeper wells which terminate in sand and gravel and in ground moraine deposits are generally of calcium-magnesium-bicarbonate type. Dissolved solids are usually less than 700 mg/l in shallow wells.

In the shale-bedrock aquifer, the water is highly mineralized. Because of the high concentration of dissolved solids (iron sulfate and chloride) this aquifer is used only when alternative sources of groundwater are not available. The older (Devonian, St. Peter, Prairie du Chien-Jordan and Franconia-Galesville) aquifers contain water of good quality but with varying amounts of hardness. The Prairie du Chien-Jordan and Franconia-Galesville aquifers yield water with moderate amounts of iron. The Mount-Simon-Hinckley aquifer contains water of good quality and normally softer than that in the Prairie du Chien-Jordan aquifer, but it is too deep for general use in the southwestern part of the state.

In Iowa the quality of groundwater in all three bedrock aquifers is good to excellent. Water from the youngest aquifer has the following characteristics: dissolved solids range from 250 to 700 mg/l, but are generally less than 500 mg/l; hardness ranges from 250 to 500 mg/l; pH is generally between 7.2 and 7.8; nitrate concentrations are generally less than 10 mg/l; fluoride concentrations are generally less than 1.5 mg/l; and iron content ranges from less than 0.3 to over 8 mg/l, but generally is less than 1 mg/l. Water from the alluvium and drift generally contains less than 500 mg/l dissolved solids and the iron concentration ranges up to 13 mg/l.

In Illinois, water from all bedrock aquifers is hard and the lowest aquifer is highly mineralized. Water from the Siluro-Devonian aquifer is very hard with dissolved-solids concentrations in excess of 500 mg/l. Water from the Cambro-Ordovician aquifer is not as hard as that from the Siluro-Devonian aquifer but still requires water softening for most uses; water quality decreases with depth. The Mount Simon aquifer has fairly good quality in the upper 100 feet but hardness and mineralization increase with depth.

More than 40 percent of the Illinois public groundwater supplies exceed 500 ppm in total dissolved minerals. No public groundwater supply contains less than 150 ppm minerals, as can be seen from the statistical data on mineralization for 770 public supplies given below.

Total Dissolved Minerals

Concentration (ppm) greater than	Number of supplies	Percent of total supplies
2,000	10	1.3
1,500	31	4.0
1,000	73	9.5
750	130	16.9
500	325	42.3
400	497	64.7
300	703	91.4
200	766	99.5
150	770	100.0

In Indiana the natural groundwater quality throughout the state is generally suitable for most domestic requirements. The water quality of both the consolidated and unconsolidated aquifers along the route is in the range of 100 to 800 ppm of total dissolved solids.

In Ohio the mantle of glacial deposits overlays bedrock which contains several aquifers that differ in geologic age, depth and quality of water. The water is likely to be contaminated with acid from coal-bearing formations. The quality of water produced from the surficial aquifers is commonly of better quality than that derived from bedrock aquifers, but at some localities thay are about equally hard or mineralized. The best

Devonian aquifers are the Columbus and Delaware Limestones west of the Scioto River. These are highly permeable strata and are prone to contamination by surface water. Contamination may already have occurred during petroleum exploration. Formations of Silurian age contain water, but it is commonly salty; some of this reaches the adjacent Scioto and Muskingum Rivers. Better quality groundwater in aquifers of Silurian age is available from limestones and dolomitic beds in western Ohio. These have not been extensively exploited because of the availability of groundwater from glacial deposits. The water from these beds is hard chemically, and commonly contains elevated amounts of minerals including sulfur.

Groundwater in western Pennsylvania is variable in quality, particularly water from the bedrock formations. Naturally high iron concentrations are common in several Permian and Pennsylvanian formations. Brine and acid drainage are encountered in the oil and gas fields and coal mining areas. Acidic waters are especially prevalent in the Monongahela headwaters and in parts of the Allegheny drainage sub-basin, where the pH may be as low as 4.

Uses of Groundwater

Figure 2.1.3.5-24 shows the Northern Border Pipeline route as it relates to withdrawal and use of groundwater. The solid circles represent the annual withdrawal of 100 million cubic meters (81,000 acrefeet or 72 million gallons per day) from wells. The major withdrawals near the route occur east of the Mississippi River. Large concentrated uses of that water occur near Peoria, Illinois where industrial activities use 500 million cubic meters per year. The remainder of the withdrawals are widely scattered and are discussed separately below.

In Montana, water from deep aquifers is not used. The shallow aquifers are used for domestic and stock purposes. Wells generally yield less than 50 gallons per minute and there are probably fewer than two wells per square mile.

In North Dakota, bedrock aquifers are used principally for domestic stock and municipal purposes. There is some use for irrigation, gravel washing and for sanitation purposes in small dairies.

In South Dakota, both drift and bedrock aquifers are used for domestic, stock, irrigation, municipal and industrial purposes. Along the route, groundwater is about 76 percent of all the water used. Irrigation used 19 percent of the groundwater and municipal and industrial uses are 33 percent of the groundwater.

In Minnesota, the primary uses of groundwater are for domestic, agricultural and municipal purposes.

In Iowa, the aquifers in the Cedar and Wapsipinicon River Basins are used for domestic, agricultural, municipal and industrial purposes. Both Waterloo (76,000 pop.) and Cedar Falls (33,000 pop.) withdraw large quantities. Industries and commercial establishments in Waterloo and Cedar Rapids, two of the largest industrial centers in the State, withdraw many millions of gallons per day, particularly during the summer. Most rural domestic and livestock supplies in the basins also are produced from this aquifer. The alluvium is tapped by the City of Cedar Rapids (population about 110,000) for municipal supply and by some industries in Waterloo and Cedar Rapids. Irrigation supplies are withdrawn at a few localities. The drift, although widespread, is at best a minor aquifer. The water-bearing sands and gravels in the drift are too discontinuous and sparse to be of

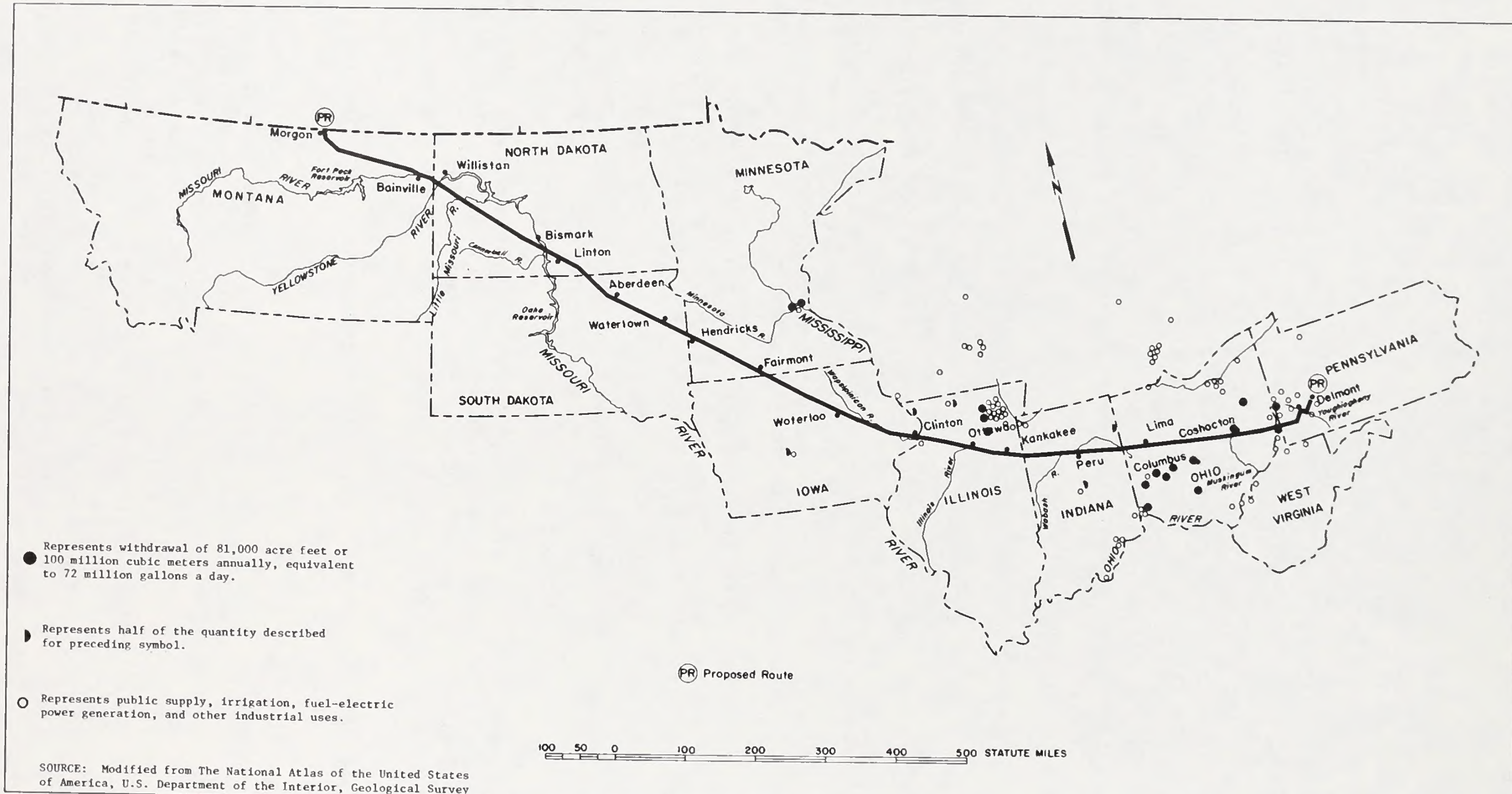


Figure 2.1.3.5-24 Groundwater withdrawal and use

significance. A limited number of farms obtain their supplies from the drift.

In Illinois, the groundwater is extensively used for domestic, agricultural, municipal, industrial and commercial purposes, the largest use near the pipeline being the industrial use near Peoria.

In Indiana, much use of groundwater occurs. Glacial deposits, as well as bedrock aquifers, are capable of yielding more than 100 gallons per minute. Buried bedrock valleys along the Wabash yield up to 800 gpm and are used for domestic, agricultural, municipal, commercial and industrial purposes.

In Ohio, there is extensive use of groundwater for all purposes. Yields over 100 gallons per minute are common and in glacial lake clay and till deposits they are on the order of 20 gallons per minute.

In West Virginia and Pennsylvania, groundwater from shallow aquifers is used more extensively than deep aquifers. Rates up to 600 gallons per minute are possible. The water is used for all purposes.

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2.1.3.6 Vegetation

The proposed pipeline will cross natural plant communities along about 357 miles of its 1,600 mile length. The following table lists these communities and shows their linear extent along the pipeline route:

Existing Natural Plant Communities Crossed by Proposed Pipeline and Extent in Miles

Mixed-Grass Prairie	253 miles
Tall-Grass Prairie	3 miles
Oak-Hickory Forest	5 miles
Beech-Maple Forest	12 miles
Appalachian Oak Forest	59 miles
Waterway and Floodplain Hardwoods	25 miles
Total	357 miles

Significant areas of natural vegetation will be traversed in the western range lands of Montana and the Dakotas and in the eastern deciduous forest region of eastern Ohio, West Virginia, and Pennsylvania. Approximately 25 miles of flood plain and waterway hardwoods will be crossed at various locations along the route.

Major Plant Formations, Associations and Communities

Units of vegetation are generally classified in order of magnitude as plant formations, plant associations and component plant communities. The vegetation units along the proposed pipeline route are illustrated in Figures 2.1.3.6-1 and 2.

The proposed pipeline involves two major plant formations: the Prairie-Grasslands and the Deciduous Forests. There are six major associations and numerous component communities within the two formations.

The natural vegetation is determined by a climate that gradually changes from semi-arid in the Mixed-Grass Prairie to humid in the Eastern Broadleaf Forest. This gradual climatic change from west to east causes the Mixed-Grass Prairie in the West (where average annual precipitation is less than 20 inches per year), a mixture of Tall-Grass Prairie and forests in the Midwest (where precipitation is higher than 32 inches per year) and Deciduous Broadleaf Forests in the East (where precipitation normally ranges between 36 and 48 inches per year). See Figure 2.1.3.6-1.

The general complexity of the natural vegetation patterns is attributed to the effect of north-south gradients in temperature and precipitation and to differences in physiographic position and soils. The effects of climate and vegetation combine with other factors to produce soils that differ in fertility. Soil fertility has been the major factor in the development of these regions and the subsequent modification of the natural systems.

In this section plant species are referred to by common name and in most descriptions of component plant communities only the dominant or significant sub-dominant plants are discussed.

The Mixed-Grass Prairie (Missouri River Basin)

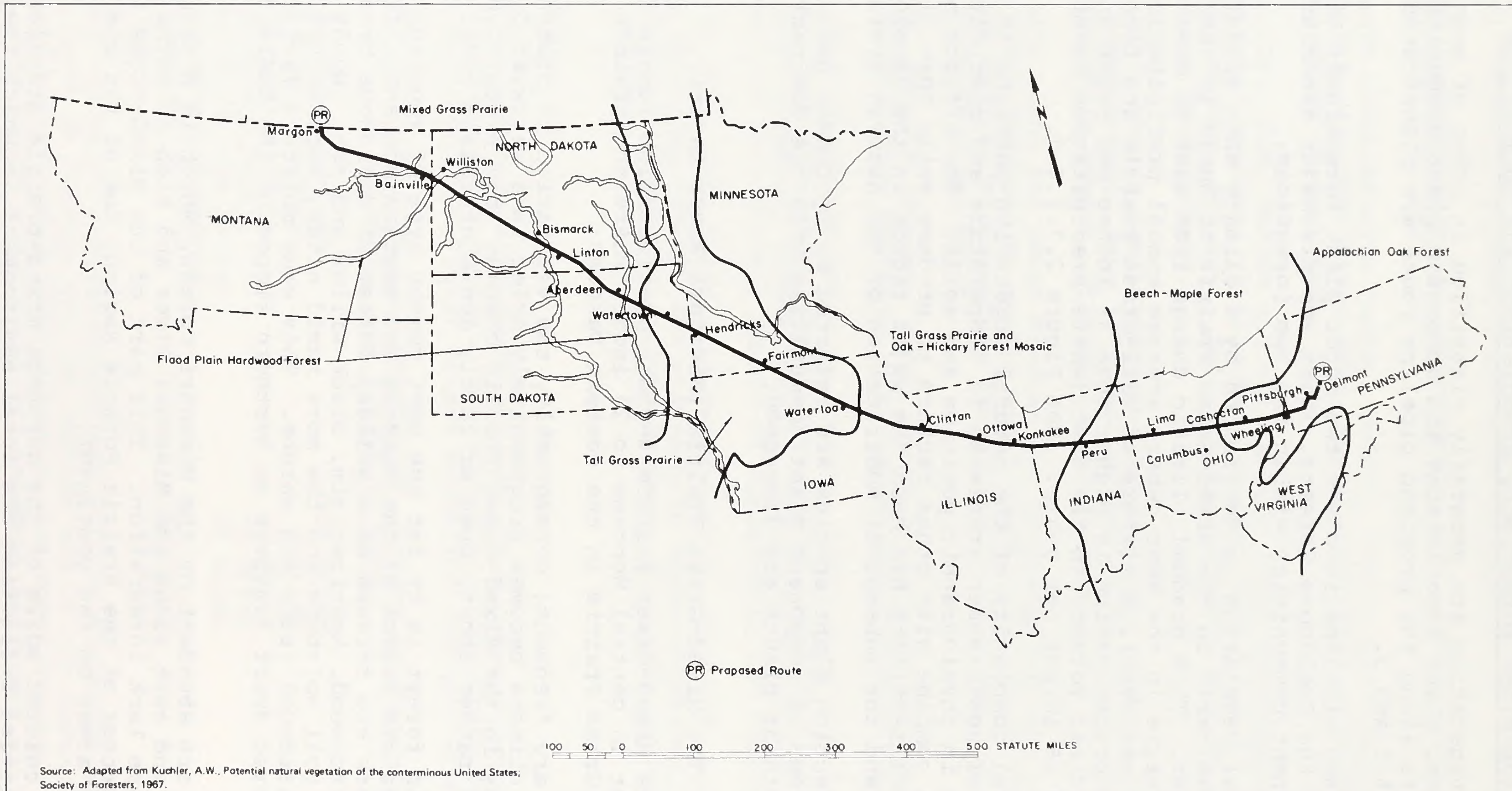
Across the Mixed-Grass Prairie Region, precipitation ranges from 10 inches per year in central Montana to 20 inches where the prairie grades into the Tall-Grass Prairie in the eastern Dakotas.

Droughts are frequent; consequently, the vegetation is drought resistant. As the climate becomes progressively drier in a westward direction, the physiognomy in the Mixed-Grass Prairie changes from a dense, mediumtall grassland to a rather short, open or fairly dense grassland cover.

Floodplain forest is by far the most common type of woodland in the Mixed-Grass Prairie Region of the Dakotas and eastern Montana. It occurs along the rivers and streams as a gallery forest of deciduous broadleafed trees like cottonwood, American elm, black willow and ash. Woody growth is a function of soil moisture and the more humid sites, such as swales, often support some hardwood trees and shrubs. This same moisture factor accounts for the scattered dwarf junipers on northern slopes of the badlands and in deep coulees.

Wetlands are abundant on the Missouri Coteau, which is a terminal moraine north and east along the Missouri River and rich in potholes where drainage systems lack integration. This part of the Mixed-Grass Prairie is the southern sector of the Prairie Pothole Region, one of the most important duck producing areas on the continent.

The dark colored soils of the northern mixed-prairie grasslands have fertility qualities reflecting the total environment in which they were



Source: Adapted from Kuchler, A.W., Potential natural vegetation of the conterminous United States; Society of Foresters, 1967.

Figure 2.1.3.6-1 Potential natural vegetation

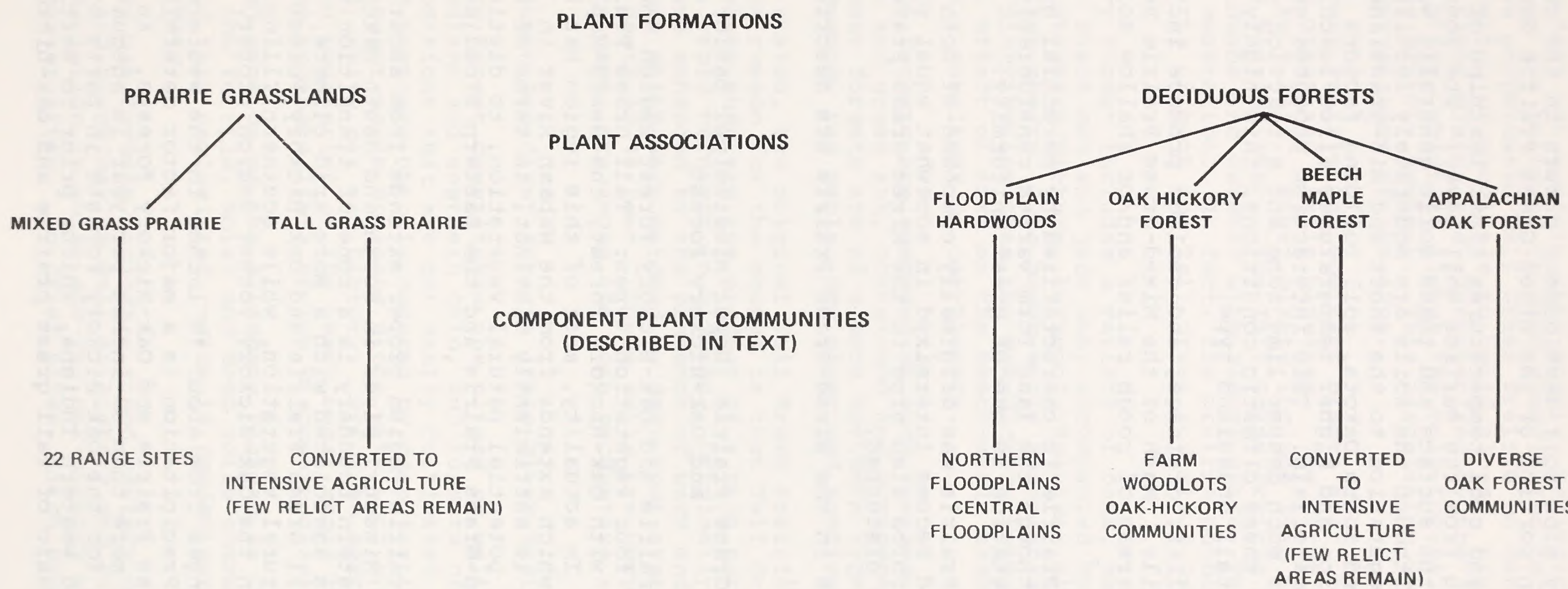


Figure 2.1.3.6-2 Vegetation units along the proposed route

developed. Relatively slow soil development occurs in the cool semi-arid climate of the western portion of the Mixed-Grass Prairie Region.

Scanty rainfall and cool temperatures limit leaching of the soluble products of weathering from the surface soil layer. The zone of lime accumulation is near the surface and these soils generally will have an aklaline reaction. Although the soils are moderately fertile, the climatic conditions restrict vegetation to the short and mid-grassland types. Moving eastward into North and South Dakota, soil building factors intensify. Additional precipitation and higher temperatures allow leaching to extend into the soil parent materials. This interaction produces soils possessing a very dark surface, a much deeper lime zone and a reaction of neutral to slightly acid. Under these climatic conditions, this highly fertile soil can support a mid to tall grassland type.

Variations in relief, drainage, and geology produce inclusions of shallow or akaline soils. Much of the Mixed-Grass Prairie Region produces small grains or hay; areas of rough relief and/or shallow soil remain as rangeland.

The Mixed-Grass Prairie is characterized by perennial grass and grasslike sedges. Although the land form varies considerably, the appearance of the vegetation is one of great uniformity.

The Mixed-Grass Prairie was originally composed of both mid-grasses and short-grasses that had become intermixed in somewhat equal proportions. A variety of perennial forbs also grow in the Mixed-Grass Prairie but seldom dominate except where disturbed.

Plant communities in the Mixed-Grass Prairie are described in detail later in this section.

Tall Grass Prairie (Upper Mississippi Basin) and Oak-Hickory Forest

The Tall Grass Prairie and Oak-Hickory Forest Region consists of a conceptual pattern of four vegetation types: Tall Grass Prairie, a mosaic of tall grass prairie with Oak-Hickory Forest, the Beech-Maple forest and flood plain forests. In actuality, most of this region has been combined into a single region which extends from the Wabash River in Indiana into the Dakotas. This region is sufficiently distinct, in terms of both present land use patterns and potential natural vegetation, to distinguish it from the more western Mixed-Grass Prairie and the Eastern Broadleaf Forest Regions.

The Tall Grass Prairie Region proper extends from about 98 degrees West Latitude, east of the Missouri River in North and South Dakota, to north-central Iowa. Its western boundary is a zone of transition with the Mixed-Grass Prairie which is associated with a more arid climate. In northeastern Iowa and Illinois, Tall Grass Prairie and Oak-Hickory Forest alternate as types of potential natural vegetation, while southern Illinois and southern Indiana are located in the Oak-Hickory Forest Region proper.

Precipitation ranges from about 18 inches in the western portion to 38 inches in the east. Precipitation is a major factor determining the locations of Tall Grass Prairie and Oak-Hickory Forests. An annual precipitation rate of more than 30 inches per year is adequate for forest growth; this accounts for the Oak-Hickory Forests in parts of southern Iowa, southern Illinois, and western Indiana, which, prior to settlement, were characterized by a mosaic of tall grass prairie and oak-hickory forest.

Precipitation alone does not explain this mosaic; periodic fires in a relatively dry region are believed to have contributed to the mosaic. The theory is that fires perpetuated Tall Grass Prairie on certain sites and limited the distribution of woodlands to humid slopes, higher elevations and flood plains. The flood plains are characterized by the distinct flood plain forest association, which is almost the only forest present in the Tall and Mixed-Grass Prairie Regions. This association extends as narrow belts along the major streams of the area.

In the Tall Grass Prairie the dominant plants are: big bluestem, switchgrass, Indian grass and little bluestem. The first three species reach heights of 5 to 8 feet. Other plants include lead plant, goldenrod, field pussytoes and blazing star. The Tall Grass Prairie Region includes an abundance of wet sloughs and marshes with slough grass, rushes and sedges as the characteristic vegetation. In fact, the prairie pothole region occurs in the glaciated parts of both the Tall Grass and Mixed-Grass Prairie Regions.

The Oak-Hickory Forest includes a variety of oaks, such as bur oak, white oak, red oak, black oak and jack oak, accompanied by such species as butternut hickory, shagbark hickory, basswood, American elm, white ash, black walnut and black cherry. The beech-maple association, which is much more restricted in distribution than the Oak-Hickory Forest, occurs on drier sites. The general effect of fire on the beech-maple association is to develop or maintain a subclimax of oak-hickory.

The flood plain forests are composed of such species as silver maple, American elm, white and green ash, cottonwood and sycamore. In Minnesota and the Dakotas, these forests are of a more northern type, dominated by black willow, cottonwood, red maple, box elder and American elm.

As previously stated, the original Tall Grass Prairie has been changed by agriculture. The reason for the change is that Tall Grass Prairie soils are very fertile, since they are the product of a rich nutrient cycle that was maintained by a rapid turnover in biomass. Originally, the efficiency of this ecosystem was enhanced by the presence of warm and cool season grasses, with heights which were matched by deep root systems that enriched the soil down to a depth of 10 feet. These soils are very rich in organic matter and, with drainage, are among the most productive soils known to man.

Eastern Broadleaf Forests (Ohio River Basin)

The Oak-Hickory Forest constitutes the climax on welldrained sites in parts of western Indiana and southern Ohio, and forests of this type occur on physiographic positions that are not easily cultivated. However, most of central Indiana and northern Ohio is covered by deep fertile till on which American beech and sugar maple dominate along with such species as buckeye, white ash, basswood, white oak and hickory. Prior to settlement, the southern and eastern boundaries of the beech sugar maple type corresponded approximately to the southern limit of the Wisconsin glacial advance.

The unglaciated section of the Allegheny Plateau in Ohio and Pennsylvania lacks the fertile, moist and deep soils characteristic of the glaciated parts, and this unglaciated region is predominantly wooded with Appalachian oak forests.

The Appalachian oak forests include a mixed variety of oaks, such as white oak, red oak and black oak as well as hickory and black birch. The most widespread association is white oak-red oak-hickory with white oak predominating on moister sites. On drier sites, pitch pine and Virginia pine assume a dominant position next to dry-site oaks such as scarlet oak, black oak, chestnut oak and scrub oak. The climax tends to develop toward the chestnut oak association.

On moist sites, the mixed oak forests are displaced by a mixed mesophytic forest of such a diverse composition that no two or three species assume a dominant position. While prevalent along the west side of the Allegheny Plateau in southeastern Ohio, mixed mesophytic stands occur throughout the Plateau in hollows and coves with deep soils and high available moisture. In addition to the oaks, characteristic species are yellow poplar, white ash and sugar maple.

The major drainages in the Broadleaf Forest Region are generally bordered by a central flood plain forest association which is dominated by silver maple and American elm.

The wetlands of the deciduous forest region are of the swamp, bog and marsh type. The swamps are wooded with the black ash American-elm red maple association and such shrubs as alder, red-osier dogwood, willow and buttonbush. Marsh vegetation consists of sedges and grasses, while shrubs such as berry and leatherleaf occur on the bogs. Wetlands were extensive in northern Ohio and northern Indiana, particularly on the Lake Plain of northwestern Indiana; however, many of these wetland areas have been drained for agricultural purposes.

Component Plant Communities

As previously stated, there are many component plant communities within each vegetation association. While the Mixed-Grass Prairie is a large taxonomic unit with a uniform aspect of perennial mid and short-grasses, many variations of species composition and production potential occur because of local site conditions. These plant communities result primarily from variations in climatic factors, soils, topography and subsurface moisture conditions. The same situation occurs in the other vegetation associations through which the proposed pipeline passes. There are specific plant communities within the tall grass prairie and the various deciduous forest associations.

Since most of the natural plant communities through which the proposed pipeline passes occur in the mixed-grass prairie association and eastern deciduous forest, these communities will be described in more detail than others.

No attempt will be made to describe in detail the pre-existing plant communities of the Tall Grass Prairie or Beech-Maple Forest since these areas have been almost completely converted to intensive agriculture.

The classification of plant communities is arbitrary and depends on the individual or agency establishing the system. In this report the range and woodland site descriptions of the U.S. Soil Conservation Service were used, since they were available for the pipeline area. Additional range and woodland site description information is available from the appropriate U.S. Soil Conservation Service State Offices.

These descriptions describe potential or climax plant communities occurring under specific site conditions. They were developed primarily through the study of relict or near pristine areas where lack of abnormal disturbance has allowed the climax vegetation to develop.

Detailed surveys for plant communities occurring along the pipeline route are not generally available. However, the following descriptions will describe those plant communities likely to be encountered in each region through which the pipeline passes.

Montana, North Dakota, South Dakota

In the mixed-grass prairie association the pipeline route through Montana, North Dakota and South Dakota traverses a variety of distinctive plant communities.

The climax plant communities are a product of soils and climate in an area where climatic differences are comparatively moderate and soil and topographic differences are pronounced.

Precipitation varies from 10 inches in northern Montana to 20 inches in South Dakota with 70-80 percent occurring during the growing season.

Growing seasons vary from 100 to 150 days but along most of the route, the average growing season is between 110 to 130 days. Soils and topography appear to be the primary factors determining the species composition and productivity of plant communities. Other factors such as high water tables and overflow conditions are important on some sites.

The following described range sites are typical of those found along the mixed-grass prairie segment of the pipeline route. Minor variations in species composition will occur, with short and mid-grasses dominating the drier regions and tall grasses becoming more prominent as more favorable climatic conditions occur. Forage production increases notably on similar sites as precipitation and growing seasons increase.

Wetland Range Site Description

The characteristic vegetation of this site is dominated by plants which are adapted to very wet soil conditions but not so wet as to support marsh vegetation. The site supports a variety of tall and midgrasses, sedges and rushes. Dominant species are slough sedge, rivergrass, prairie cordgrass and slim sedge. Subdominant species are Baltic rush, common spikesedge, northern reedgrass, reed canarygrass and American mannagrass. Common forbs, such as long-rooted smartweed, curled dock, tall white aster and Rydberg's sunflower are about 5 percent of the total vegetative production.

Subirrigated Range Site Description

This range site has the potential to produce a luxuriant stand of tall prairie grasses. Big bluestem is the major dominant. Switchgrass, Indiangrass, Canada wildrye and prairie cordgrass are other tall grasses that occur on the site but in lesser amounts. Western wheatgrass and inland saltgrass occur in small amounts. Kentucky bluegrass is usually present as a part of the understory. Sedges and forbs occur in appreciable amounts. Trees and shrubs are never abundant though such shrubs as indigobush amorpha, a legume, may be conspicuous. Quite often this site is truly dominated by big bluestem which makes up 75 to 90 percent of the vegetation.

Wet Meadow Range Site Description

Sedges and tall grasses dominate the general aspect of this site which usually presents a lush meadow appearance. Dominant species are slim sedge, woolly sedge, fescue sedge, prairie cordgrass and northern reedgrass. Subdominant species are switchgrass, Baltic rush, fowl bluegrass and mat muhly. About 5 percent of the total vegetative production is made up of forbs.

Overflow Range Site Description

Both tall and medium grasses dominate the site in excellent condition. Dominant species are big bluestem, green needlegrass, western wheatgrass and needleandthread. Subdominant species are porcupinegrass, bearded wheatgrass, thickspike wheatgrass, Penn sedge, fescue sedge, little bluestem and Kentucky bluegrass.

Several forbs, such as Rydberg's sunflower, tall goldenrod and tall white aster make up about 10 percent of the total herbage production. Several woody plants are commonly found on the site, depending on its position in the landscape. Common woody plants, such as western snowberry, prairie rose, common chokecherry, buffaloberry and green ash, may compose about 5 percent of the total herbage production.

Saline Lowland Range Site Description

Salt-tolerant mid-grasses dominate this site. Dominant species are Nuttall alkaligrass, inland saltgrass, alkali cordgrass and salt-tolerant ecotypes of western wheatgrass and slender wheatgrass. Subdominant species are alkali muhly, foxtail barley, mat muhly and prairie bulrush. Forbs such as alkali plaintain, silverweed cinquefoil and Pursh seepweed make up about 10 percent of the total herbage production.

Closed Depression Range Site Description

Mid-grasses dominate the general appearance of this site. Dominant species are western wheatgrass and prairie cordgrass. Subdominant species are fowl bluegrass, foxtail barley, inland saltgrass and common spikesedge. Forb species, such as curled dock, poverty weed and smartweeds, will make up about 15 percent of the total herbage production. Minor amounts of annual forbs may also be present.

Thin Sands Range Site Description

Mid-grasses dominate the aspect of this site. Dominant species are prairie sandreed, needleandthread and sand dropseed. Subdominant species are blue grama, hairy grama, Penn sedge, threadleaf sedge and sand bluestem. Forbs make up about 10 percent of the total herbage production. Minor amounts of woody plants also occur on this site.

Shallow Range Site Description

A mixture of cool and warm-season mid-grasses dominate the general appearance of this site. Dominant species are western wheatgrass, needleandthread, little bluestem and prairie sandreed. Subdominant species are plains muhly, blue grama, sideoats grama, threadleaf sedge and Penn sedge. The percentage of wheatgrasses is usually somewhat greater on loamy soils versus sandy soils and amounts of prairie sandreed are greater on sandy soils versus loamy soils. About 10 percent of the total herbage production is from forbs and woody plants.

Clayey Range Site Description

Climax vegetation on this site is primarily a mixture of short and mid-grasses, sedges and forbs. Dominant species are western wheatgrass, green needlegrass and prairie junegrass. Subdominant species are sandberg bluegrass, plains reedgrass, blue grama and upland sedges. Common forbs are scarlet globemallow, prairie thermopsis and western yarrow. Only minor amounts of woody species are present.

Sands Range Site Description

Dominant grasses of the climax vegetation are prairie sandreed, needleandthread, sand bluestem, and little bluestem. Subdominant species are blue grama, prairie junegrass, sand dropseed, western wheatgrass, and upland sedges. Forb species make up about 10 percent of the total herbage production. Woody species, such as prairie rose, western snowberry and leadplant amorpha are in smaller amounts.

Sandy Range Site Description

The dominant grasses in the climax vegetation are needleandthread and prairie sandreed. Subdominant species are prairie junegrass, blue grama, western wheatgrass, green needlegrass and upland sedges. A number of early season forbs are usually present such as western yarrow, silverleaf scurfpea and shell-leaf penstemon. Woody plants such as western snowberry and leadplant amorpha, make up about 5 percent of the total herbage production.

Silty Range Site Description

Mid-grasses dominate the general appearance of this site. Dominant species are western wheatgrass, needleandthread, green needlegrass and blue grama. Subdominant species are prairie junegrass, Penn sedge, threadleaf sedge, needleleaf sedge and sandberg bluegrass. About 10 percent of the total vegetative production is from forbs. Minor amounts of woody species may also occur on the site.

Thin Upland Range Site Description

Climax plant cover is a mixture, characteristic of the transition between the true and mixed prairie. Little bluestem is of major importance. Other important decreasers are green needlegrass and plains muhly. Sideoats grama, western wheatgrass, needleandthread and blue grama are common increasers. Forbs, such as blacksamson and woody plants, such as leadplant and rose, are of common occurrence on this site.

Shallow to Gravel Range Site Description

Climax plant cover consists of a mixture of mid and short grasses. The mid-grasses dominate the site. Needleandthread is a major component. Blue and hairy grama and threadleaf sedge are important short growing plants. Forbs, such as blacksamson and shrubs are of considerable importance.

Claypan Range Site Description

The climax plant cover is a mixture of mid and short grasses with the mid-grasses dominant. Western wheatgrass is of major importance. The cool season grasses needleandthread and green needlegrass are usually present. Blue grama is the principal short grass. Woody plants are not significant.

Thin Claypan Range Site Description

The climax plant cover is a mixture of the mid and short grasses with the short grasses dominant. Western wheatgrass and blue grama are of major importance. Forbs are usually not significant. Pricklypear cactus occurs in small amounts.

Very Shallow Range Site Description

Climax plant cover consists of a mixture of mid and short grasses. Needleandthread is a major component. Blue and hairy grama and threadleaf sedge are important short growing plants. Forbs and woody plants are of considerable importance.

Dense Clay Range Site Description

Western wheatgrass is dominant, making up 60 percent of the total composition. Other species occurring in amounts up to 5 percent include green needlegrass, Sandbergs bluegrass, Nuttall saltbush, inland saltgrass, big sagebrush and a variety of forbs.

Saline Upland Range Site Description

Dominant species include Nuttall saltbush, western wheatgrass, alkali sacaton and Sandberg bluegrass. Other species occurring in amounts up to 5 percent each include plains reedgrass, greasewood and a variety of forbs.

Shallow Clay Range Site Description

Western wheatgrass commonly constitutes over 30 percent of the composition. Other prominent species occurring in amounts of 10-15 percent are bluebunch wheatgrass, plains muhly and various forbs. Minor species include green needlegrass, blue grama, plains reedgrass, Sandberg bluegrass and big sagebrush.

Thin Hilly Range Site

Bluebunch wheatgrass comprises about 40 percent of the composition. Western wheatgrass and needleandthread grass occur at about 20 percent each. Other species occurring in amounts up to 5 percent each include little bluestem, dry land sedges and various forbs.

Gravel Range Site Description

Needleandthread and western wheatgrass together comprise 50 percent of the composition. Plains muhly, blue grama and a variety of forbs and shrubs make up the remaining species composition.

Forage Production from Range Sites
of the Mixed Grass Prairie

Range Site	Annual Air Dry Forage Production Below Normal Yr (lbs/ac)	Normal Yr (lbs/ac)	Above Normal Yr (lbs/ac)
Wetland	4,600	5,200	5,800
Subirrigated	4,200	4,800	5,400
Wet Meadow	3,500	4,000	4,500
Overflow	2,300	2,600	2,900
Saline Lowland	2,150	2,500	2,850
Closed Depression	2,000	2,400	2,800
Thin Sands	1,300	1,500	1,700
Shallow	1,150	1,400	1,650
Clayey	1,500	1,800	2,100
Sands	1,800	2,150	2,500
Sandy	1,700	2,000	2,300
Silty	1,650	1,960	2,250
Thin Upland	2,000	2,300	2,700
Shallow to Gravel	1,500	2,000	2,300
Claypan	1,600	2,000	2,400
Thin Claypan	1,200	1,450	1,700
Very Shallow	900	1,300	1,700
Dense Clay	250	500	800
Saline Upland	150	250	350
Shallow Clay	400	650	900
Thin Hilly	500	750	1,000
Gravel	200	325	450

Northeast South Dakota and Southwest Minnesota

This is the area where zonation between the Mixed Grass Prairie and the Tall Grass Prairie is evident. The species composition of plant communities or range sites is very similar to that described for the Mixed Grass Prairie. Tall grass species tend to increase, but the major difference is an increase in forage production.

Forage Production of
Northeast South Dakota and Southwest Minnesota

Range Site	Annual Air Dry Forage Production Below Normal Yr lbs/ac	Normal Yr lbs/ac	Above Normal Yr lbs/ac
Wetland	6,000	6,500	7,500
Subirrigated	4,800	5,600	6,400
Over Flow	4,000	4,800	5,500
Saline Lowland	3,500	4,200	5,000
Sands	2,800	3,200	3,700
Sandy	2,800	3,300	3,800
Silty	3,200	3,600	4,300
Clayey	2,800	3,300	3,800
Thin Upland	2,600	3,100	3,800
Shallow to Gravel	2,000	2,600	3,200
Very Shallow	1,500	1,900	2,200
Clay Pan	2,200	2,600	3,000

Southwest Minnesota to Western Indiana

This is the area of the original Tall Grass Prairie. Unfortunately there is very little information available on the original plant communities since these prairies were converted to cornfields at a very early date.

Studies of the few remaining relict areas indicate that big and little bluestems and other tall grass species generally dominated. Wet areas were common with cattails, rushes, sedges and water tolerant grasses dominating.

Throughout the eastern portion of this area oak-hickory forests were interspersed with the prairie. The forests generally occurred in flood-plains and local areas of favorable moisture conditions. Some of these forests are still present along drainageways and as farm woodlots. Since this area is now completely devoted to intensive agriculture, there is no point in describing the plant communities that once existed.

Eastern Indiana--Central Ohio

The original plant communities in this area were deciduous hardwood forests dominated by beech and maple. Like the Tall Grass Prairie, this area was converted to agriculture in the early period of western expansion.

Today 90 percent of the area is in crop production. Only scattered woodlots are left of what was once an extensive forest area. Few, if any, of the woodlots are in climax condition. Woodland harvesting and grazing by livestock maintain these communities in a disclimax of oak and hickory. The greatest proportion of upland stands are usually classified as oak-hickory forests. Sugar maple and beech, which were among the dominant trees of the virgin forest, are much less prominent in the existing second growth woodlands. These are composed of such trees as white oak, red oak, black oak, bur oak, shagbark hickory, white ash, yellow poplar and basswood. In the bottomland hardwood forests, the amount of American elm has been declining steadily due to Dutch elm disease. The silver maple-elm and black ash-elm-red maple associations are still quite characteristic of the flood plains and low spots which have been drained for agriculture.

Eastern Ohio, West Virginia, Western Pennsylvania

Mixed oak forests predominate on the Allegheny Plateau and they blend into the northern hardwood forest types of northeastern Ohio, northern Pennsylvania and the more elevated portions of southwestern Pennsylvania. White oak-red oak-hickory is the most common forest type in the mixed-oak forests; however, there is considerable variation in composition with physiographic characteristics. For example, stands occurring on dry sandstone ridges and southern slopes are commonly composed of chestnut oak, scarlet oak, black oak, pitch pine and Virginia pine with an under stand of heath-like shrubs such as mountain laurel, blueberry and huckleberry. In many respects these stands are identical to the extensive northeastern oak-pine association located to the east of the Allegheny front in southwestern Pennsylvania. In contrast, mixed mesophytic forests are found in coves and other low areas with deep, moist soils. Species like Ohio buckeye, yellow-poplar and cucumber magnolia are characteristic components in addition to the oaks and the understory is often rich in wild flowers.

The silver maple-American elm type occurs on flood plain forests along the larger streams of the Plateau or on the Till Plain, but a characteristic component, cottonwood, becomes rare near the limit of its range in the more eastern part of the Deciduous Forest Region in Ohio. Hemlock, although associated more with northern hardwood than with mixed oak forests, is found in narrow drainages throughout eastern Ohio, West Virginia and southwestern Pennsylvania. Other natural stands of conifers are fairly scarce. Some white pine is found in association with the northern hardwood forest in northeastern Ohio, and pitch pine and Virginia pine sometimes form nearly pure stands as a subclimax type on extremely dry ridges in southeastern Ohio.

These woodlands represent a diversified and comparatively stable assortment of habitats and are the product of decades of natural succession with only limited interference by man. It would generally take more than a century to carry a stand through the pioneer stages and subclimax stages to a climax condition. This is rarely attained because of commercial logging. In Ohio for example, 56 percent of the commercial forest land is in the sapling stage due to abandonment. This has taken place during recent decades on marginal farmlands in the unglaciated regions because of such practices as high-grading or commercial clear-cutting which were formerly not applied on a sustained yield basis. Stands approaching virgin conditions are extremely rare throughout the region and worthy of preservation.

In general, the harvest of forest products is more important in the more wooded Allegheny section than in the woodlots of the Till Plain, and this can be attributed to differences in extent. On many rugged sites of the unglaciated Plateau, timber management is the only practical form of land use besides mining.

Human Influences on the Vegetation

While the previous section deals with potential vegetation, this section will deal with presently existing vegetation or the lack of it due to man's activities.

Prior to man's appearance on the scene, the entire 1,600 mile route of the proposed pipeline was covered by a pattern of natural plant communities. The magnitude of man's influence is apparent when we examine the present land use along the pipeline route. (See Figure 2.1.3.11-2.)

Only 357 miles or approximately 22 percent passes through existing natural plant communities. Of this, 256 miles is western rangeland, 73 miles surviving woodlots and 25 miles riparian plant communities along drainage bottoms.

Over 1,200 miles along the right-of-way is devoted to intensive agriculture. The remaining 32 miles provide permanent rights-of-way for roads, railroads, utility corridors, etc.

Even where natural plant communities exist, their present condition reflects man's use.

Northern Great Plains

Throughout Montana, North Dakota and South Dakota, the better rangelands along the pipeline route have been plowed and converted to dry cropland. The principal crop is spring wheat.

The spring wheat region is located to the north and east of the Missouri River and extends from the northeastern corner of Montana to the Corn Belt in the most eastern part of the Dakotas. Spring wheat is ideally suited for this region because it is well adapted to areas where precipitation amounts to less than 30 inches a year, and the cool climate produces a high quality kernel. Spring wheat farming involves summer fallowing and stripcropping so that about half the cultivated fields are seeded while the fallow areas store moisture needed to increase next year's yield.

Selective grazing on the rangelands for the past 50-75 years has resulted in changes in the vegetative composition of plant communities. Palatable plants such as the wheat grasses and needle grasses have decreased while less palatable plants such as sand dropseed, muhly and brush species have increased.

Corn Belt

The original vegetation pattern of the Tall Grass Prairie and Oak-Hickory Forest Region has been transformed completely by agricultural development. Farmlands cover over 95 percent of the entire area traversed by the pipeline in Minnesota, Iowa, Illinois, Indiana and western Ohio. The pipeline crosses the major part of the "Corn Belt" or "midland feed" agricultural region. The Corn Belt produces more than two-thirds of the corn, oats and soybeans in the United States and about one-third of all the livestock for the Nation. The high level of productivity has been attributed to very fertile soils, with good texture and moisture-holding capacity, a 140 to 180 day frost-free period, 22 to 30 inches of precipitation, of which more than half falls during the growing season and to a level topography. Corn planting begins early in May, and the plant requires about 90 to 120 days to mature. Corn is normally harvested for grain, but it may be grazed, hogged down or cut for silage and fodder. The crop is usually grown in rotation with soybeans, small grains or clover. A crop rotation of two-years of corn and one-year of soybeans is common. Small grains and red clover are often substituted for soybeans where slopes increase the probability of erosion.

Ideal conditions for corn are closely paralleled by those needed for soybean production, and as stated above, soybeans are commonly grown in rotation with corn. Traditionally, soybeans have been important as a nitrogen fixer since corn requires high amounts of this type of fertilizer.

In view of the enormous importance of agricultural production, little remains of the original vegetation patterns. The Tall Grass Prairie has almost completely disappeared, and native grassland communities are rare. The native grass species occur mixed with the introduced varieties, but they rarely occur in units recognizable as original habitat. The native grasses have maintained themselves somewhat better in low wet areas, but artificial drainage has also claimed most of these areas for agricultural production.

Woodlands have also been affected by the quest for fertile land. The high quality hardwoods, like black walnut, have been removed through high grading, and fires and overgrazing have curtailed the extent and quality of the remnant forests. Wildlife values, aesthetic values and recreation values are relatively low, not only because natural habitats are at a premium, but also because the type of agriculture amounts almost to a monoculture practiced with an intensity that leaves no room for marginal communities or activities.

Eastern Broadleaf Forests

The Eastern Broadleaf Forest Region is extremely variable in physiography and soils. These factors determine the extent of cropland and pasture lands in relation to woodland. All of the Eastern Broadleaf Forest Region was originally wooded, with the exception of scattered areas of prairie, wetlands, burned-over grass and land subjected to Indian agriculture. Subsequent settlement and development of the region had a profound effect on the original vegetation pattern, primarily through logging and agriculture.

Since glaciation has greatly affected present land-use and vegetation patterns, a distinction will be made between the glacial Till Plains of Indiana and west-central Ohio, and the unglaciated Allegheny Plateau of eastern Ohio and western Pennsylvania.

The fertile Till Plains and Lake Plains of Indiana and Ohio supported forests with high quality hardwood stands, and early exploitation consisted of "high-grading" for the best black walnut, yellow-poplar, sugar maple, white oak, red oak and black cherry. This was followed by a period of indiscriminate cutting and clear-cutting for agriculture. With good soils, a growing season of from 100 to 180 days, and from 35 to 40 inches of rainfall well distributed over the year, conditions are very favorable for agriculture, which has become increasingly intensive.

Early agricultural development affected mainly the wooded parts of the Till Plains, since scattered areas of bluestem prairie were poorly drained. With the development of tile drainage and recognition of the particularly high productivity of prairie and wetland soils, large scale drainage projects were initiated during the latter part of the 19th century. As a result, prairie relics survive today only in the form of a few nature preserves, and the extent of wetlands has been greatly reduced. In the northern half of Indiana and western Ohio, about 70 percent of the most productive agricultural land is tile-drained.

With the exception of a few areas marked by more rugged glacial topography on the Lake Plains, less than 10 percent of the Till and Lake Plains are wooded. These woodlands are restricted to scattered woodlots and to sites adjacent to major drainages like the Wabash River. Grazing has degraded woodlots throughout the Midwest, since it leads to a complete destruction of understory vegetation and soil compaction which eventually transforms woodlots into pastures with only a few clumps of trees. The high agricultural capability of soils on the Till Plains is matched by an equal potential for high quality hardwoods. As a result, logging is comparatively intensive in glaciated parts of Indiana and Ohio, even though the total yield is higher in unglaciated regions.

Exploitation has produced qualitative changes in the woodlands of the Till Plains. The originally extensive maple-beech associations have been displaced by oak-hickory associations that are less than 80 years old. Oak-hickory associations constitute about 60 percent of the total wooded area; and the balance consists of maple-beech-birch and bottom land associations.

Forestry plays an important role on the Allegheny Plateau and in unglaciated sections in the south of Indiana and Ohio. The proportion of the land in forest increases from 10 to 40 percent in eastern Ohio up to as much as 80 percent in parts of southern Indiana, southeastern Ohio, northern West Virginia and southwestern Pennsylvania. In these regions, agriculture is restricted by relief and shallow, rocky, acid and infertile soils. In fact, a large area of the Allegheny Plateau in north-central Pennsylvania and the ridges in the Ridge and Valley Province were never farmed. The extent of forest cover has been increasing due to natural succession, fire protection, artificial reforestation and abandonment of agricultural lands.

Historically, forestry began in this region with a long period of high-grading for white pine, hemlock and high quality hardwoods such as maple, yellow birch, black cherry, red and white oak and American chestnut. High-grading was followed by a period of widespread clear-cutting for charcoal, chemical wood, fuel wood and building materials. In some places, agricultural development took place simultaneously, but adverse terrain and soil characteristics often discouraged agricultural development, so that much of the land was abandoned after cutting. This resulted in an era of uncontrolled wildfires, until forest fire protection was initiated at the turn of the century. Regeneration during this century has produced an abundance of even-aged oak-hickory and mixed-oak forests that are presently in the pole and young sawtimber stages of development.

All of the associations characteristic of the original natural vegetation still occur on the plateau in eastern Ohio and western Pennsylvania. Forest type abundance has shifted in favor of the mixed-oak associations and at the expense of the originally more abundant white pine and hemlock component. Similarly, the northern hardwood type is now generally more restricted, since oak and red maple are vigorous sprouters and succession has not reached the point where the shade-tolerant American beech, sugar maple and hemlock are dominant species. Another change in composition has been the loss of the valuable American chestnut due to the chestnut blight fungus.

Agriculture on the unglaciated plateau differs profoundly from that of the Indiana-Ohio Till Plains. The former is a hay and dairy region, and hay is the most important crop because it can be grown on sites unsuitable for row crops. Corn is the most important row crop, but the acreage devoted to soybeans is insignificant in comparison to production on the Till Plains. In the place of soybeans, oats are the most frequently grown small grain. Truck farming and fruit production are relatively important on the western portion of the Allegheny Plateau.

Unregulated coal mining accounts for some of the most drastic and long term disturbances to the terrestrial environment of the Ohio River Basin. In 1965, the total acreage affected by coal mining amounted to 95,200 acres in southern Indiana, 212,800 acres in southeastern Ohio, 192,000 acres in West Virginia and 302,400 acres in Pennsylvania. Vegetation patterns have also been affected by quarrying for clay, limestone, sand and gravel, by oil and gas developments, power corridors, highways and by urban and industrial development.

Unique, Sensitive and/or Threatened Ecosystems

As mentioned in previous sections agricultural and forestry enterprises have practically eliminated many of the original plant associations along the pipeline route.

Where small relict areas have survived in the true prairie or beech-maple associations they might be considered unique areas worthy of preservation.

A 7,600-acre area of relict potholes and native prairie, The Ordway Memorial Prairie, was purchased by the Nature Conservancy in July, 1975. It is located 6 miles southwest of Leola, McPherson County, South Dakota. This tract was acquired for scientific and educational purposes. It has been set aside as a nature preserve and biological research station. The property is also dedicated as a State of South Dakota Bicentennial Project. The proposed pipeline route would traverse this relict area from the northwest to the southeast for an approximate distance of 4 miles.

The prairie pothole region of the Dakotas presents an ecosystem that is definitely unique, sensitive and probably threatened.

Glacial stagnation created a knob-and-kettle topography in the northern parts of the Mixed-Grass Prairie and Tall Grass Prairie Regions. The area is known as the prairie pothole region, and the pothole terrain is best developed on the Coteau du Missouri. The prairie pothole region has fertile soils and, depending on topography, its parts have been affected to different degrees by drainage for agricultural purposes.

Potholes are of all shapes and sizes; some cover 100 acres or more, but most potholes are less than 10 acres. These prairie potholes are considered as the backbone of duck production in North America. Given a few wet years, the prairie pothole region can pyramid duck populations to enormous proportions, but successive droughts will cause waterfowl populations to dwindle almost in direct proportion to the decline in available water.

Melting snow is the major source of water for nearly all prairie potholes and marshes. The potholes retain this water in places where drainage systems lack integration. The number of potholes per unit area varies from year to year depending on the moisture conditions.

The environment of the pothole is determined by such factors as the low permeability of the glacial till, inflow and outflow due to seepage, permanence and depth of the water and salinity. Water permanence is more important than water depth. These aspects vary by degrees from one pothole to another, and all potholes are different even if they are separated by only a few feet. These differences, in turn, provide for a wide range of habitat conditions that bestow the high waterfowl value upon the prairie pothole region. Waterfowl in all stages of life need many different types of vegetation. The kinds and amounts of pothole vegetation depend on depth, on permanence and on relative salinity of the pothole. This accounts for the distinction between three zones of emergent vegetation; wet meadow, shallow marsh and deep marsh, on the basis of increasing average depth of the water.

Wet-meadow zones are found in potholes, or portions thereof, that contain water of varying depths for only brief periods after spring snowmelt or immediately following heavy rainstorms. Shallow-marsh zones generally contain water through spring and early summer, but often are dry from midsummer through fall. In deep-marsh zones, water is ordinarily maintained throughout the spring and summer, frequently extending into fall and winter. The wet-meadow zones are dominated by fine-stemmed grasses or grasslike plants of relatively short stature and including species such as fowl bluegrass, northern reedgrass, wild barley, saltgrass and baltic rush. The shallow-marsh zones are dominated by medium-stemmed grasses and grass-like plants that are intermediate in height compared to plants of the wet-meadow and deep-marsh zones and include tall mannagrass, giant burreed, slough sedge, white-top, sloughgrass, common-spikerush and common three-square. Plants in the deep-marsh zones, coarser and taller than characteristic plants of other zones, commonly include cattails, river bulrush, hardstem bulrush and alkali bulrush. Certain plant species including giant burreed, broadleaf water-plantain, slender bulrush and variable-leaf pondweed are intolerant of saline conditions and restricted to the fresher potholes. A limited number of halophytic species including alkali grass, samphire, alkali bulrush and widgeon-grass occur commonly in saline potholes. Many species are found in brackish potholes, and a few, such as hardstem bulrush and sago pondweed, reach their best development under these intermediate conditions.

The wetland classification of the Fish and Wildlife Service is also based on the permanence and depth of the water supply. This classification consists of five types: intermittent wet areas, temporary marshes, shallow marshes, deep marshes and open water. The intermittent areas contain standing water for only a few days in a wet spring or after heavy rains and are generally not more than 20 inches deep at any time. They are always dry by June 1, and in many years they are dry throughout the season. Few have any effect on crop production except to delay seeding in years of heavy runoff. The vegetation of these low prairie areas is characterized by Kentucky bluegrass, slender wheatgrass, Canada anemone, wolfberry, tall goldenrod, smallflower aster and perennial ragweed. Temporary marshes are shallow depressions that usually contain water for a few weeks in the spring and after heavy rains. They may hold water through June and into July in years of heavy runoff. They may hold up to 24 inches of water in the spring in a year with heavy runoff or may be completely dry after an open winter. In dry or moderate years, crops may be raised in these areas, but in wet years they are flooded too long for cultivation. The primary vegetation of these temporary marshes or wet meadows consists of such species as false aster, fowl bluegrass, sedges, lowland white aster, northern redgrass, prairie cordgrass and baltic rush.

Shallow marshes commonly contain up to 30 inches of water in the spring and will hold water through July of a wet year. A few such areas hold no water in years with below-normal precipitation. They are all too wet to cultivate in years with near-normal runoff. Tall mannagrass, giant burreed, western water plantain, marsh smartweed, sloughgrass, slough sedge and white top are characteristic of the shallow marsh. Deep marshes hold up to 48 inches of water in a wet spring and often hold water all year. In dry years, most of them go dry sometime during the summer, but almost always have some water in the spring. Most are overgrown with emergent aquatic vegetation, including such plants as slender bulrush and alkali bulrush. Open water is a class of potholes containing up to 60 inches or more of water in a wet spring and able to hold at least 36 inches without overflowing either over land or into permeable underground channels. These areas may have a ring of marginal wetland vegetation.

Drainage for agricultural purposes constitutes the major problem in wetland and waterfowl management in the prairie pothole region. Drainage via open ditches has been widespread. The draining of a single pothole often causes the coincidental drainage of others. For example, the material excavated from a ditch designed to drain one pothole may be dumped into another. Tile drainage and terracing are other agricultural practices that will intercept runoff and cause the extinction of specific potholes or affect the water table sufficiently to degrade the wetland quality of the potholes in the area. Over the years, drainage has reduced the waterfowl production potential of the prairie pothole region in the United States from about 15 million to 5 million ducks per year.

The proposed pipeline route will traverse approximately 270 miles of prairie pothole country in North Dakota, South Dakota and Minnesota.

Drainage bottoms crossed by the pipeline might be classified as sensitive ecosystems. Generally they supply habitat conditions in limited amounts that are important to many wildlife species. Because of their location in flood plain areas they are subject to severe damage when disturbed.

Threatened and Endangered Species

The subject of threatened and endangered plant species has been addressed in recent years by various agencies, universities and other groups.

Lists of such plant species are available from many sources and generally include plants that occur very sparsely in natural communities or are found in the outer limits of the plant's range.

While many of these species are unique when found in a certain geographic area they may be quite common in other areas.

Dr. Theodore Van Bruggen of the University of South Dakota, for example, has compiled a list of 139 plant species considered rare or endangered in South Dakota. Included in the list are species such as lodgepole pine, limber pine and tufted hair grass which are rare in South Dakota but cover thousands of acres in Colorado and Wyoming.

The most comprehensive work on this subject is perhaps the Report on Endangered and Threatened Plant Species prepared by the Smithsonian Institution in 1974. The following list indicates the number of species by states considered threatened or endangered by the Smithsonian. The list includes only species considered endangered or threatened throughout their range.

State	Endangered Species	Threatened Species
Illinois	5	16
Indiana	1	9
Iowa	1	2
Minnesota	3	7
Montana	2	8
North Dakota	0	3
Ohio	3	12
Pennsylvania	4	11
South Dakota	0	1
West Virginia	0	11
Total	19	80

The occurrence of threatened or endangered plant species along the proposed route would be difficult to ascertain. It has been recognized in previous sections that certain plant communities considered unique, sensitive or threatened might occur on areas to be disturbed. These include relicts of the true prairie or beech-maple associations, the potholes and a community of arbor vitae and muhly along the Pecumsaugan Creek in Illinois. Endangered or threatened species are more likely to occur in unique or relict plant communities than where the species natural habitat is common.

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2.1.3.7 Wildlife

Dominant Wildlife Populations

Terrestrial

The Mixed Grass Prairie Region

Along the proposed route in Montana, the Dakotas, and Minnesota in the upper Missouri Basin where once the Mixed Grass Prairie flourished, we find today those animals that could adapt to the environmental changes induced by man.

Larger fauna include American pronghorn (antelope), mule and white-tailed deer, bighorn sheep and wild turkey.

Beaver, weasel, tree squirrels, jackrabbits, mink, muskrat, prairie dogs, porcupine, skunks, raccoon, red fox, bobcat, and small mammals such as mice, voles, ground squirrels, chipmunks and gophers are common. Cottontail rabbits, snowshoe hares, badgers, bats and coyotes are among the wildlife.

Ten species of hawks, six species of owls and one species of vulture nest, or are otherwise found, in the area along the proposed pipeline route. The nesting hawks include Coopers, sharp-shinned, marsh, ferruginous, red-tailed, Swainson's, and broad-winged plus the American kestrel, the pigeon hawk, and the prairie falcon. The owls that breed in the area are the screech, great-horned, long-eared, short-eared, burrowing, and barred species. The only vulture that breeds in the area is the turkey vulture.

Other birds include sandhill cranes, whooping cranes, osprey and bald and golden eagles. Only the latter still breeds in the pipeline area. The passerines include all the perching birds and this group worldwide contains over half the known birds. In the pipeline area scores of species of passerines breed and many other species utilize the area along the pipeline route during migration. These birds are listed in Section C by preferred habitat types.

The lakes and small wetlands form favorable habitat for some 22 migrant shore birds and provide breeding sites for ten other kinds of shore birds. The breeding species include the American avocet, piping plover, killdeer, long-billed curlew, marbled godwit, upland plover, spotted sandpiper, willet, Wilson's phalarope and the common snipe.

Other birds, which are also classed as game, include Hungarian (gray) partridge, sharp-tailed grouse, sage grouse, ring-necked pheasants and mourning dove.

Principal waterfowl species in the proximity of the proposed pipeline, either as migrants or breeding birds, include blue-winged teal, mallards, shovellers, pintails, gadwalls, coot and Canada geese. Other species are present but in somewhat fewer numbers. The glaciated part of the Mixed Grass Prairie Region includes the western part of the prairie pothole region, as shown in Figure 2.1.3.7-1. This area is the principal waterfowl production area in North America, and it compares favorably with the best on the continent, with breeding density of over 20 ducks per square mile as shown in Figure 2.1.3.7-2. Although the pothole region represents only 10 percent of the total water fowl production area in North America, it produces 50 percent of the duck crop in average years, and more in bumper years.

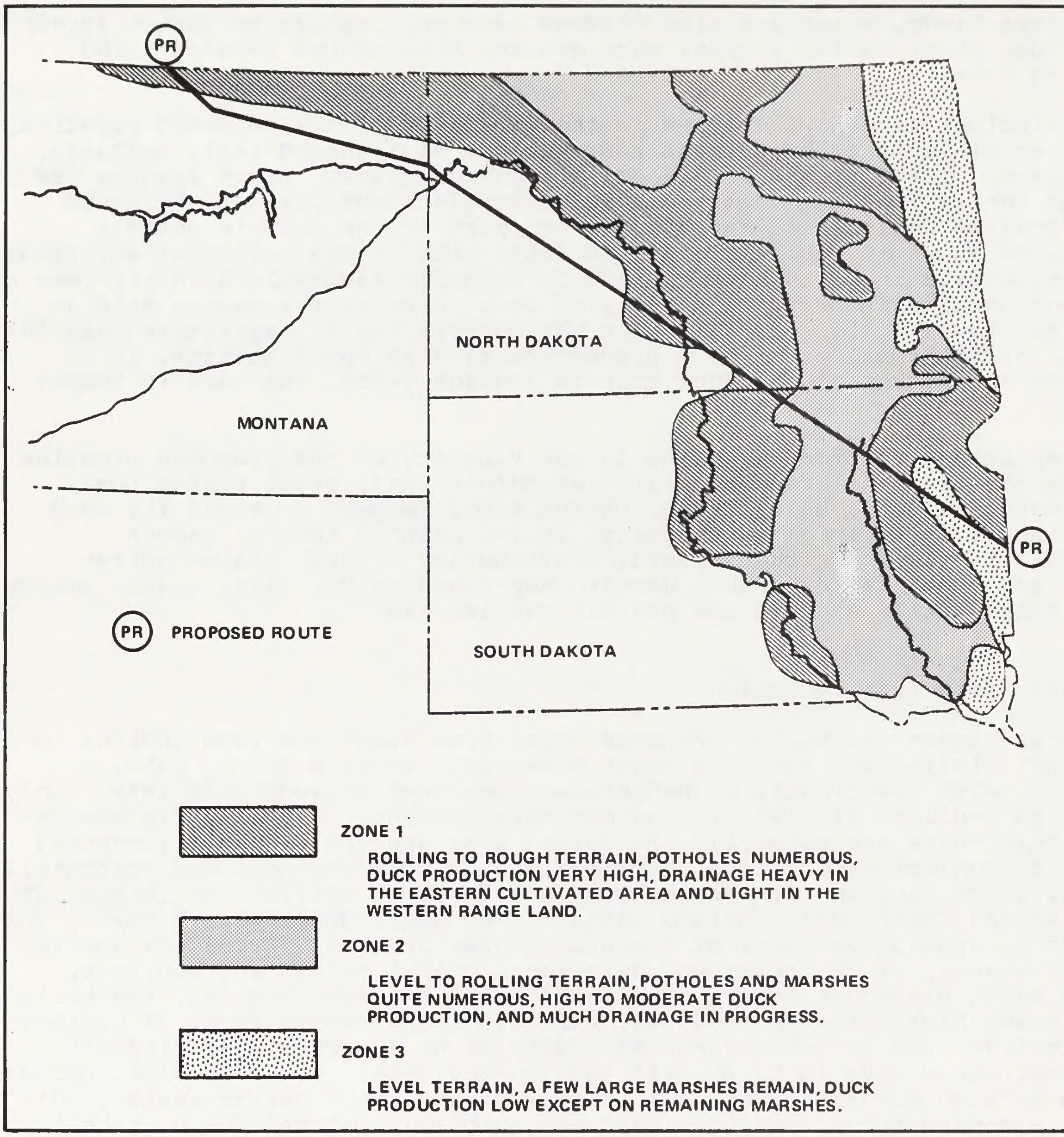
Amphibians recorded as being in the vicinity of the proposed pipeline include the tiger salamander, plains spadefoot toad, great plains toad, Rocky Mountain toad, Dakota toad, chorus frog, leopard frog and the wood frog. Reptiles include the snapping turtle, painted turtle, smooth softshell turtle, sagebrush lizard, short-horned lizard, plains garter snake, red-sided garter snake, western hog-nosed snake, racer snake, smooth green snake, bullsnake and the prairie rattlesnake.

The Tall Grass Prairie Region

This segment along the proposed route from Minnesota into Indiana in the upper Mississippi Basin is today primarily cropland (corn, oats, soybeans) with practically no hedgerows, fencerows or woodlands left. Only scattered woodlots are left throughout this segment. The wildlife species along this route are primarily the upland game species such as ringnecked pheasant, Hungarian partridge, bobwhite quail, mourning dove and cottontail rabbit, which live in farm areas. The species that utilize the infrequent woodlots and their edges include white-tailed deer, gray and red foxes, fox squirrels, opossum and most of the upland game species. Predatory species such as weasel, skunk, hawks and owls range over farmland and woodlots. Common avian predators of the area include the American kestrel, red-tailed hawk, marsh hawk, great horned owl, barred owl and common crow. A variety of songbirds such as meadowlark, many species of sparrows, kingbirds, cowbirds, etc., live in or migrate through the area. Numerous mice, shrews and voles also occur throughout this type of habitat. Garter snakes, bull snakes, leopard frogs, American toad and snapping, painted and softshell turtles all occur along the route.

The limited flood plain in this segment provides habitat for many of the above species and for otter, bobcat, raccoon, wood duck and great blue heron.

Very few wetlands are left in the tall grass prairie. Waterfowl migrating through the region benefit from Federal and state refuges, game management areas, the river networks and the few remaining ponds and marshes. The wooded swamps characterized by the upper Mississippi River National Wildlife Refuge and areas along the Wapsipinicon River in Iowa are valuable waterfowl areas and support a variety of animals and birds similar to those listed for the flood plains and wooded areas. Canada geese, blue-



Source: Adapted from Schrader, Th. A., *Waterfowl and the Potholes of the North Central States*, Yearbook of Agriculture, 1955, pp. 596-604.

Figure 2.1.3.7-1 Prairie pothole region of Montana, North Dakota, and South Dakota

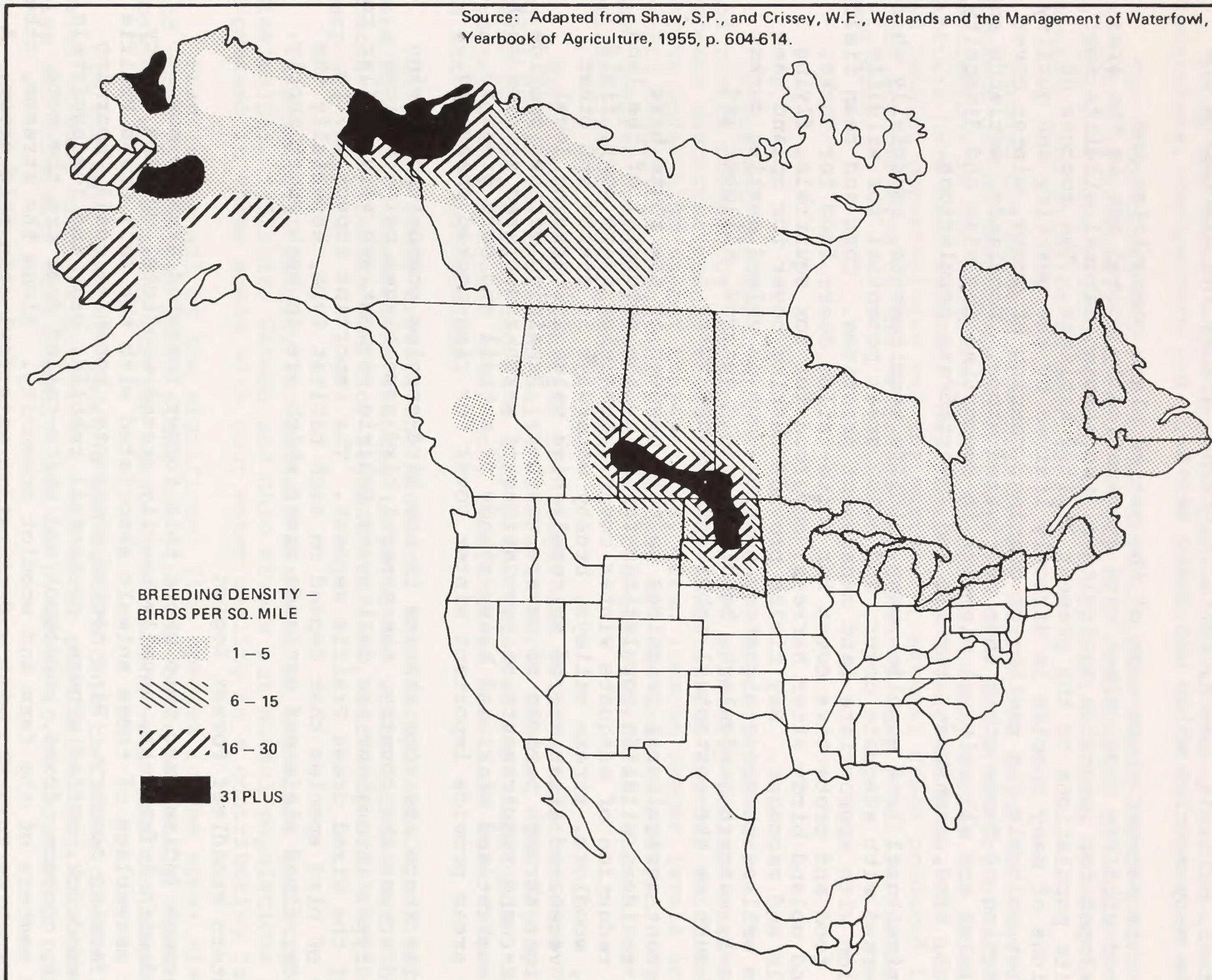


Figure 2.1.3.7-2 Distribution of North American waterfowl during the breeding season

winged teal, mallards, coots, rails, bitterns, grebes and blackbirds are among the many species which use these areas.

In this segment where most of the native plant communities and associated wildlife populations were systematically rooted out as the area was developed for intensive agriculture, the remnant natural wildlife must adjust its populations to the present limited habitats. The success of populations of many species is directly limited by the quantity and quality of habitat suitable for nesting or denning, rearing of young, winter cover or production of foods other than cultivated crops. Woodlands, wetlands and flood plains are all critical elements in supporting the size and diversity of mammal, bird, amphibian, reptile and invertebrate populations.

Agricultural land supplies many wildlife requirements, especially where interspersed with adequate cover, and holds great potential for wildlife production with appropriate land management practices. Corn and bean fields provide food and protective cover for white-tailed deer; food for ducks, geese and upland birds after harvest; and food for fox squirrels, flying squirrels and raccoons. Hay fields provide nesting cover for upland game birds as well as numerous migratory species such as upland nesting ducks, dickcissel, eastern meadowlark, bobolink, field sparrow, killdeer and mammals such as the cottontail rabbit and meadow vole.

Present agricultural practices in this segment of the route have reduced resident wildlife populations far below the potential of the land through reduction of adequate winter cover. Remaining fence rows, field borders, woodlots, stream valleys, brushy waterways in fields and other heavily vegetated areas are of extremely high value in carrying local populations through periods of severe weather. Remaining marshes provide the year-round requirements of populations of marsh-associated species such as the muskrat and mink, and heavy stands of cattail and cord grass in shallow areas provide important winter cover for ring-necked pheasants.

While there are some changes in the bird species composition moving eastward across the country, the general bird assemblages using various habitat types throughout the Tall Grass Prairie segment are very similar to those of the Mixed Grass Prairie segment. The important aspect is the variety of bird species that depend on each habitat type, especially the woodlands, flood plain and wetlands areas which are in such short supply.

The Eastern Broadleaf Forest Region

Through Indiana and Ohio where this former forested area is now cropland with infrequent, usually heavily grazed woodlots, we find a very similar assemblage of those animals associated with the Tall Grass Prairie Region farming country. Ring-necked pheasants, bobwhite quail, mourning doves, woodcock, ruffed grouse, cottontail rabbits, gray and fox squirrels, raccoons, opossum, foxes, woodchuck and white-tailed deer are the more obvious members of the farm and woodlot community. Along the streams, other species such as muskrat, mink and migrating waterfowl join this group. A variety of songbirds and various hawks use the woodlots and riparian areas as nesting, feeding and roosting areas. Grackles, redwinged blackbirds, purple finch, flycatchers, blue jays, cardinals, redtailed and red-shouldered hawks are among the many bird species of the region.

As the route progresses into West Virginia and Pennsylvania where it crosses rough, more heavily wooded country, we again find many of the same farm and woodland wildlife species, but with increased concentrations of forest species, such as ruffed grouse, fox and gray squirrels, white-tailed deer, woodcock and some black bear.

Along the forest edges are the purple finch, wrens, warblers and flycatchers; woodpeckers and jays are common in the mixed forest stands.

The flood plain habitat in the West Virginia-Pennsylvania portion of the route is extremely limited. Industrial, residential and agricultural developments have eliminated many of the original habitats of waterfowl, waterbird and wildlife in general.

Through the Eastern Broadleaf Forest Region are found the same critical elements of the environment that limit the size and diversity of wildlife populations in the other regions. Woodlands, brushy swales and flood plain habitats have been reduced. Here again, the cover, the edge, the nesting and denning opportunities and the variety of natural foods produced in these areas are the keys to the continued existence of many wildlife species in this area.

Aquatic

Throughout the upper Missouri and upper Mississippi basins the creeks and rivers crossed by the proposed route are primarily lowland warm water streams characterized by those fish and invertebrate species which can thrive under high summer temperatures, often lowered oxygen levels and turbid conditions resulting from natural and man-induced erosion. Typical game species include largemouth bass, bluegill, crappies, channel catfish, walleye, sauger and northern pike.

Excellent sport fisheries for sauger and walleye exist in Oahe Reservoir, and in the Heart and Knife Rivers in North Dakota. The Wapsipinicon River in Iowa, classified as a 5(d) River selected for study under the Federal Wild and Scenic River Act, furnishes an excellent warm water fishery in attractive surroundings.

Where the route crosses the Missouri, Mississippi and Ohio Rivers and Oahe Reservoir, commercial fishing is permitted under license and such species as smallmouth buffalo, bigmouth buffalo, suckers, black bullhead and carp are taken.

A commercial fishery for mussels was once an important industry in the Mississippi, Illinois, Wabash and Ohio Rivers but mussel populations are now depressed in these areas with poor water quality as a contributing factor.

Practically all of the significant fish species in the upper Missouri and upper Mississippi basin along the pipeline route are early summer spawners with bass and sunfish spawning extending well into the summer.

In the Ohio Basin in Indiana and Western Ohio the route crosses warm water streams with characteristic warm water populations but with population size and diversity occasionally limited by domestic or industrial pollution.

In the northeastern Ohio basin in eastern Ohio, West Virginia and Pennsylvania the streams are more of an upland type with gravel, rubble or rock bottoms; steeper gradients and swifter currents. Industrial wastes, thermal pollution and acid mine effluents severely limit aquatic populations in many streams in this region. Fish populations are again primarily of a warm water type with excellent smallmouth populations in some streams. Some limited commercial fishing takes place in the Ohio River for carp, buffalo, catfishes and other finfishes and for mussels, but water quality is a limiting factor. Table 2.1.3.7-1 lists the major fish species taken in sport and commercial fisheries and shows the time of year when they spawn, the type of egg deposition and types of habitat.

Table 2.1.3.7-1 Major sport and commercial fish species, spawning habits, and preferred habitats

Species of Fish	Spawning Season	Type of Egg Deposition	Suitable Habitat
Walleye	Spring	Eggs Scattered	Clear, Firm-Bottomed Lakes & Streams
Sauger	April-May	Eggs Scattered	Rivers & Lakes
Northern Pike	Spring (After Ice Breaks)	Eggs Scattered	Bays, Marshes, Pools & Slow-Moving Streams
Largemouth Bass	May-June	Nest Builder	Ponds, Lakes & Slow-Moving Streams
Smallmouth Bass	May-June	Nest Builder	Hard-Bottomed Streams with a Current
Spotted Bass	April-May	Nest Builder	Quiet Lowland Pools of Streams
Bluegill	May-June	Nest Builder	Lakes, Ponds, Streams & Reservoirs
Green Sunfish	May-July	Nest Builder	Lakes, Streams & Reservoirs
Pumpkinseed	June-July	Nest Builder	Clear, Warm Waters
Orangespotted Sunfish	June-July	Nest Builder	Lakes, Streams & Reservoirs
Rock Bass	May-June	Nest Builder	Rivers, Streams & Lakes
Black Crappie	Spring	Nest Builder	Lakes & Sluggish Streams
White Crappie	Spring	Nest Builder	Lakes
White Bass	Spring	Eggs Scattered	Rivers & Lakes
Yellow Perch	April-May	Scattered Ribbon-like Masses	Rivers & Impoundments
Black Bullhead	Spring	Nest Builder	Ponds, Creeks & Rivers
Brown Bullhead	April-May	Nest Builder	Ponds, Creeks & Rivers
Blue Catfish	May-July	Nest Builder	Large Rivers & Impoundments
Channel Catfish	April-August	Nest Builder	Lakes & Streams

(cont.)

Species of Fish	Spawning Season	Type of Egg Deposition	Suitable Habitat
Flathead Catfish	Spring	Nest Builder	Rivers
Shovelnose Sturgeon	Spring	Eggs Scattered	Large Streams & Rivers
Pallid Sturgeon	June-July	Eggs Adhesive	Turbid Rivers & Impoundments
Paddlefish	Spring	Eggs Scattered	Large, Sluggish Rivers
Muskellunge	April	Eggs Scattered	Lakes & Rivers
Rainbow Trout	Spring	Eggs Buried in Gravel	Cold, Clean Streams, Ponds & Lakes
Brown Trout	Fall	Eggs Buried in Gravel	Cold, Clean Streams, Ponds & Lakes
Brook Trout	Fall	Eggs Buried in Gravel	Cold, Clean Streams, Ponds & Lakes
Lake Trout	Fall	Eggs Scattered	Deep Impoundments
Smallmouth Buffalo	Spring	Eggs Scattered	Rivers & Lakes
Bigmouth Buffalo	Spring	Eggs Scattered	Rivers & Lakes
Carp	Spring	Eggs Scattered	All Waters
Goldeye	March-May	Eggs Scattered	Rivers & Lakes
Burbot	Winter	Eggs Scattered	Large Rivers & Lakes
Sucker epp.	Spring	Eggs Scattered	Most Waters
Longnose Gar	Spring	Eggs Scattered	Rivers & Lakes
Drum	Spring	Eggs Scattered	Streams & Lakes
Quillback	April-May	Eggs Scattered	Large & Medium Streams & Rivers
Chain Pickerel	Spring (After Ice Breaks)	Eggs Scattered	Streams, Ponds, & Lakes
Redfin Pickerel	Spring (After Ice Breaks)	Eggs Scattered	Streams, Ponds & Lakes

Along with the more obvious sport and commercial fish species, are a variety of minnows, darters and other forage species which add interest and variety to stream, river and lake aquatic populations.

Habitat Requirements and Limiting Factors of Major and/or Characteristic Species

Terrestrial Species

American pronghorn (antelope) prefer native prairie and open grassland during most of the year. Requirements during critical winter months include good woody browse on, or near, more rolling rougher terrain. Pronghorn densities vary, but a population level approaching 1.5 animals per square mile would be good in the pipeline area. Hunting and natural mortality combine to hold herds to a level compatible with other competing land uses. Mule and white-tailed deer share the habitat in the pipeline area although mule deer show a preference for the prairie butte and badlands terrain and white-tailed deer more frequently inhabit woody cover on either upland or along watercourses. Mule deer drop out of the picture as the route moves east into the tall grass prairie area. In some areas, intensive agricultural operations and overgrazing by domestic animals has reduced the carrying capacity for mule and white-tailed deer. California bighorn sheep were introduced in western North Dakota in 1956 to replace the extinct and native Audubon sheep. About 350 bighorns occupy portions of the badlands. Areas remote from human activity may be a necessity of this species. Certainly any unnecessary disturbance is unwise.

Prime beaver streams are considered as those having densities of one colony per 1.5 miles of stream. Further, a good beaver stream is one that has (1) a moderately slow current, (2) a permanent year around water supply, (3) a negligible amount of organic and inorganic pollutants, and (4) an abundance of any combination of cottonwood, aspen or willow. Weasels inhabit a variety of habitat but prefer thickets, brush fence rows and rock piles. Limiting factors for weasels, as for most smaller mammals, include loss to larger predators, accidental death, trapping and disease. Under normal circumstances their population maintains itself. Tree squirrels are residents of heavily wooded areas usually restricted to river bottoms in the pipeline vicinity until the route reaches the Appalachian oak forest region. Yearly populations depend largely on the extent of winter mortality and the success of the breeding season. Jackrabbits are residents of the open plains. Cover more than two feet high is generally avoided except during severe weather. Mink and muskrat populations are dependent on sloughs, rivers and streams. Trapping and natural mortality depress populations seasonally, but if habitat remains good, their populations rebound. In the past, prairie dogs were more abundant but control measures and land use changes have reduced their number considerably. Prairie dogs do not live where the grass grows so tall they cannot see over it. In close association with the prairie dog is the rare black-footed ferret. If the former disappears, the latter will almost certainly follow. The porcupine is common in the timbered areas. It has few natural enemies, although coyotes and bobcats can kill them. The main limiting factors would be land use changes that would remove timber or other woody growth. The skunk is ubiquitous in the pipeline area, preferring diversified habitat. Their populations can fluctuate greatly; apparently rabies is a main controlling factor as the skunk is a chief reservoir of the disease. Raccoons are generally found in the habitat associated with water--river drainages and sloughs. Drainage and removal of timbered habitat are among main controlling factors, as well as hunting and trapping. Red and gray foxes are adaptable to most habitat types but prefer rolling farmland with brush patches and sloughs. The principal factors suppressing their numbers are detrimental land use changes, trapping and hunting and, in some localities, the coyote. Bobcat are found throughout the pipeline area but prefer cover associated with river drainages. Trapping, hunting and some natural mortality are the main factors depressing their numbers. Small mammals including mice, voles, shrews, native and introduced rats, ground squirrels, chipmunks, and gophers inhabit the entire pipeline locality from the lowest to the highest elevations and from dry to wet sites. They are capable of surviving against a wide range of environmental restraints which are often effective barriers to larger and more specialized animals. They constitute a basic stage in the food chain. Cottontail rabbits require a year around supply of excellent food and cover. The ideal situation is a thicket adjacent to a picked cornfield. Yearly populations depend largely on the extent of winter mortality, breeding season success and availability of good cover and food. Snowshoe hares occur along the Missouri River bottoms in the vicinity of the pipeline. Populations are small and its basic requirement is woods and brush. Badgers prefer sandy type soils where digging is easier, but they are found throughout the pipeline route. Their natural enemies are few and, aside from man, they generally live unmolested lives. Bats are generally considered beneficial because of their destruction of numerous night-flying insects. During the winter some recorded bat species hibernate and others migrate to warmer climates. The big hoary, or gray bats, migrate to the southern states while the endangered Indiana bat and the big brown bat are examples of hibernators. Coyotes are very adaptable and can prosper among humans provided they are not pressed too hard. They are generally found along river drainages and in heavy brush because of better food supply and escape cover. Changing farming practices which cause the loss of tall dense vegetation has made the coyote more vulnerable to hunting and caused the loss of denning locations. The main controlling factors of this animal are hunting, poisons and unfavorable land use changes.

Wild turkeys are found in the rough, broken country associated with the Heart and Little Missouri River drainages and with the Killdeer Mountains in North Dakota and in the more extensive areas of woodlands in Pennsylvania and West Virginia. Summer and early fall rarely present food problems and diets usually consist of grass, leaves, matured seeds, waste grains and insects. However, harsh winters and a general lack of winter food sources often drives wild turkeys to nearby farms and ranches where they feed off of stacks, primarily oats, which are used for cattle feed. A recently completed range inventory revealed most suitable turkey habitat is now occupied west of the Missouri River.

Each hawk species has different habitat preferences. The Ferruginous and Swainson's hawks prefer open terrain and nest in low trees or on the ground. Red-tailed hawks utilize trees in the open or woodlands for nesting but generally hunt in open country. March hawks nest in marshes or in tall grass on the ground and hunt grasslands, cropland and marshes. The broad-winged hawk, Coopers hawk and sharp-shinned hawk all nest and hunt mainly in woodlands. American Kestrels nest in trees usually in open terrain and the prairie falcons usually nest on cliffs in canyon or badland habitats. Most owls nest and utilize woodlands extensively for their life requirements but short-eared owls nest on the ground and hunt grasslands and burrowing owls nest in holes in the ground and hunt open terrain. Turkey vultures generally nest along buttes or escarpments.

Sandhill cranes which formerly bred in the pipeline area are now only a migrant. Also, migrant whooping cranes stop in the Dakotas during spring and fall migration periods.

The Missouri and Prairie Coteaus, generally known as the pothole area, are highly favorable to waterfowl production since innumerable patches of marsh, potholes, ponds and lakes, collectively offer all possible combinations of water depth, aquatic vegetation and shoreline cover.

Ducks and geese tend to migrate within a limited number of geographically defined corridors or flyways, and the pothole region of Montana lies squarely across the Central Flyway as illustrated in Figure 2.1.3.7-3. This flyway is used by waterfowl which breed on the prairies and tundra northeast and east of the Rocky Mountain system and winter in Texas and Latin America. Northeastern Montana is crossed also by an approach to the Mississippi Flyway, which is used by Canadian and Alaskan waterfowl which winter along the Gulf Coast. The pothole region of the Dakotas represents an integral part of this same flyway. Hence, the pothole region is of great continental importance to waterfowl for both breeding and migration. While geese and ducks are the prominent species, other waterbirds utilize the area on their migration or as summer range.

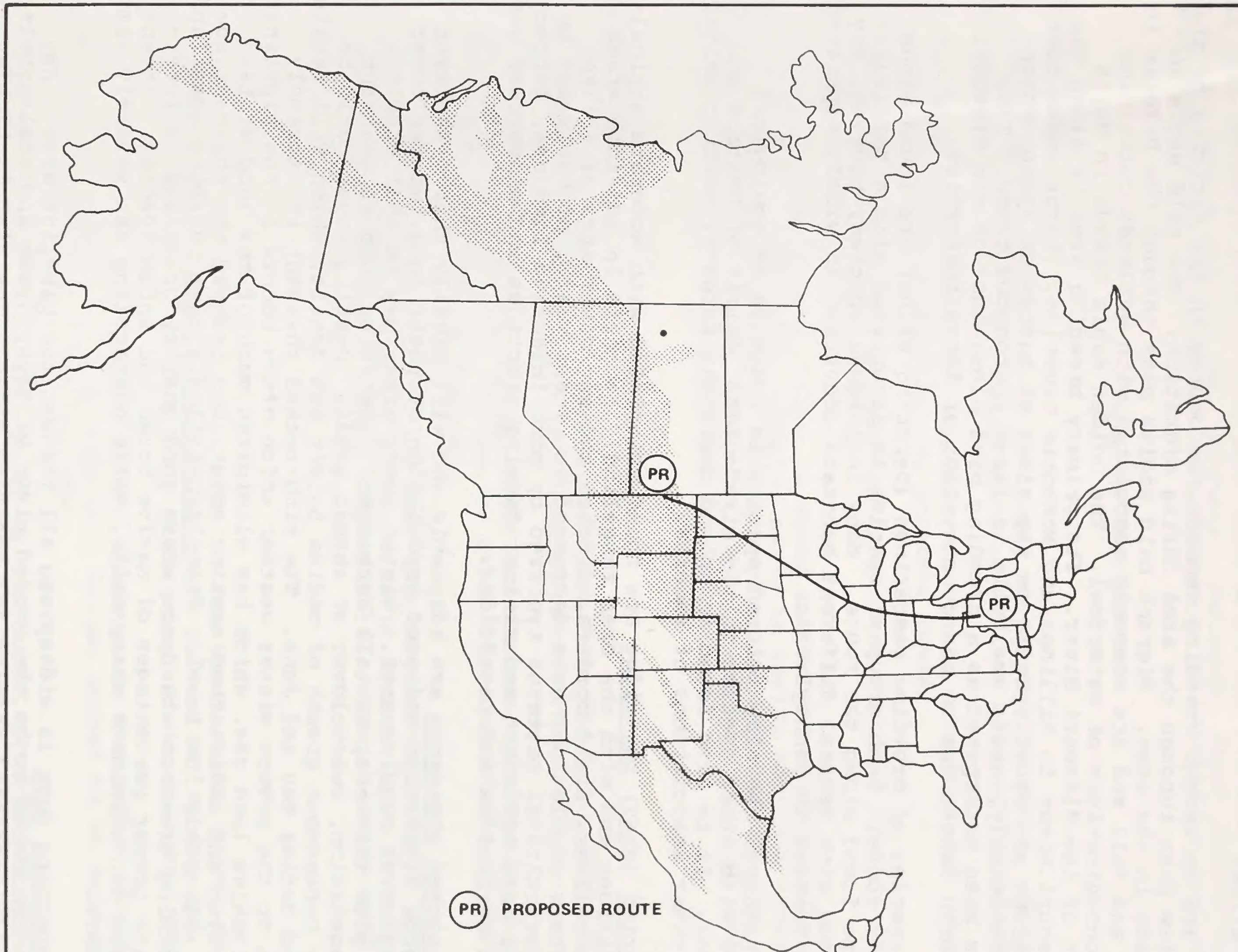
Waterfowl of the region, breeders or migrants or both, consist of the three major groups: geese, pond or dabbling ducks and diving ducks. The geese are predominantly terrestrial vegetarians, but nest and rest in or on wet areas or open waters. Although some Canada geese breed at several scattered points in the area, the great flocks from Canada, like the snow geese, merely pass through in transit to breeding or wintering areas. Dabbling ducks favor smaller shallow inland ponds and marshes. They can feed ashore, dip in the shallows, or even dive for food; the mallard and pintail are of particular significance as breeders. The redhead, canvasback and lesser scaup are important diving ducks. However, as a group, the dabblers are more abundant; mallards, pintails, green-winged and blue-winged teals are the most abundant representatives.

Annually, waterfowl pass through three relatively sensitive periods: nesting, moulting and migration. Most breeding species arrive on their summer range in the pothole region during April. The total process of reproduction through hatching, including territory and nest-site selection, nest building, laying of the eggs, incubation and hatching, demands a period of from 30 to 40 days, depending on the species. For example, the canvasback requires about 5 weeks from laying the first egg through hatching. Some birds nest late and some nest a second time; for these, hatching may not occur until late July.

A wide variety of other water or marsh birds such as coots, snipe and rails occur in wetland areas across the country. In addition, the great majority of all North American shorebirds (plovers, sandpipers and many related species) migrate through, and at least 10 species breed in northeastern Montana and the Dakotas. Migrant whooping cranes stop in the Dakotas during spring and fall migrations.

Generally, shorebirds reach their greatest abundance in the prairie pothole region, particularly the coteau, and are scarce elsewhere. Exceptions are the killdeer and the upland plover which are found quite commonly throughout the Great Plains region of North Dakota. Also, the long-billed curlew now breeds only in the southwest corner of the state, primarily in Slope and Bowman Counties. Formerly it was a common breeder throughout most of the state.

There is no common ingredient of habitat for all shore birds but prairie grasslands and wetlands form the key environmental components for most of these species' requirements. The American avocet and the piping plover generally prefer the more saline lakes and wetlands and nest on the beaches. Killdeer and spotted sandpipers have wider latitudes in habitat preferences and also nest along the shoreline. The other shorebirds



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 2.1.3.7-3 Pattern of waterfowl migration in the central flyway generally utilize fresher wetlands and all nest in grasslands, particularly unplowed prairie.

There are no recent breeding records for osprey in the vicinity of the route. A few pass through the area during migration. The bald eagle no longer breeds in the area. Migrant bald eagles pass through the Dakotas in the spring and fall and are commonly associated with wetlands containing fish and concentrations of waterfowl. The Golden eagle breeds in North Dakota west of the Missouri River. Its primary breeding area is along the Little Missouri River in Billings and McKenzie Counties. Large nests composed of sticks are usually built on the sides of buttes or steep escarpments. Occasionally, nests are built in large cottonwood trees. This species has been extirpated as a breeding bird along most of the Missouri River in North Dakota due to the construction of large reservoirs.

Many species of breeding passerines (perching birds) are found along the proposed route. Each group of species is associated with a particular habitat type found along the route. Many individual species, however, may be associated with several different habitats occurring in widely separated areas from Montana to Pennsylvania.

For instance, the clay-colored sparrow is found in an ecological association with other species in the mixed-grass prairie of Montana and North Dakota. It is also found in upland deciduous forests, shelter belts, etc. with other associations of species.

Hungarian (gray) partridge are found associated with moderate agricultural conditions and with the open rangeland. It nests in odd-idle areas such as fencelines, field borders, ditches and any other area of a like nature. Their populations have decreased in recent years, probably due to changing agricultural patterns typified by more intensive land use, larger farm sizes, more efficient and cleaner farming practices and widespread use of various herbicides and pesticides.

Ring-necked pheasants are adaptable and will usually thrive wherever there is good dispersion and good association of their food, winter cover and nesting cover requirements. Winter cover areas may be shelterbelts, willow or plum thickets, or tall herbaceous vegetation such as emergent aquatic vagetation, sweetclover or annual weeds. Nesting cover could be almost any herbaceous growth of medium height and density which will remain undisturbed during May and June. The ring-necked pheasant is extremely vulnerable to the severe winter weather which often occurs in the pipeline area. Intensive land use, which has eliminated much of the good winter survival cover and undisturbed nesting cover, has reduced the pheasant numbers to a relatively low level. The sharp-tailed grouse inhabits grassland areas, reaching greatest abundance where good quality grassland is interspersed with proper percentages of native brush and shrub species. Intensive farming can eliminate sharp-tails, while overgrazing can severely limit their numbers.

The mourning dove is widespread all through the pipeline area. Key sites are considered to be the wooded river valleys, draws and shelterbelts which provide essential nesting and roosting sites. The bird is highly dependent on wheat, and the corn and wheat harvest probably plays an important part in the formation of flocks in mid-summer and in the local movement of such concentrations.

Unlike the rich bird and mammal faunas, the amphibian and reptilian faunas are limited along the route. The explanation of this scarcity lies in the Western area's continental climate, primarily the extreme cold and dryness. Low winter temperatures are a handicap to both groups, but cold affects the reptiles more than the amphibians. Aridity restricts the amphibians more severely because they must have water for breeding and because most of the adults require damp habitats. Wetlands, flood plains and aquatic habitat are critical to the maintenance of amphibians particularly.

Aquatic Species

Northern Pike

The northern pike is found in a wide variety of habitats. They can be found in both cold and warm water lakes as well as slow-moving rivers.

The species is common in the waters of Lakes Sakakawea and Oahe; the two large reservoirs crossed by the proposed route.

These highly predacious fish are most often found in or near dense aquatic weed beds in shallow water.

Northern pike usually prefer to spawn in flooded marshy areas along lakes or rivers. They begin spawning early in spring as water temperatures start approaching 40 degrees F. Young northerns begin leaving the spawning area when they reach 1.5 to 3 inches in length and head for the open water of the lake or river from which their parents came.

Yellow Walleye

The range of the yellow walleye extends from the Great Slave Lake east to Labrador and south to North Carolina and northern Arkansas.

It is found mainly in larger lakes and streams, preferring clear, shallow waters over gravel, bedrock or other firm substrates in lakes, and clear, deeper stretches in streams.

Spawning occurs from March to June when water temperatures are 38 degrees F to 50 degrees F (3.3 degrees C to 10 degrees C). Eggs are broadcast over gravel riffles or gravel-rock shoals. Spawning over sand or silt bottoms results in very low egg survival.

Sauger

Sauger are found in the area west of the Appalachian Mountains from northern Louisiana northward to the southern Hudson Bay region and northwesterly throughout most of the Mississippi River drainage system.

The sauger, a close cousin of the walleye, is most often found in silty rivers and large lakes or impoundments. Sauger appear to be more tolerant of high turbidity levels than walleye.

The feeding and breeding habits of the sauger are similar to those of the walleye.

Yellow Perch

The yellow perch had a native range from central Manitoba to the Maritime Provinces, south to South Carolina along the Atlantic Coast and west to Kansas and Missouri.

It occurs most abundantly in clear, weedy lakes and sluggish streams. Its numbers are drastically reduced by increased turbidity and siltation.

Spawning takes place near shore at water temperatures between 45 degrees F and 55 degrees F (7.2 degrees C to 12.8 degrees C), typically in early spring. Eggs are laid in gelantinous strings, woven in and around aquatic plants or brush.

Largemouth Bass

The range of the largemouth bass extends from South Dakota to southern Ontario and south to Florida, the Gulf States and northeastern Mexico. It has been widely introduced elsewhere.

It predominates in clear, weedy, non-flowing waters. Nesting begins when water temperatures reach about 60 degrees F. Nests are constructed in sand, gravel, roots or vegetation at a median depth of thirty inches.

Fry consume zooplankton. As they grow larger, insect larvae enter the diet. Adults eat mostly fish; other food items are worms, mussels, frogs, crayfish, snails and large insects. Typical fishes in the diet are bluegills, yellow perch and other sunfishes, threadfin shad, golden shiners and other minnows, bullheads, darters, and small basses.

Smallmouth Bass

The smallmouth bass was originally found from Minnesota through the Great Lakes to Quebec and south to northern Alabama and eastern Oklahoma. It has been often successfully introduced outside this range.

The largest populations are found in large, clear lakes and cool streams of moderate-to-high gradient which have bottoms of gravel, boulder or bedrock. Nesting begins when water temperatures reach 40 to 60 degrees F (4.4 to 15.6 degrees C). The male constructs a dish-shaped nest (as other sunfishes do) on sand, gravel or rocks in water 10 inches to 12 feet deep. Spawning takes place at temperatures from 58 to 70 degrees F (14.4 to 21.1 degrees C).

Smallmouth fry consume mainly zooplankton. Young fish one to two inches long eat mainly insects and small fish. Adults prefer crayfish, fish and insects.

White Crappie

White crappie were originally found in ponds, lakes, bayous and low-gradient flowing waters east of the Rockies. They ranged from the southern Great Lakes south to Texas and Alabama. They have been widely introduced into suitable areas throughout North America.

White crappie tolerate a wide variety of habitats. In turbid or silty environments, the white crappie generally predominates over the black crappie. White crappie were more abundant than black crappie in Texas waters when the pH was greater than 7.0.

They spawn from March to July (depending on geographic location) when water temperatures reach 64 to 68 degrees F (17.8 to 20 degrees C), often near brush, stumps or rock outcroppings, usually in water 3 to 8 feet deep.

Young crappie consume largely zooplankton. Then, as the fish grow older, insects and other invertebrates become very important. Fish becomes the dominant food of adults.

Bluegill

This scrappy panfish can be found inhabiting waters of almost all areas of the United States.

The largest populations occur in clear, non-flowing waters over a variety of bottom types. In heavily vegetated areas, this species, like the pumpkinseed and yellow perch, may become too numerous, resulting in a stunted population. Spawning occurs throughout most of the growing season when water temperatures are normally between 22 and 27 degrees C. Males build nests over a variety of bottom types, mainly fine gravel, and water depths.

At a length of 10 to 12 millimeters, the young bluegills take up a planktonic existence in the upper three meters of the water body, remaining for six to seven weeks while feeding on zooplankton. As the bluegills grow in size, larger items such as insect larvae and amphipods are added to the diet. Adult bluegills feed mainly on aquatic insects, small crayfish, and small fish.

Pumpkinseed

This member of the sunfish family was originally found in southern Canada, the upper Mississippi River system, the Great Lakes region, and along the Atlantic Coast to Georgia. It has also been widely introduced elsewhere.

Habitat preferences are similar to the bluegill's, except that dense growths of aquatic vegetation are preferred. It reportedly does not overpopulate a lake as easily as the bluegill, because of a dietary preference for a greater fraction of small fish, including its own young. Nest building starts when water temperatures reach 15 degrees C. Details of reproduction are similar to the bluegill. Incubation time is about 3 days at 28 degrees C.

Pumpkinseeds feed mostly on insects, crustaceans and snails. Larger pumpkinseeds take a greater proportion of small fish.

White Bass

White bass have been introduced widely into lakes and reservoirs. The species can be found for example in Lakes Sakakawea and Oahe.

They live in larger streams and impoundments from northeastern Mexico throughout the Mississippi Valley to Minnesota and Michigan.

White bass spawn in spring as the water temperature approaches 60 degrees F. Adult fish run upstream to spawn in riffle areas. A mature female may deposit up to half a million eggs.

Rainbow Trout

The rainbow is a native of the west coast of North America from Alaska to southern California.

Rainbows have been planted in both Lake Sakakawea and Lake Oahe and in watersheds in West Virginia and Pennsylvania crossed by the proposed route. During high flow periods in the spring, they may move into the lower reaches of the Heart River. Rainbow trout require clean, cold waters of streams, ponds or lakes. They do best where water temperatures seldom exceed 65 degrees F and reach 75 degrees F only rarely, and then for only a short period of time.

Rainbows characteristically spawn in the spring, migrating upstream to deposit their eggs on cleaned gravel in shallow water. The eggs hatch under several inches of gravel, requiring newly hatched fry to make their way up to open water.

Small rainbows feed almost entirely on insects. As they become larger, minnows and other items are added to the diet.

Goldeye

Goldeye range from the Ohio to lower Tennessee Valley northward to Manitoba, excluding the Great Lakes drainage basin.

The species is quite abundant in the Missouri River, Lake Sakakawea and Lake Oahe. They may also be found in the Little Missouri, Knife and Heart Rivers; and in Little Muddy and Spring Creeks. They typically inhabit large rivers and lakes; however, small streams are required for spawning. Goldeye appear to be rather tolerant of high levels of turbidity.

The principal food items of the goldeye are minnows, crayfish and insects.

Channel Catfish

The original range of the channel catfish extended from the southern prairie provinces of Canada south through the Great Lakes and Mississippi Valley, including the Gulf States and Mexico. Since it is a favorite warmwater game fish for many, it has been widely introduced into other areas.

Channel catfish are found primarily in fairly large rivers and streams with low to moderate gradients. They are abundant in some sluggish streams, lakes and large reservoirs. Bottoms of sand, gravel or boulders are preferred; silt bottoms may be tolerated if the rate of silt deposition is low. They are seldom found in dense aquatic vegetation.

Immature channel catfish appear to tolerate faster currents than adults and often feed at night in riffle areas. They inhabit shallow riffles and turbulent areas near sand bars. Yearlings and subadults often overwinter under boulders in swiftly flowing water. Adults spend the day in deeper areas and feed in shallow water at night.

Channel catfish are typically omnivorous, usually feeding near the bottom. They may feed both at night and during the day. Small fish consume mainly insect larvae. Larger fish take an increasing proportion of fish, larger insects and crayfish with increasing size. Other items reported to be important foods at different localities were elm seeds, terrestrial insects, algae and pondweeds. Spawning occurs at temperatures between 70 and 85 degrees F (21.1 and 29.4 degrees C). (Usually in a secluded semi-darkened area under rocks, below logjams, in holes or in other protected spots.)

Spottail Shiner

This shiner is found from Alberta to Quebec and south along the Atlantic coast to Georgia and in the Mississippi Valley to Missouri and Kansas.

It is representative of the many minnow species of the water crossed by the proposed route.

The spottail shiner prefers clear waters with a bottom of sand or gravel. Its decrease in certain Ohio waters has been attributed to increased silting and turbidity.

Spottail shiners mature at ages one to two at lengths of 3 to 5 inches. They reportedly spawn in closely packed groups, with no evidence of nesting.

Young spottails up to 10 millimeters eat mainly rotifers and algae; up to 70 millimeters, microcrustacea (zooplankton); larger shiners eat insect larvae, zooplankton, fingernail clams, fish eggs and small shiners.

Unique, Sensitive and/or Threatened Populations

While the pipeline route does traverse the range of the endangered black-footed ferret in the Dakotas no sightings have been made in the immediate vicinity of the route nor were any nearby prairie dog towns, an indispensible habitat factor, observed during a low level helicopter survey of the pipeline route. The wide ranging endangered peregrine falcon could occur along the route but no critical habitat for this species has been identified as being located close to the route. The endangered whoping crane migrates through the Montana portion of the route. The endangered Indiana bat also ranges widely across the country traversed by the route. In Illinois critical hibernation habitat for this species is located in an abandoned mine within 2,000 feet of the route. In this same local area along Pecumsaugan Creek is found an unusual plant and animal assemblage for this area involving white pine, arbor vitae, Plains Muhly a rare grass in Illinois and the timber rattlesnake. Other species, whose status is as yet undetermined, but about which there is concern, and which could be found in the pipeline area include: northern swift fox, ferruginous hawk and mountain plover. In western Indiana locally rare species such as the Plains pocket gopher, Franklin's ground squirrel and the badger may occur within the right-of-way. The State of Ohio has identified the river otter, the bobcat, the coyote, the eastern wood rat, the sharp-shinned hawk, the bald eagle, the king rail, Kirtland's warbler, the upland sandpiper, the common tern, the Northern copperbelly and the Eastern Plains garter snake as being endangered species in Ohio. Many of these species live in or pass through those same remnants of natural habitat such as woods and flood plains which are noted previously as major elements in supporting wildlife species diversity. From the national standpoint there are no nationally recognized endangered fish species in streams traversed by the route.

Most of the states which the pipeline crosses have their own lists of endangered fish species. Many of the species on these lists are those whose natural range is peripheral to the individual state. While a species may be numerous in the center of its range, it is rare on the periphery of the range. Naturally those states with interesting peripheral species are concerned with protecting these unique elements of their aquatic fauna. Many shiners, darters and dace fall into this category. Some of the species of these lists once had much wider ranges and much larger populations, but man-made changes in their habitat have caused drastic drops in their populations. For example, the sturgeons and the paddlefish have had many of their original migration routes and spawning and nursery areas in the large river systems blocked by dams, inundated by reservoirs or degraded by pollution. Overfishing has had a role in the decline of some of these populations. The remaining populations of such species may be depending on borderline habitat conditions for their continued existence so that wherever they are still found, any degradation of the habitat has to be avoided. Another example are the once cool, clear streams in the very eastern portion of the route which support a variety of interesting darters. Here pollution of various kinds, mine acid, industrial, municipal, thermal, has greatly reduced the amount of suitable habitat left. Here again, the key to continued survival of these species is the avoidance of any degradation of aquatic habitat. This means both the quality of the water and the substrate conditions.

In Table 2.1.3.7-2 are shown the primary fish species of state concern along the proposed route. Since for most of these species precise locations of occurrence are not available, streams along the route which fall into a suitable habitat category, and which are part of a watershed where these species occur must be regarded as actual or potential habitat for these species in subsequent impact analysis.

The identification of endangered aquatic invertebrates is still in an early exploratory stage. There are none on the Federal endangered species list. The tuberculed-blossom pearly mussel of the Ohio River, the Higgens Eye pearly mussel of the Mississippi River and the pink mucket pearly mussel of the Muskingum River have been proposed as endangered and were listed in the Federal Register Vol. 39, No. 202, October 17, 1974. The proposed route makes river crossings within the potential range of these species. The Mississippi, the Illinois, the Wabash and the Ohio were among the rivers that once supported extensive mussel fisheries but pollution, dredging and other factors have almost eliminated these endeavors. The State of Ohio now lists 16 mussel species as being endangered. Improvement of water quality and protection of remaining mussel beds from undue disruption are important elements in maintaining and restoring mussel populations. The existence of significant mussel populations at crossing sites could only be determined by actual field sampling.

2.1.3.8 Ecological Considerations

Previous sections describe in detail the climate, soils, vegetation and wildlife existing along the pipeline route.

In nature all of these components are interrelated and no single parameter can be adequately treated without consideration of the effects of others.

The purpose of this section is to discuss briefly the basic ecological processes that have created the present conditions previously described.

Table 2.1.3.7-2

Fish Species of State Concern Along Proposed Route

	Mont	N. Dak	S. Dak	Minn	Iowa	Ill	Ind	Ohio	W. Va	Pa
Lake Sturgeon			x	x	x	x				
Shovelnose Sturgeon		x	x	x						
Pallid Sturgeon	x	x	x		x					
Western Sand Darter					x	x				
Eastern Sand Darter								x		
Channel Darter									x	
Least Darter										x
Longhead Darter										x
Slender Head Darter			x							x
Tippecanoe Darter										x
Blacknose Shiner			x			x				x
Blackchin Shiner		x	x		x					x
Bigeye Shiner						x				
Pallid Shiner						x				
River Shiner			x						x	
Bridled Shiner										x
Tonguetied Minnow								x	x	
Finescale Dace	x		x							

(cont.)

Fish Species of State Concern Along Proposed Route (continued)

	Mont	N. Dak	S. Dak	Minn	Iowa	Ill	Ind	Ohio	W. Va	Pa
Southern Redbelly Dace									x	
Longnose Dace					x					
Sturgeon Chub	x		x							
Blue Sucker	x		x				x			
Longnose Sucker			x							x
Olive Sucker									x	
Pirate Perch										x
Mountain Madtom										x
Shortnose Gar	x									
Trautman's Catfish								x		
Sauger								x		
Flathead Catfish		x								
Allegheny Brook Lamprey										x
Paddlefish			x							

Major Ecosystems

Living organisms and their non-living environment are inseparable in nature.

An "ecosystem" is the basic functional unit of that relationship. Ecosystems may be conceived of and described in various parameters. So long as the major biotic and environmental components are present and operate together in functional stability, the entity is an ecosystem. Thus, the entire prairie may be considered to be an ecosystem, or, alternatively its smallest temporary pond. Even though existence of the latter is limited in time, it may be a functioning ecosystem.

The major natural ecosystem types along the pipeline route generally coincide with the major vegetation associations described in Section 2.1.3.6.

The mixed grass prairie, the tall grass prairie, the pothole country, the flood plains and the eastern deciduous forests are readily identifiable terrestrial ecosystems. Streams, lakes and wetlands constitute the aquatic ecosystems along the pipeline route.

Each of these major ecosystems contains a unique combination of plant and animal communities having its own food chain, energy circuit, nutrient cycle, environmental elements and pattern of development and evolution.

As with plant units the major ecosystems may be defined in terms of many smaller units within the larger delineation.

In this study only the larger ecosystem units are considered. As previously noted, only 357 (22%) miles of the 1,600 mile pipeline traverses extensive areas of natural plant communities. Most of the route is through cultivated land. Small, scattered, natural ecosystems such as flood plains, wetlands, potholes, and woodlots are present along the pipeline route.

Since man and his livestock have become permanent biotic factors that are responsible for almost complete destruction of past ecosystems, it is difficult to describe agricultural lands as possessing natural ecosystems. Although the major elements of a natural ecosystem are present, they are artificial in character. Man has changed the natural environment through drainage, cultivation, and other agricultural or ranching activity. He annually plants and harvests his crops and applies fertilizers to replace lost nutrients. Such activity engenders many new ecosystems that support different plant and animal communities from those of the past.

The Mixed Grass Prairie

The proposed pipeline traverses approximately 600 miles of the mixed grass prairie in Montana, North Dakota and South Dakota. About 250 miles of the proposed line crosses natural plant communities; 350 miles cross prairie lands now converted primarily to the production of spring wheat that is grown in a wheat-fallow rotation. The range and agricultural fields are interspersed to produce a uniquely interrelated environmental condition.

The existing rangelands are generally in areas where soils and topography have created severe limitations for agricultural use.

Where soils are light textured and shallow the potential plant communities are dominated by perennial mid-grasses and a few tall grasses including little bluestem, big bluestem, needleandthread, prairie dropseed, plains muhly, sideoats grama, and a variety of scattered perennial forbs and shrubs.

On the heavier clay soils the following perennial grasses usually dominate: Western wheatgrass, prairie cordgrass, switchgrass, green needle grass, and alkali sacaton. These sites also contain a variety of perennial forbs and a few shrubs.

When abnormal disturbance occurs in the mixed grass prairie, i.e., continuous heavy grazing, the dominant tall and mid-grasses tend to diminish and are replaced by short grasses and mid-grasses of lower palatability. These may include various combinations of blue grama, buffalograss, sand dropseed, western wheatgrass, dryland sedges and the less palatable perennial forbs.

With severe overuse the plant communities may deteriorate to sparse stands of short grasses and invading annual plants that expose the soil to serious erosion.

Estimates by the Montana State Soil Conservation Committee and Range Conservationists of the Soil Conservation Service in the Dakotas indicate that about half of the mixed grass prairie through which the pipeline route passes is rated as being less than good condition; while half is rated as being in good to excellent condition.

In terms of forage production, this means that half of the rangelands along the proposed pipeline are producing 50 percent or less of their potentials. This is true primarily because of the historic heavy use by livestock, especially during the "open range" period prior to the 1930's.

As the producer elements of the ecosystem change because of consumer activity, a new balance must be achieved so that energy inputs and consumption of food material are again in a state of equilibrium. The balanced relationship between wildlife populations and vegetation associations that were once productive in the mixed grass prairie habitat has been reduced to sub-climax condition where the most desirable and productive wildlife food plant species have not been able to withstand intensive super-imposed livestock use. The level and diversity of present wildlife populations are related to existing range conditions where, even from a livestock viewpoint, at least half the range is only in fair or less than fair condition. On this open range with its extremes of climate, the cover provided by the limited areas of brush in the gullies and brush and trees along the stream courses is a critical element of the prairie ecosystem. These cover areas are also shared with livestock so that forbs used by wildlife as food are heavily cropped by livestock. The quality of the cover is reduced as heavy livestock use opens up these areas.

Some 356 miles of the route in these states passes through an area that is now cultivated. Most of the area, thus, represents an artificial one-crop ecosystem, wherein fields are planted to wheat or left fallow in alternate years. Wildlife cover in the form of fencerows, hedgerows and uncultivated areas is practically non-existent in this dry farming area. With a limited variety of wildlife foods and the absence of cover many of the wildlife species which once flourished on the mixed grass prairie can no longer thrive in these areas.

A very special set of individual ecosystems, the wetlands and potholes are interspersed with cropland along the route in the Dakotas. Extensive drainage of these areas has taken place in the past and drainage is still continuing. This is the primary waterfowl production area in the lower 48 states. A wide variety of other water and marsh birds also utilize these areas during breeding or migration. These areas include seasonally flooded basins or flats, inland fresh meadows, inland shallow fresh marshes, inland deep fresh marshes and inland open fresh water or Type 1 through 5 of the wetlands classification used in Fish and Wildlife Circular 39 "Wetlands of the United States". Many individual wetland areas along or in the path of the proposed route have been acquired by U.S. Government in fee simple or as easement to help fulfill Federal responsibilities under international treaty for the protection and management of waterfowl.

Tall Grass Prairie, Oak-Hickory and Beech-Maple Forests

The proposed route from Minnesota to Ohio crosses areas which were once Tall Grass Prairie, Oak-Hickory Forest or Beech-Maple Forest. Along the route these natural ecosystems have all essentially been converted into a cultured ecosystem, cropland. The conversion has been so complete that only 20 of over 700 miles of the proposed route crosses remnants of the earlier natural ecosystems. About 3 miles of Tall Grass Prairie, 5 miles of Oak-Hickory Forest and 12 miles of Beech-Maple Forest comprise this 20 miles. These remnants are far from being representative of the original climax vegetation.

Of great significance to the cropland ecosystem and the wildlife it supports is the almost complete elimination of fencerows, hedgerows and uncultivated corners. This type of small scattered area of wildlife cover once provided the base for a much larger and more diversified wildlife population even in areas of intensive agriculture. This makes the remaining woodlands, now existing primarily as small scattered woodlots along the route, and the approximately 10 to 11 miles of flood plain habitat, critical elements in the essentially cropland ecosystem. The cover and nesting habitat and the different types and seasonal availability of food which are afforded by woodlot and flood plain habitat are limiting factors in the size and diversity of wildlife populations in this overwhelmingly cultured ecosystem.

In terms of energy inputs and consumption of food materials man harvests most of the ecosystem production for his own use.

What is left on areas not farmable remains for wildlife use.

Wildlife species and populations, thus, must be in new balance with the limited food and cover available. Surviving species are those able to adapt to living in close proximity to man. Such species include deer, skunks, raccoons, foxes, cottontail rabbits, squirrels, pheasants, quail, waterfowl, small rodents, and song birds.

Appalachian Oak Forests

In eastern Ohio, West Virginia and Pennsylvania the route crosses an area which was originally the Appalachian oak forest.

Today along the route there is a patchwork of second growth woodlands and small cultivated fields and pastures. There are narrow strips of bottomland hardwoods in the restricted valleys of this region. Forest edge species such as cottontail rabbits, ruffed grouse, gray squirrel, fox squirrel and white-tailed deer are characteristic of this region.

The bottomland hardwood furnishes habitat for wood ducks and for a variety of fur bearers and birds which prefer these areas.

The interspersion of croplands, pasture, upland woodlands and bottomland woodlands provide a variety of cover, food, nesting habitat and edge which provides niches for a considerable diversity of mammals, birds and plants. In this rugged topography with narrow valley floors the bottomland hardwoods and flood plain habitat is particularly vulnerable to agricultural, industrial, or urban development since productive flat areas are at a premium.

As in the other regions man is the primary consumer in the modified ecosystem. The energy inputs to the ecosystem are harvested as wood, crops, and livestock. Wildlife utilizes what man leaves of these products.

Ecosystem Productivity

The primary productivity of an ecosystem is defined as the rate at which radiant energy is stored by photosynthetic or chemosynthetic activity of producer organisms (green plants) in the form of organic substances which can be used for food.

In terrestrial ecosystems the common unit of primary productivity is pounds of air-dried forage/acre/year. Major factors influencing the productive capability of an ecosystem include availability of water and nutrients and length of growing season. Thus, the productive ability of natural ecosystems along the pipeline route tends to increase from west to east.

This is illustrated by the production capabilities of climax plant communities described in Section 2.1.3.6. In Montana, where growing seasons are relatively short and precipitation limited, the mixed grass prairie may produce 500 to 2,000 pounds of air dry forage per acre. The tall grass prairie farther east may produce as much as 8,000 pounds because of more favorable precipitation and longer growing seasons.

Fluctuations in climatic conditions from one year to the next results in significant annual variations in forage production. In the Great Plains Region cyclic prolonged droughts cause dramatic decreases in production that disrupt normal farming and ranching operations.

In general the primary factors affecting terrestrial ecosystem productivity also affect aquatic ecosystem productivity. Of course, the loss of water from an aquatic system would destroy that ecosystem. However, in years of more favorable climatic conditions the aquatic ecosystem will produce more food material than in less favorable years.

As previously stated it is difficult to treat agricultural lands as true ecosystems. Man has been able to increase productivity through elimination of the original ecosystem and establishment of a cultural ecosystem. High productivity in crops is maintained through large energy inputs involved in cultivation, fertilization, insect control, etc. These energy supplements are generally derived from fossil fuels and are replacing or supplementing the solar energy of the original ecosystem.

In terms of food produced per unit of energy expended, the natural ecosystem is more efficient than the cultured ecosystem.

Ecosystem Interrelationships

The conversion of solar energy to organic food material by living plants is only one stage in the complex interrelationships between living organisms and the environment that constitutes the ecosystem.

The transfer of food energy from plants through a series of organisms with repeated eating and being eaten constitutes the food chain.

At the same time dead organic matter is assimilated by microorganisms which are eaten by detritivores which also have predators.

With each step in the food chain there is a loss of energy. This loss in energy is offset by energy converted by the plant from the sun so the system continues to function in a state of dynamic equilibrium.

Although species and environmental conditions differ these same processes occur in the aquatic and woodland ecosystems.

There are frequently interrelationships between ecosystems. For example, the aquatic system of a South Dakota pothole might depend upon the surrounding prairie for nutrients and water draining off the land surface. Birds that nest in the pothole feed on the prairie. Predators remove animals or fish from the pond to the land. Watering herbivores fertilize the pond with their droppings. Migratory waterfowl make seasonal use of aquatic environments over wide areas, but may feed on agricultural lands where food is available.

These facts are important in evaluating project impacts, since one ecosystem may be disturbed but indirectly affect other systems.

Ecosystem Parameters and Critical Factors

As vegetation develops, the same area becomes successively occupied by different plant communities. This process is termed plant succession.

If a bare wheat field is left to natural processes a sequence of plant communities will occur starting with annual plants adapted to the bare field environment and culminating in the climax plant community of the original prairie.

Likewise if an oak-hickory forest is cleared and then returned to nature a succession of plant communities will occur; grassland, grass shrub, pine forest and ultimately the climax oak-hickory forest. This process may require over 150 years.

A mature climax ecosystem is one where the producer organisms (plants) are in the ultimate stage of succession allowed by the physical environment and the annual production is in balance with annual consumption and energy flows.

Man has been a primary influence responsible for alteration of the original climax ecosystems. When a stable community is maintained by man or his domestic animals in a stage of development below climax, it is called a disclimax.

Applying these principles to the proposed pipeline route the following conditions are evident:

In the mixed grass prairie overgrazing has produced disclimaxes or regression of successional stages of plant communities. Here livestock have replaced many of the native herbivores and have consumed more food than the system could annually replace. The result is a lower plant community producing more short grasses than mid-grasses and consequently a lower annual production. Through grazing management the trend can be reversed and a climax ecosystem reestablished.

In the tall grass prairie regions the climax plant community has virtually disappeared to provide man with the rich agricultural lands of the cornbelt. This is generally true also for the beech-maple forest climax of Indiana and eastern Ohio.

In the eastern deciduous forests the climax hardwood communities have been harvested several times for wood products. Today the stands are in lower successional stages and if undisturbed will ultimately reach climax.

Where cultural ecosystems have resulted in annual crop species production the remnants of natural plant communities become the critical factors in maintaining diversity in terrestrial animal populations.

The diversity of aquatic animal populations is also related to remnants of undisturbed aquatic environments.

Factors which have effected these natural aquatic environments include siltation, pollution from commercial, industrial and agricultural wastes, channelization, stream obstruction and inundation from reservoirs, etc.

It is obvious from the many fish species which occur on state endangered species lists that these species and probably many other related aquatic organisms, not yet investigated, are in a very tenuous situation. Additional stresses could be intolerable.

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2.1.3.9 Economic Factors

The economic and social environment along the 1,600 miles of the proposed Northern Border Pipeline is as diverse as the natural environment. Generally the intensity of economic activity increases from northwest to southeast along the pipeline route as the population density increases and the nature of economic activity changes from the extensive dry land farming and livestock grazing of the more rural northern Great Plains, to the more intensive cash crop and livestock feeding activity of the Mid-West and finally the more urban and industrialized Great Lakes manufacturing belt transected by the eastern portion of the pipeline route. As a matter of convenience in description, the route of the proposed pipeline is divided into three roughly homogenous economic areas: (1) The western 600 miles is essentially rural and semi-arid with economic activity centering around dry-land farming and cattle ranching. This area will be referred to as the western grazing and wheat area. The States of Montana, North Dakota and South Dakota encompass this segment of the line. (2) The economy of the central 500 miles of the pipeline, that portion of the line that lies in the States of Minnesota, Iowa and the western half of Illinois, is characterized by an intensive, high value agricultural production. This is called the Corn Belt area. (3) The eastern 500 miles of the pipeline which extends from eastern Illinois through Indiana and Ohio to western Pennsylvania is more urbanized and highly specialized in manufacturing. In the following descriptions this is referred to as the Great Lakes manufacturing belt area. Economic homogeneity is not complete for areas as large as these, of course. Some of the most productive agricultural activity of the country is in the Illinois, Indiana and Ohio Great Lakes manufacturing belt area, while considerable manufacturing takes place in the eastern Iowa, western Illinois section of the corn belt area. This division of the pipeline route is seen in Figure 2.1.3.9-1.

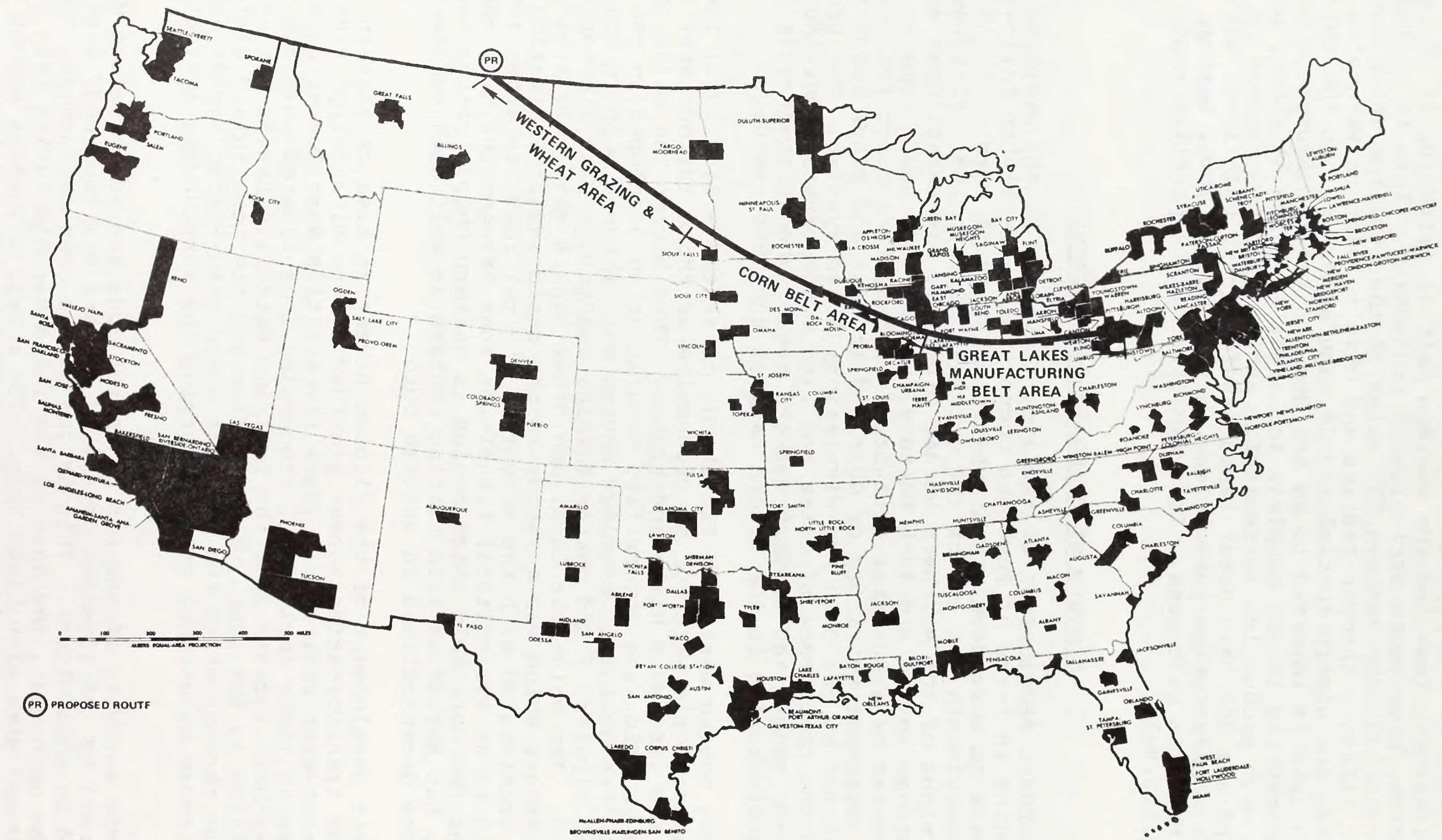
History of Economic Development

The economic development of the area traversed by the proposed Northern Border pipeline in terms of European occupation and activity followed the generally east to west development characteristics of much of the United States. Pennsylvania was one of the original 13 colonies. Pittsburgh, the eastern terminus of the Northern Border pipeline, was established as a military outpost in the mid-18th century, and by 1800 had become an important center of industrial activity as a departure point for settlement of the old northwest territory of Ohio and Indiana and other lands that could be reached by the Ohio and Mississippi River systems. The proximity of coal and the confluence of water and land transportation corridors to the Minnesota iron ranges and eastern markets established Pittsburgh's dominance in steel manufacturing in the second half of the 19th century.

Settlers moving west from Pittsburgh to settle agricultural land found lands in eastern Ohio were not as productive as those further west in the corn belt, and were more hilly and broken. This became the major coal producing area in Ohio, and diversified manufacturing developed in the second half of the 18th century. Settlers moving west through Ohio in the area of the proposed pipeline found better farming conditions with flatter and more fertile land. The Ohio-Erie Canal and other canals gave this area early access to markets which was a factor in the rapid industrialization of the area which accelerated with the advent of the railroad era after 1850. Central Ohio is an agricultural transition zone between the hill country to the east and the corn belt which begins in western Ohio. Cities became industrial, but served as farm trading centers as well with manufacturing becoming more decentralized in western Ohio.

Economic development of the Clinton-Davenport area of eastern Iowa was based on the transportation access provided by the Mississippi River and later the east-west railroads. These river cities were lumbering and sawmill centers in their early days, processing logs floated down the river from the northern forests into the building materials needed for settlement of the prairies to the west. These cities and the more inland cities of eastern Iowa through which the pipeline would pass--Cedar Rapids and Waterloo--have become industrial centers serving the surrounding agricultural areas.

Economic activity of the north central Iowa and southwestern Minnesota area traversed by the pipeline developed as, and has remained, more highly specialized in agriculture. This is one of the most productive, prosperous areas of the corn belt, the last of the ice movements having left it a prairie covered with rich black loam. The relatively small amount of industrialization that has developed is agriculturally related.



Source: 1970 Census of Population, U.S. Department of Commerce, Bureau of the Census, 1973, p. 8-9.

Figure 2.1.3.9-1 Standard metropolitan statistical areas of the United States

The western third of the pipeline route, that is, the western grazing and wheat area of South Dakota, North Dakota and Montana, is probably the most homogeneous of the three major geographic segments of the pipeline in its economic activity. The fur traders who worked the area along the Missouri River in the first several decades after purchase of this area from France were followed by cattlemen who turned large herds of cattle loose to winter in the northern Great Plains area in the 1870's and 80's. This open range era ended when the particularly harsh winter of 1887-88 destroyed most of this northern herd. A more established form of ranching has taken its place. Almost all of this area is west of the 20-inch rainfall line and proved to be too arid for general farming. Present activity consists of wheat farming and cattle grazing.

Principal Economic Activities

Economic Products

The following discussion of current economic activity, economic products, etc. follows the same three part division of the proposed pipeline route used above and is based on data for those counties which would actually be traversed by the pipeline. References to states means just those counties of that state in which the pipeline lies.

Western Grazing and Wheat Area

The major products of the counties along the western 600-mile stretch of the pipeline that lies in Montana, North Dakota and South Dakota are agricultural, with spring wheat and range cattle predominating. Cattle are about 50 percent of the value of farm production and wheat an important portion of the balance. Hay, both wild and alfalfa, is the second most important crop. The size and nature of farms change within the area as one travels southeast from the Montana-Canadian border to the South Dakota-Minnesota border. The average size of farms which is 2,000 to 3,500 acres in the three Montana counties, decreases to 1,000 to 1,800 acres in the North Dakota counties, to 500 to 1,000 acres in the South Dakota counties and 450 acres in eastern South Dakota. Farms which are typically cattle ranches or dry-land wheat farms in Montana and North Dakota become more general cash grain farms with a wider variety of products in South Dakota where better soil and more moisture make the land too valuable for grazing but still not as productive as the corn belt land into which it transitions to the southeast. Other agricultural products include flax, this being the major flax producing area of the U.S., oats, barley, rye and in limited areas of North and South Dakota, dairy products. Sheep are also raised on some North and South Dakota farms, and corn produced in South Dakota.

Most of this area is west of the 20-inch rainfall line where even wheat farming is a gamble. In the western part of this area alternating crop with summer fallow to accumulate two year's rainfall to raise one year's crop is a typical practice. There is little irrigated land in this or any other area along the pipeline route. One small section of the Burford-Trenton project is crossed in Williams and McKenzie Counties, North Dakota; a larger section of the Oahe Irrigation Unit of the Bureau of Reclamation is crossed in Brown County, South Dakota; some irrigable land also lies along the pipeline route through the Fort Peck Indian Reservation in Roosevelt County, Montana. Although farm goods are the most important products of this area, the total value of agricultural goods produced in this area is the smallest of the three areas of the pipeline route. Farming is a full-time occupation for farmers of this area with relatively few parttime farms, and fewer farmers reporting off-farm work than in the corn belt area or manufacturing belt area.

Mineral products of the area include petroleum in McKenzie and Williams Counties, North Dakota (the only significant petroleum production in North Dakota) and Roosevelt County, Montana, and coal in Oliver and Mercer Counties, North Dakota. The limited amount of manufacturing that occurs in the area is mostly meat processing and other food processing most of which is carried on in the southeastern end of the area. A small recreation industry of the area is based upon pheasant hunting in the Dakotas and the water of Fort Peck, Sakakawea and Oahe Reservoirs.

Corn Belt Area

Economic products of the counties along the 500-mile stretch of the pipeline route from eastern South Dakota to central Illinois are still mostly agricultural but with considerable industrial production as well, especially in the eastern end of the corridor. This area produces the greatest total value of agricultural goods of any of the three areas crossed by the pipeline. The value of agricultural production is relatively consistent across the area from northwest to southeast with an increasing value of manufacturing activity added to this agricultural base from the center of the area to its southeastern limit.

Almost the entire land area is in farms and in contrast to the western grazing and wheat area to the northwest, all but about 15 percent of farm land is in crops. The average farm size is about 250 acres with some tendency for farms to be smaller at the southeastern end of the area than the northwestern end. Average value of products, however, increases towards the southeastern part of the area. The basic crop is corn and the basic farm operation is growing corn to feed to cattle and hogs which are the marketed product. More than one half of the value of farm products marketed is livestock.

Oats and flax are also raised as well as sheep with climate and soils versatile enough to permit shifting production to meet changing market conditions. Soybeans are frequently second to corn in value produced. Although there is relatively little dairying compared to areas to the north, some dairy products are prepared for the Chicago and other urban markets. Feed lots that finish cattle raised elsewhere also aim at these nearby urban markets.

This area is intensively industrialized from east central Iowa to the outskirts of Chicago in north central Illinois. Manufacturing activity of the area is quite diversified although individual towns have become somewhat specialized. Waterloo, Iowa, a standard metropolitan area bisected by the proposed pipeline, is a factory center producing farm machinery and meat products. Cedar Rapids, another SMSA bisected by the proposed route, manufactures meat and other food products, radio equipment, heavy machinery and other metal products. It is also an education center with three colleges. Nearby Iowa City is also a university and medical center. Davenport, Iowa and its neighbors across the Mississippi River, Moline and Rock Island, Illinois, are a crossroads of railroad and river transportation, specializing in the manufacture of farm machinery, with some diversification into the manufacture of food, clothing and other metal products. Davenport is also a major shopping and retail center. Of the other cities in the pipeline corridor in this area, Clinton, Iowa manufactures plastics and food. Streator and Ottawa, Illinois are the sources of glass ceramics and other sand and clay products. Printing and publishing are also among the major activities in this area.

There is little mineral production in this corn belt area other than the normal production of construction materials such as sand and gravel, with the exception of the large cement output of Cerro Gordo and Scott Counties, Iowa.

The Great Lakes Manufacturing Belt Area

This is the most urbanized, industrialized section of the proposed pipeline route. Twenty-four SMSA's are within, or touch a line 50 miles on either side of the pipeline route. In addition, the area is covered by a network of smaller industrial towns within easy commuting distance of each other. As manufacturing activity is decentralized among many towns, so also are the manufacturing products widely varied and diversified. Illustrative of this diversity of products in these medium-sized towns are a few examples: Kankakee, Illinois--home appliances, furniture, farm implements; Lafayette, Indiana--prefab houses, electrical equipment, metal and rubber fabrication; Lima, Ohio--railroad locomotives, electrical motors, precision tools, auto parts; Marion, Ohio--power shovels, earth moving and mining equipment; the complex of towns around Pittsburgh, Pennsylvania--producing products ranging from steel and steel products to chinaware and other glass and ceramic products.

The manufacture of food products is also important throughout the area, which points up the fact that this is a very productive agricultural area as well as a manufacturing center of the nation. Farms are generally smaller--average about 150 acres--than the two areas to the west. Farming in the area transitions from highly prosperous corn belt type farms in Illinois and Indiana to subsistence hill farming in eastern Ohio and western Pennsylvania.

Production of farms in the Illinois-Indiana part of this area is much like the corn belt area to the west, but with somewhat more emphasis on cash grains, the most important of which are corn, soybeans, oats and wheat. Cattle and hog raising is still dominant, and along with limited dairy production is aimed at the Chicago market in the western portion of this area, Pittsburgh to the east and other metropolitan areas throughout the region. Farms in the eastern Ohio and Pennsylvania portions of the area are unmistakably poorer than in the corn belt area, but still better than in the hill country to the south. There are also more part-time farms in this eastern end of the area, with farmers doing more work off their farms in the mines and factories.

Coal is present in Kankakee and Grundy Counties, Illinois, and has been mined in the past though there is no present production. The Coshocton, Tuscarawas, Guernsey, Harrison and Jefferson County area of eastern Ohio is the largest coal producing area in Ohio. The three counties in Pennsylvania, Allegheny, Westmoreland and Washington and Brook County, West Virginia are among the major coal producing counties in those states.

Economic Markets

Little specific can be said of the markets for products as diverse as those produced along the proposed pipeline route. The smaller, more limited manufacturing activity in the western grazing and wheat area and in the western part of the corn belt area typically serves a more local market while the wheat produced moves to national and international markets. Manufactured products of the Great Lakes manufacturing belt area are sold in national and international as well as local markets. The more populous eastern half of the route is itself an important market for products produced elsewhere in the nation and the world.

Figure 2.1.3.9-2 graphically shows the value of agricultural products produced in the proposed pipeline route area.

Employment and Income

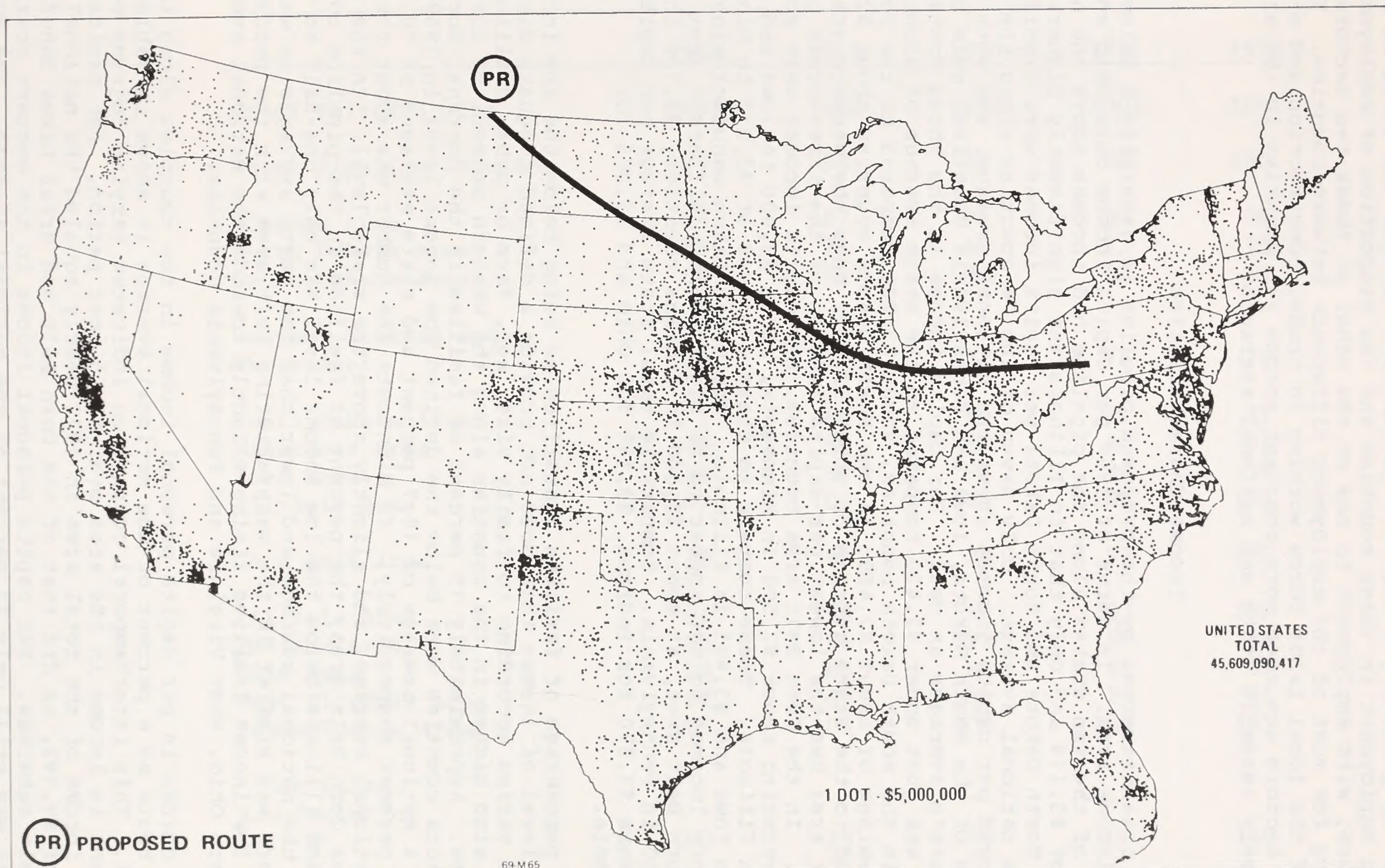
Principal Employers and Work Force Statistics

The total civilian labor force of the 76 counties touching the proposed Northern Border pipeline route was approximately 1,818,000 workers in 1970. This was less than 10 percent of the total civilian labor force of the 10 states within which these counties lie. The distribution of this work force among the three segments of this area under consideration further illustrates the economic disparity of these segments. Approximately 71,000 workers or just 4 percent of the total live in the western grazing and wheat area and more than one-third of these are in a single county. The Corn Belt area has about 482,000 people in its civilian labor force--27 percent of the total in the counties along the pipeline. Of these, three-quarters live in the three SMSA's and three medium-sized towns of the area. Sixty-nine percent of the civilian workers of the three areas, 1,266,000 people, live in the Great Lakes manufacturing belt area with three-quarters of this number residing in the Pittsburgh Metropolitan Area. Nearly one-half of the total civilian labor force of the three areas, in fact, lives in the Pittsburgh SMSA.

The unemployment rates in the pipeline counties in 1970 varied considerably around the national average of 4.4 percent. The Montana counties were higher while the counties along the line from North Dakota to western Ohio were generally lower. Unemployment rates were about the same as the national rate in the eastern Ohio and Pennsylvania counties. It is not felt that too much significance should be given to these differentials in rates of employment. They may reflect little more than the difference between industrial and agricultural areas.

The industrial classification of workers indicates a considerable difference in economic activity in counties along the pipeline route. In the United States as a whole, an average of 25.9 percent of the civilian labor force is employed in the manufacturing sector. Among states, Montana, North and South Dakota rank among the states within the lowest levels of manufacturing employment with less than one-third the national average so employed, while Ohio, Indiana and Pennsylvania rank among the highest with half again the national percentage of their workers in manufacturing jobs.

Looking at the pipeline counties themselves, the three Montana counties average about 6 percent of their civilian workers in manufacturing, the North Dakota counties 3 percent, South Dakota counties 4 percent and Minnesota counties 12 percent. In all these states, the county manufacturing employment ratios are substantially below the state averages. There is considerable variance between counties as well. For example, one South Dakota county has .4 percent of its labor force employed in manufacturing, while another has 7.6 percent. The pipeline counties in the other states along the route have manufacturing employment shares considerably above the national average, but somewhat more similar to their respective state averages. These county manufacturing employment shares average about 27 percent in the 15 Iowa counties, 36 percent in the Illinois counties, 38 percent in Indiana, 33 percent in Ohio and 30 percent in the three Pennsylvania counties.



Source: 1969 Census of Agriculture, U.S. Department of Commerce, Bureau of the Census, 1973, p. 58.

Figure 2.1.3.9-2 Value of farm products sold, 1969

There is generally a negative correlation between the level of manufacturing employment in these counties and the proportion of employment in agriculture, with employment in one or the other of these two sectors accounting for most of the employment difference between counties. The shares of the local labor force working in trade, construction and other economic sectors are much more constant across all counties in the area and more closely resemble state and national averages.

Income Characteristics

The area traversed by the proposed pipeline is generally a below average income area. In terms of 1969 per capita income only Ohio and Illinois of the ten states along the pipeline had incomes above the national average of $3,119 and only that in Illinois was significantly higher. Montana, North Dakota and South Dakota per capita incomes were significantly below the national average. Only seven of the 76 counties along the pipeline enjoyed per capita incomes above the national average, and with the exception of the South Dakota, Iowa and Pennsylvania counties, were below their state's averages as well. Per capita income in the three Montana counties was just under $2,400 compared to the state average of about $2,696; in the South Dakota counties, about $2,200 compared to the South Dakota average of about $2,469; in the North Dakota counties about $2,400 contrasted to the state average of about $2,387; thus the western grazing and wheat area has the lowest per capita incomes of the three areas of the pipeline. In the Corn Belt area counties, per capita incomes were somewhat higher averaging about $2,500 in Minnesota, about $3,000 in Iowa and over $3,050 in Illinois. These compare to state averages of $3,038 in Minnesota, $2,884 in Iowa and $3,495 in Illinois. The Great Lakes manufacturing belt area county incomes do not appear to be significantly different from those of the Corn Belt area, at about $2,800 in Indiana counties, $2,700 in Ohio and $3,200 in Pennsylvania. Comparable total state average per capita incomes were $3,070 for Indiana, $3,199 for Ohio and $3,066 for Pennsylvania.

The percentage of families classified as being below the low income level (a level of income that does not provide a defined adequate diet, etc., and varies according to family size, age, farm or urban dwelling, etc.) is also higher in the counties along the western segment of the pipeline route. Approximately 15 percent of families in the Montana, North and South Dakota counties were below the defined low income level in 1969, compared to a national average of 10.7 percent and state averages of 10.5, 12.4 and 14.8 percent respectively. In Minnesota the number was about the same as the national average, and slightly above the state level. In the more prosperous Corn Belt area, the percent of families in the pipeline counties of Iowa and Illinois below the low income level was only one-half to three-quarters the national average and lower than the state averages as well. The picture was similar in the manufacturing belt area with the percentage of below low income families rising slightly towards the national average in the eastern Ohio, West Virginia and Pennsylvania counties.

The change in per capita personal income in the counties along the pipeline route as a percent of the national average is shown in Table 2.1.3.9-1. This intertemporal comparison indicates varying degrees of improvement in income in the area over the 5 year period. Per capita personal income of the total area in 1972 nearly equaled the national average of $4,492, as did that of the Corn Belt and Great Lakes Manufacturing Belt subareas. Per capita personal income in the western grazing and wheat area was still only 79 percent of the national average. The North Dakota pipeline counties (75 percent) and South Dakota counties (81 and 71 percent) were the poorest counties along the route in 1972, while the

Table 2.1.3.9-1 Per capita personal income for major areas and subareas, percent of national average, 1968-72

	1968	1969	1970	1971	1972
Total United States	100%	100%	100%	100%	100%
Total Pipeline Counties	99	98	98	98	100
Montana Area	86	87	91	83	88
North Dakota Area	66	71	69	72	75
South Dakota Area	80	79	80	80	81
Western Grazing and Wheat Area	76	77	77	78	79
South Dakota Area	71	69	69	71	71
Minnesota Area	78	80	84	80	85
Iowa Area	99	99	99	96	99
Illinois Area	107	106	105	106	109
Corn Belt Area	99	99	99	97	100
Illinois Area	96	98	99	103	102
Indiana Area	93	96	91	96	96
Ohio Area	88	88	88	87	88
West Virginia Area	82	82	81	86	86
Pennsylvania Area	105	103	103	104	105
Great Lakes Manufacturing Belt Area	100	99	99	100	100

Source Regional Economics Information System, Bureau of Economic Analysis U.S. Department of Commerce.

western Illinois counties (109 percent) and Pennsylvania counties (105 percent) were the wealthiest.

Table 2.1.3.9-2 relates personal income, per capita income and population of each subarea and state area (pipeline counties only) along the route. All 76 counties of the pipeline route represent only 2.28 percent of the nation's personal income and population.

Income data illustrates in different ways the economic structure of the areas along the pipeline. In the total area of the pipeline counties total personal income is 2.27 percent of the nation. All major sources of this total income are a similar share of their national totals except farm proprietors' income which is 4.49 of the national total indicating this source of income is proportionately twice as great in the area as in the nation as a whole. In the western grazing and wheat area, farm proprietors' income is more than eight times more important that it is in the nation; in the Corn Belt area, four times as important; in the Great Lakes Manufacturing Belt area farm proprietors income is one-fifth less important than in the nation. The same relationships are evident in a comparison of earnings shares. Farm earnings are disproportionately large in all areas except the Great Lakes Manufacturing Belt area, earnings from government sources are disproportionately low except in the western grazing and wheat area, with little military employment in any of the areas.

Earnings by industrial sectors as a percent of the total of personal income shows farm proprietors' income as 4.38 percent for the total 76 county area, 20.07 percent in the western grazing and wheat area, 8.46 percent in the Corn Belt area and only 1.69 percent in the Great Lakes Manufacturing Belt area. The somewhat higher share of property income and lower proportion of transfer payment in the Corn Belt area also indicates the higher wealth position of this subarea, while the higher share of wage and salary income in the Great Lakes Manufacturing area indicates the importance of industrial employment there.

The pipeline counties in every state specialize (in the sense that this is a more important activity here than in the nation as a whole) in farm earnings with the exception of the Pennsylvania counties. This degree of specialization runs from 10 times greater than the national share in Montana and 12 times greater in Minnesota to only one-twenty-fifth the national share in Pennsylvania. North Dakota, South Dakota, Minnesota and the Great Lakes Manufacturing Belt area of Illinois have some specialization in local government; North Dakota, South Dakota and Pennsylvania a slight specialization in wholesale and retail trade and Ohio, West Virginia and Pennsylvania, some specialization in private non-farm earnings. All state areas have a very low degree of employment in Federal military earnings except Indiana which has a relatively strong specialization in this sector.

Local Tax Structure and Base Characteristics

Table 2.1.3.9-3 gives an idea of the large number of jurisdictions with taxing powers in each state along the pipeline route. These numbers are for the entire state in each case, but the number of taxing bodies with which the Northern Border pipeline will have to deal in the 76 counties through which it passes should be roughly proportional. This table at least gives an idea of the complexity of taxing that will be involved. The number of counties along the proposed pipeline are just 10 percent of the total number of counties in the 10 states. As these are among the less developed counties, the number of taxing jurisdictions is likely less than 10 percent of the number indicated in this table.

Table 2.1.3.9-2 Personal income, 1972 (adjusted for residence, thousands of dollars)

Area	Personal Income	Personal Income Percent of U.S.	Per Capita Personal Income	Per Capita Personal Income Percent of National Average	Total Population
Total U.S.	$935,350,005	100.00%	$4,492	100%	208,223,417
Total All Pipeline Counties	21,297,507	2.28	4,471	100	4,763,482
Montana Area	109,386	.01	3,934	88	27,808
North Dakota Area	240,183	.03	3,351	75	71,674
South Dakota Area	356,088	.04	3,624	81	98,257
Subtotal, Western Grazing and Wheat Area	705,088	.08	3,569	79	197,257
South Dakota Area	91,751	.01	3,195	71	28,716
Minnesota Area	380,554	.04	3,824	85	99,524
Iowa Area	3,289,274	.35	4,443	99	740,340
Illinois Area	1,833,232	.20	4,897	109	374,367
Subtoral Corn Belt Area	5,594,811	.60	4,501	100	1,242,947
Illinois Area	738,327	.08	4,560	102	161,925
Indiana Area	1,114,092	.12	4,329	96	257,339
Ohio Area	2,723,953	.29	3,967	88	686,618
West Virginia Area	117,440	.01	3,868	86	30,365
Pennsylvania Area	10,303,227	1.10	4,712	105	2,186,549
Subtotal, Great Lakes Manufacturing Belt Area	14,997,039	1.60	4,513	100	3,322,796

Source: Regional Economic Information System, Bureau of Economic Analysis, U.S. Department of Commerce.

Table 2.1.3.9-3 Number of local governments in each State by taxing power and type and public school systems, 1972

State	All Types of Local Government			Local Governments Other Than School Districts					School Districts
	Total	With Property Taxing Power	Without Property Taxing Power	Total	Counties	Munici-palities	Town-ships	Special Districts	
Montana	922	858	134	440	56	126	-	258	552
North Dakota	2,726	2,617	109	2,340	53	358	1,368	561	386
South Dakota	1,770	1,667	103	1,542	64	308	1,034	136	228
Minnesota	3,395	3,262	133	2,950	87	854	1,798	211	445
Iowa	1,818	1,605	213	1,355	99	951	-	305	463
Illinois	6,385	5,337	1,048	5,208	102	1,267	1,432	2,407	1,177
Indiana	2,792	2,206	586	2,477	91	546	1,008	832	315
Ohio	3,259	3,098	161	2,619	88	936	1,320	275	640
West Virginia	508	337	171	453	55	226	-	172	55
Pennsylvania	4,935	3,159	1,776	4,407	66	1,012	1,552	1,777	528

Limited to governments actually in existence. Excludes, therefore, a few counties and numberous townships and "incorporated places" existing as areas for which statistics can be presented as to population and other subjects, but lacking any separate organized county township or municipal government.

Source. U.S. Bureau of the Census, Census of Governments, 1972, Vol. 1, Government Organization. (Adapted from Statistical Abstract of the U.S., 1974.)

Table 2.1.3.9-4 identifies those states along the pipeline route which have state income taxes--all do except for South Dakota. This table also gives some general data on the rates and structure of the income tax in each state.

Pipeline states which have state retail sales taxes are identified by type and rate in Table 2.1.3.9-5. Only Montana of the 10 states has no state retail sales tax. In five of the states, South Dakota, Minnesota, Illinois, Ohio and Pennsylvania sales taxes are also levied by certain cities and/or counties. No data has been developed to indicate how many of these might be counties through which the pipeline passes.

The dollar value of tax and excise tax collections by type of tax in each state in 1973 is seen on Table 2.1.3.9-6. The general sales tax is the largest source of revenue for every state except Montana which has no general sales tax and for which the individual income tax is the largest source of funds. The individual income tax is second in importance in 9 of the 10 states and the tax on motor fuels third.

Property taxes which are the main source of revenue of most local governments are most important in Montana and South Dakota where they are just over one-half of all revenues. The disparity in economic size between these states is illustrated by the fact that total revenues of the State of Illinois, the largest, were 19 times greater than the total revenues of South Dakota, the smallest.

Expenditures on education were the largest expenditures in all 10 states with expenditures on highways second in all states except Illinois and Pennsylvania (states with the largest metropolitan population) where expenditures on public welfare were greater.

Economic Trends

The economic activities of the three areas along the pipeline are well established and unlikely to change significantly in the near future, with the exception of the area in North Dakota which could experience the development of a coal gasification industry based upon the lignite resources there. The same type of development is also possible in the three Montana counties, although probably not as likely. In other counties along the pipeline route, the agricultural and manufacturing activity will likely continue as established. The manufacturing output of the area has been declining in national percentage terms as manufacturing has developed in other areas of the nation particularly the west coast and southeastern United States, but not in total output. It is nearly impossible to project changes in individual counties particularly those in or adjoining metropolitan areas which may become the site of new subdivision developments.

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Table 2.1.3.9-4 State individual income taxes, 1973

State	Rate Range: Percent	Rate Range: Steps in Range	Taxable Income Brackets: Lowest Amount Under-	Taxable Income Brackets: Highest Amount Over-	Personal Exemptions: Single	Personal Exemptions: Married	Personal Exemptions: Dependents	Federal Income Tax Deduct-ible	With-holding Required
Montana	2.0-11.0 1/	10	1,000	35,000	600	1,200	600	yes	yes
North Dakota	1.0-10.1	7	1,000	8,000	750	1,500	750	yes	2/
South Dakota	-	-	-	-	-	-	-	-	-
Minnesota	1.6-15.0	11	500	20,000	21 3/	42 3/	21 3/	yes	yes
Iowa	0.75-7.0	7	1,000	9,000	15 3/	30 3/	10 3/	yes	yes
Illinois	2.5	(X)	Flat Rate		1,000	2,000	1,000	no	yes
Indiana	2.0	(X)	Flat Rate		1,000	2,000	500	no	yes
Ohio	0.5-3.5	6	5,000	40,000	500	1,000 4/	500	no	yes
West Virginia	2.1-9.6	24	2,000	200,000	600	1,200	600	no	yes
Pennsylvania	2.3	(X)	Flat Rate		-	-	-	no	yes

1/ Plus 10 percent surcharge.

2/ Non-resident; not general.

3/ Tax credit.

4/ Plus tax credits

(X) Not applicable

Source: U.S. Bureau of the Census, State Tax Collections in 1973. (Adapted from Statistical Abstract of the United States, 1974.)

United States, 1974.)

Table 2.1.3.9-5 State retail sales taxes, types and rates

State	Tangible Personal Property	Admissions	Selected Service: Rest. Meals	Selected Service: Transient Lodging	Selected Service: Public Utilities	Rate on Other Services and Nonretail Business
Montana	-	-	-	-	-	
North Dakota	4	4	4	4	4	Severance of sand or gravel from the soil, 4%.
South Dakota[1-2]	4	3	4	3	3	Farm machinery and agriculture irrigation equipment, 2%; gross receipts from professions (other than medical) 4%.
Minnesota[2]	4	4	4	4	4	Food, medicines and clothing are exempt; coin operated vending machines, 3% of gross sales.
Iowa	3	3	3	3	3	Laundry, dry cleaning, automobile and cold storage, photography, printing, repairs, barber and beauty parlor services, advt., dry cleaning equipment rentals and gross receipts from amus't dev., 3%.
Illinois[2]	4	-	4	-	-	Property sold in connection with a sale of service, 4%; re-modeling, repairing and reconditioning of tangible personal property, 4%.
Indiana	4	-	4	4	4	
Ohio[2]	4	-	4	4	4	
West Virginia[1]	3	3	3	3	-	All services except public utilities and personal professions, 3%.
Pennsylvania[2]	6	-	6[3]	6	6	Cleaning, polishing, lubr. and insp. motor vehicles, rental income of coin operated amus. dev., 6%.

(1) All but a few states levey sales taxes of the single-stage type. The S.D. taxes have broad bases with respect to taxable services but they are not multiple-stage taxes. W. Va. levies a gross receipts tax of 55/100% on all business, distinct from their sales taxes.

(2) In addition to the state tax, sales taxes are also levied by certain cities and/or counties.

(3) Restaurant meals 50¢ or less are exempt.

Source: Analysis Staff, Tax Division, Treasury Dept. Data as of July 1, 1974 (adapted from World Almanac and Book of Facts, 1975).

Table 2.1.3.9-6 Tax collections and excise taxes, by type of tax, by State, 1973 (Collections include local shares of State-imposed taxes. Excise taxes as of September 1).

State	State Tax Collections 1/ (Mil. Dol.)								Excise Taxes		
		Sales and Gross Receipts									
	Total 2/	Total 2/	General Sales or Gross Receipts	Motor Fuels	Alcoholic Beverages & Tobacco Products	Motor Vehicle and Operators' Licenses	Individual Income	Corporation Net Income	General Sales and Gross Receipts (Percent)	Cigarettes (Cents per Package)	Motor Fuels (Cents per Gallon of Gasoline)
Montana	187	63	X	36	18	10	77	12	X	12	7
North Dakota	180	113	70	25	13	18	27	10	4	11	7
South Dakota	151	129	64	36	14	12	X	1	4 3/	12	7
Minnesota	1,638	709	299	145	122	89	586	171	4	18	7
Iowa	854	433	244	114	53	94	243	47	3	13	7
Illinois	3,676	2,113	1,196	374	237	303	895	229	4	12	7.5
Indiana	1,190	769	484	185	69	59	285	10	4	6	8
Ohio	2,676	1,640	808	370	254	218	374	168	4 3/	15	7
West Virginia	568	417	246	69	42	34	88	12	3	12	8.5
Pennsylvania	4,367	2,148	1,109	445	329	180	1,011	497	6	18	8

1/ Preliminary.

2/ Includes amounts for types of taxes not shown separately.

3/ Excludes state-collected supplemental local sales taxes imposed by local governments under state enabling legislation, as well as locally administered taxes.

X Not applicable.

Source: U.S. Bureau of the Census. State Tax Collections in 1973 (adapted from Statistical Abstract of the United States, 1974).

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2.1.3.10 Sociological Factors

Population

History of Area Population Growth

The early population growth in the area along the proposed pipeline route is really the history of European settlement which, by the year 1800, had reached western Pennsylvania and West Virginia; eastern Ohio by 1820; Mississippi-eastern Iowa by 1850; Minnesota, South Dakota and scattered stretches along the Missouri in North Dakota and Montana by 1890, with those areas filling in after 1900. Population growth tended to reach a peak earlier, however, in the western grazing and wheat and corn belt areas. Maximum population appears to have been reached in Phillips County, Montana from 1910 to 1920, 1950 to 1960 in the other two Montana counties and generally 1930 to 1940 through the North Dakota and South Dakota counties. A few counties with larger towns peaked a decade later. The same phenomenon is seen in the Minnesota and Iowa counties along the pipeline route with some of the eastern Iowa counties having experienced their maximum population in 1900 or earlier.

All counties in eastern Iowa classified as SMSA's, however, had larger populations in the 1970 census than in any preceding census. This is true of most counties along the route in Illinois, Indiana and Ohio with the exception of two counties in Ohio and one in Illinois which peaked out in 1900, one in Illinois which peaked in 1910-1920 and one in Indiana which reached a maximum in 1950-1960. The only urban areas along the route which did not have a larger population in 1970 were a portion of the Pittsburgh and the Steubenville SMSA's where population appears to have topped out in 1950-1960.

A comparison of the census of population of 1960 with that of 1970 indicates population in all the pipeline counties of Montana, North Dakota and South Dakota with the exception of two (Brown and Brookings, South Dakota) declined between 1960 and 1970, most of them in excess of 10 percent with a number in excess of 20 percent. Furthermore, most of these counties lost population in the preceding two decades as well. In contrast, the population of the Nation increased 13.3 percent between 1960 and 1970, that of Montana increased 2.9 percent and North Dakota's population declined just 2.3 percent and South Dakota's declined 2.1 percent. Population also declined in all but one Minnesota pipeline county in the 1960 decade, two of these more than 15 percent, three others about 8 percent. Ten of the fifteen Iowa counties also lost population in the past decade, but mostly in more moderate numbers of 2 to 4 percent. Only 2 counties, both of which are metropolitan counties had population increases greater than the national average. The Iowa state average increased just 2.5 percent.

All but three of the pipeline counties in Illinois, Indiana and western and central Ohio increased in population in the 1960-1970 interval but these increases were generally moderate; only two counties equalling or exceeding the national average. Population increases in these counties were generally less than the state increases of 10.2, 11.4 and 9.8 percent in Illinois, Indiana and Ohio respectively. The three eastern Ohio and two Pennsylvania counties suffered moderate declines in population in the same period.

Net migration rates, which show potential population based on birth and death rates, indicate an even larger outflow of population from the pipeline area than the gross population changes show. Of the 76 counties studied, all but 10 experienced a net population outflow in the 1960 decade.

The movement of people from farms to the cities is a well known phenomenon of several decades standing. This trend is still clearly seen in the 1960 census of agriculture for the 76 pipeline counties. All counties but one saw a decline in farm population that averaged 22 percent or more. Figures 2.1.3.10-1 through -4 indicate rates of change in urban and rural population.

Current Population, State, County and Local Including Distribution, Urban Areas, Density

The total number of people living in the 76 counties along the proposed pipeline route was 4,732,400 at the time of the 1970 census. The number living in the 10 state area involved was more than 10 times that number--49,100,600 people. The distribution of these people along the route was very similar to that of the labor force described earlier, with just 4 percent in the 600-mile stretch of the western grazing and wheat area, 26 percent in the corn belt area and more than two-thirds of the total, 69 percent, in the Great Lakes manufacturing belt area. In a ranking of all states of the Nation by size of population, 6 of the 10 states transected by the pipeline are in the upper half. Pennsylvania, Illinois and Ohio are among the 10 most populous states in the Nation; Montana, South Dakota and North Dakota are among the 10 least populous states.

Another way of looking at population distribution is population density, the number of persons per square mile. The pattern that appears along the pipeline route is the same as that indicated by other economic measures--a low concentration of people at the western end of the pipeline route with an increasing number as one moves toward the eastern terminus of the line.

The overall population density for the Nation in 1970 was 57 people per square mile. In Phillips County, Montana, it was 1 person per square mile. A density of 2-5 people per square mile is common in counties in the western grazing and wheat area with a county average of 7.5 people per square mile and densities over 10 per square mile only in those counties with a major town. In the corn belt area, the population density increases significantly to a county average of 76.7 people per square mile, again with a median county number of about 20-30 pulled up by the three counties with large urban populations. The average population density in counties of the Great Lakes manufacturing belt area is about 181 persons per square mile with the median about 30-40 persons per square mile. Figure 2.1.3.10-5 illustrates population distribution in 1970.

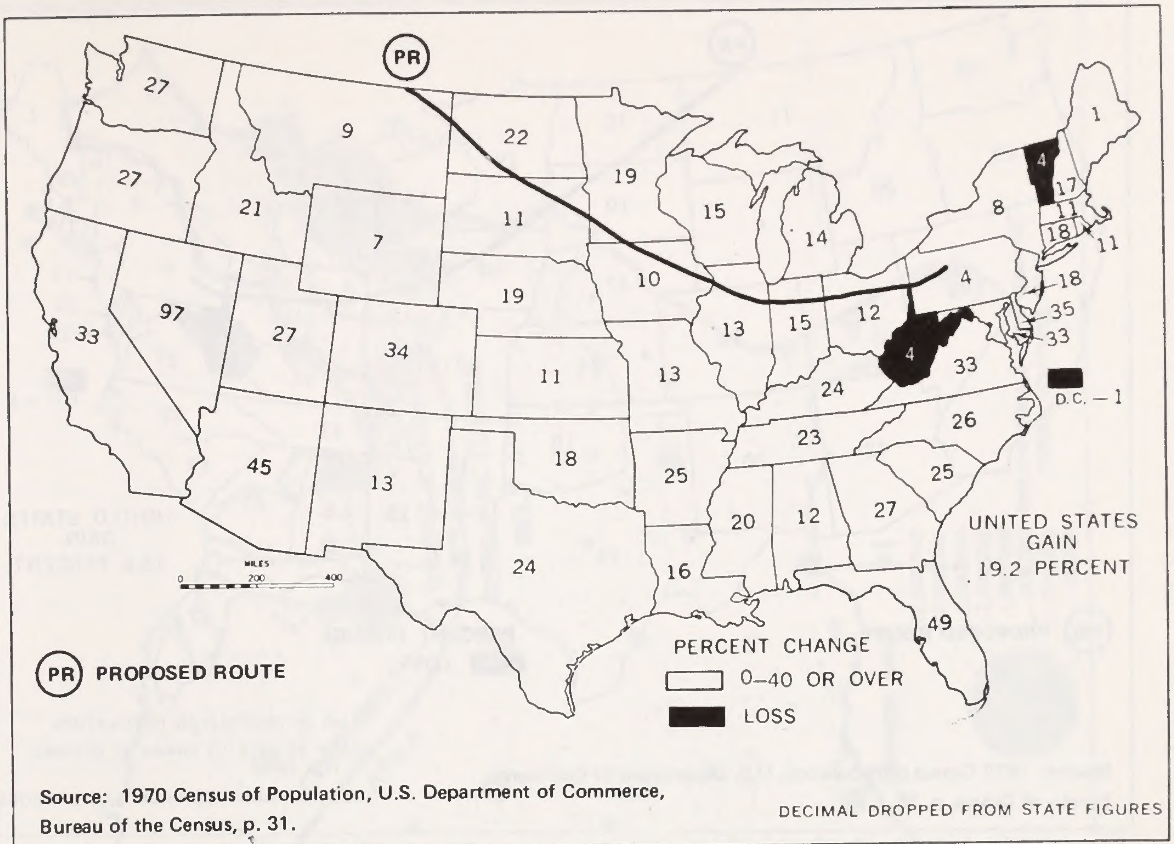


Figure 2.1.3.10-1 Percent of change in urban population by States: 1960 to 1970

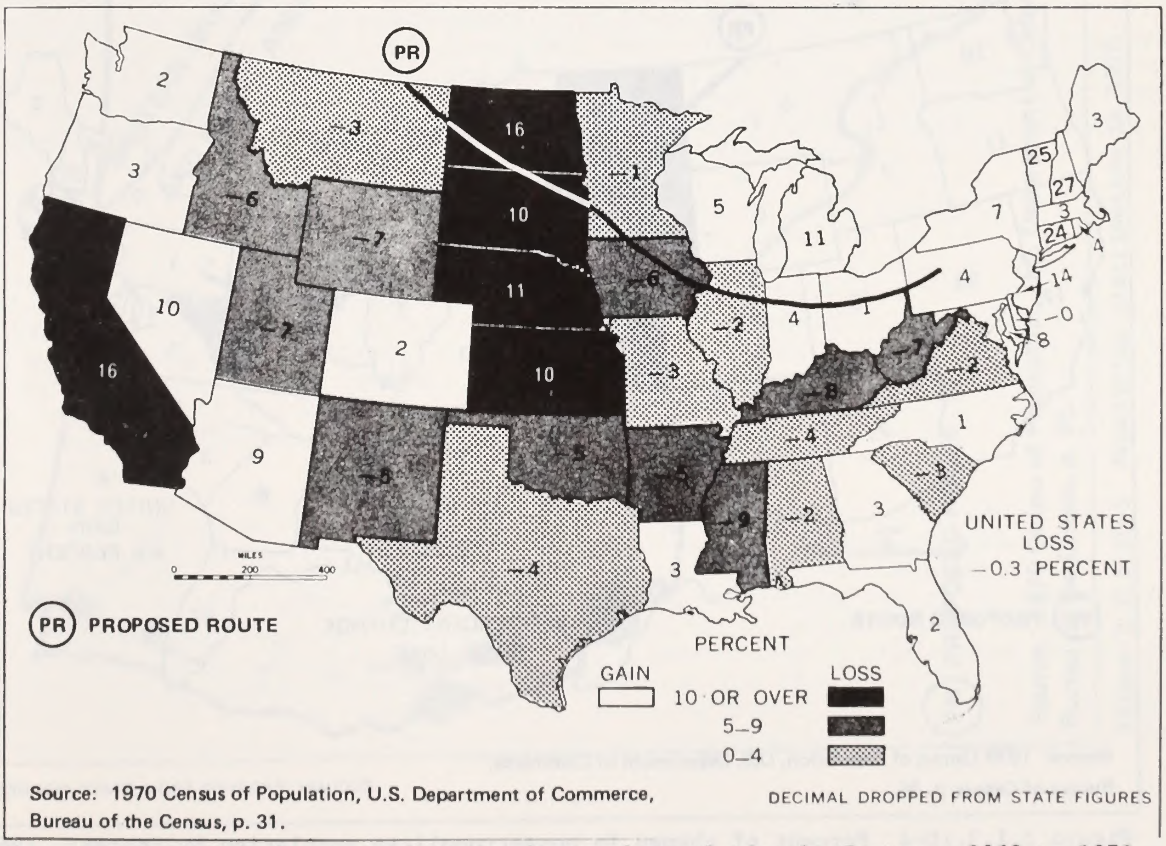


Figure 2.1.3.10-2 Percent of change in rural population by States: 1960 to 1970

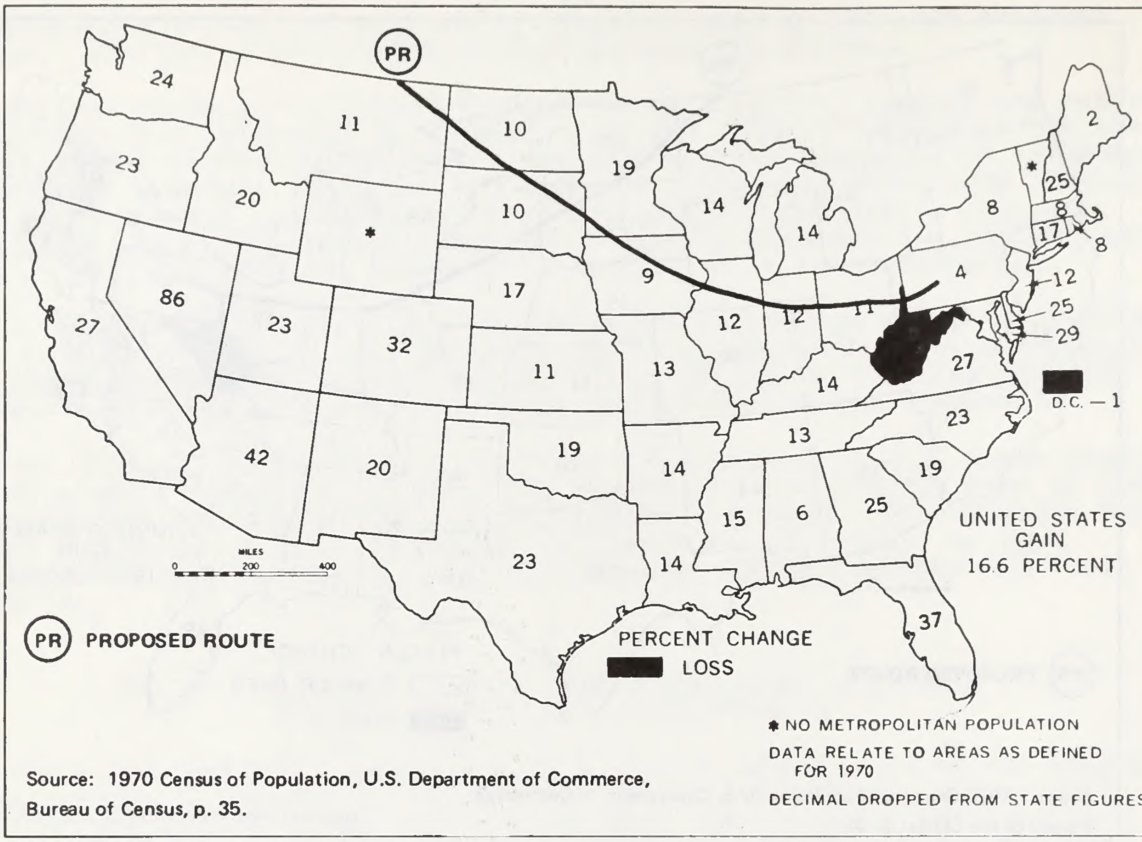


Figure 2.1.3.10-3 Percent of change in metropolitan population by States: 1960 to 1970

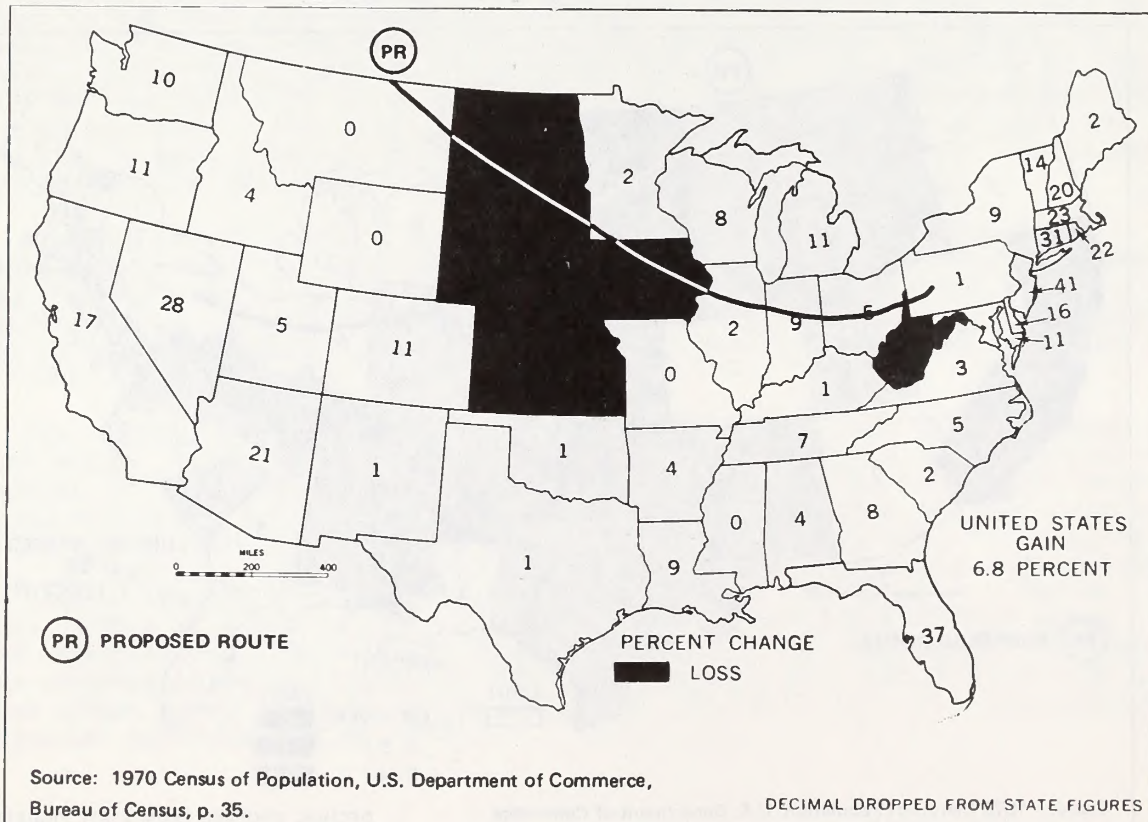
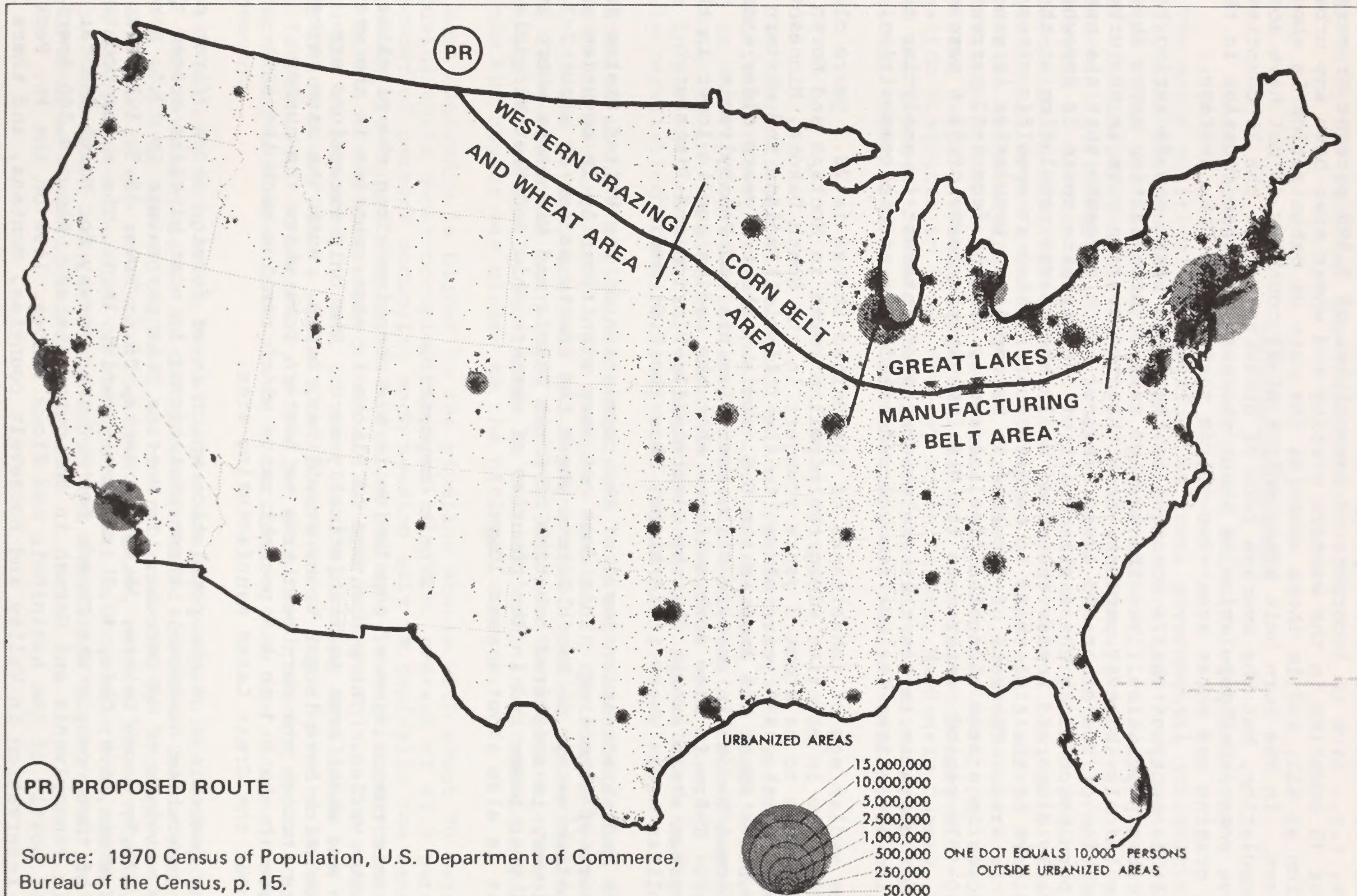


Figure 2.1.3.10-4 Percent of change in nonmetropolitan population by States: 1960 to 1970



Source: 1970 Census of Population, U.S. Department of Commerce, Bureau of the Census, p. 15.

Figure 2.1.3.10-5 Population distribution in 1970

About 73.5 percent of the people of the United States are urban dwellers, i.e., live in incorporated communities of 2,500 persons or more. Only 7 of 19 counties in the western grazing and wheat area have any urban population at all, and in these counties the rate of urbanization is about 50 percent. In the corn belt area, only 4 of 27 counties do not have some urban population, but the average rate of urbanization in the 22 counties that have some urban population is about the same as urban counties in the western grazing and wheat area--two-thirds that of the U.S. average.

Just 1 county of the 29 counties in the Great Lakes manufacturing belt has no urban population. Yet the average rate of urbanization among these counties is only about 42 percent, less than the average rate in the urbanized counties of the other two areas. All of which suggests that the much larger population along the eastern part of the pipeline route is somewhat more evenly dispersed across the area, while the sparse population at the western part of the line tends to be more concentrated at specific sites within the area. The rate of increase in metropolitan population is generally slower in states along the pipeline route, ranging from 4-12 percent in the 1960-1970 period compared to the U.S. average increase of 16.6 percent.

Other characteristics that are generally of interest in analyzing the population of an area include its age, education and ethnic composition.

The median age of inhabitants of the United States is 28.3 years old. The median age in counties along the pipeline route in Montana and North Dakota appears to be about 3 years younger; in the South Dakota, Minnesota and Iowa counties, 4-5 years older; in the Illinois, Indiana and western Ohio counties about the same as the U.S. median; about 5 years older than the national median in eastern Ohio, West Virginia and Pennsylvania counties. There is also some evidence that the median age is lower in the larger urban areas except for the Steubenville-Wierton and Pittsburgh metropolitan areas where it is higher than the U.S. median.

The median education level of the population of the United States is 12.1 years of schooling. This does not vary significantly in counties along the pipeline except in North Dakota where the county median is about 2-3 years lower, in scattered counties of South Dakota and Minnesota where it is about 1 year lower and in the counties of eastern Ohio and West Virginia where it is also about 1 year lower.

Ethnic Composition

Ethnic composition of population in the counties along the pipeline route also varies. The percentage of Blacks in most counties in the western grazing and wheat area is statistically zero. The only exceptions are counties which have larger towns or military bases. Much the same pattern persists through the corn belt area to eastern Iowa where the number increases to the 0.1 to 4.9 percent range which remains much the same throughout the Great Lakes manufacturing area.

The percentage of the population which is of foreign stock (first or second generation American) is somewhat higher in most pipeline states than the U.S. average of 16 percent. In Montana this percentage is 17.5; North Dakota, 23.7; South Dakota, 16.4; Minnesota, 18.6; Iowa, 10.5; Illinois, 19.8; Indiana, 6.8; Ohio, 12.3 and Pennsylvania, 18.1. The major country of origin of these people was Canada for Montana; Norway for North Dakota; Italy in Pennsylvania and German in the other states. About 4,000 American Indians, mostly of the Assiniboin and Sioux tribes, live on the Ft. Peck Indian reservation in Valley and Roosevelt counties, Montana, and there is a scattered Indian population through most of the North Dakota counties traversed by the proposed pipeline route.

Community Structure

Local Government, Authority and Political Subdivisions

The major political subdivisions or local governmental jurisdictions through which the proposed pipeline would pass are the 10 states and 76 counties which lie along the route. The pipeline will also pass through a number of incorporated city limits. Jeanette, Pennsylvania will be one such governmental jurisdiction. The proposed route bisects the Ft. Peck Indian Reservation in eastern Montana and will require authorization and accommodation by the tribal council of the reservation. In addition, the pipeline would cross considerable stretches of land administered by diverse authorities with varying degrees of jurisdiction. Among these are conservation districts; park, recreation, wildlife and other special land use areas; Corps of Engineer jurisdiction at some river crossings; irrigation districts in Brown County, South Dakota, MacKenzie County, North Dakota and Roosevelt County, Montana; drainage districts; weed control districts; water districts; telephone and powerline easements, etc.

Housing Characteristics

The identifiable differences in housing characteristics follow much the same division between rural and urban economies along the pipeline route as noted in description of other socio-economic characteristics. The number of housing units in the pipeline counties, estimated at more than 1.5 million units in the 1970 census, is, as might be expected, distributed in a pattern closely paralleling the distribution of population.

Housing along the pipeline route does have some characteristics differing from the national norm. For example, housing in the area appears to be older. In the Nation, one half (53.5 percent) of housing units identified in the 1970 census had been built before 1950. In the pipeline area, this percentage was generally two-thirds or more although in Minnesota, Indiana and Ohio the number was closer to the national average.

Home ownership is higher in the pipeline states with about 70 percent of housing units owner-occupied compared to a U.S. average of 62.9 percent. The number of persons occupying each housing unit is typically the same as throughout the United States, 3.2 persons per unit, except in North and South Dakota where this number rose to 3.4 and 3.3 per unit. The modernity of housing as measured by lack of some or all plumbing facilities was lower in North and South Dakota where about 9 percent of housing units lacked these facilities. In contrast, a smaller portion of housing units in the manufacturing belt area lack plumbing facilities than the national average 5.5 percent.

The vacancy rate among rental units was 6.6 percent in the Nation in 1970. The rate was higher in the Montana, North and South Dakota counties where it was 8-20 percent, closer to the national average through the corn belt and most of the manufacturing area counties, with a lower vacancy rate in the easternmost counties of the route. It is uncertain what these vacancy rates might mean in terms of actual availability of rental units in a given area at a specific point in time.

Type and Source of Educational, Health and Waste-Disposal Services

The educational and health facilities of the areas along the pipeline are related to population and income of each community. As noted above in the discussion on characteristics of the population, the median level of educational attainment of the population along the pipeline route is very similar to the national average of 12.1 years of school except in the North Dakota counties and several South Dakota counties where it is closer to 9 years of school. The portion of the population that is college educated is somewhat lower in the rural areas than urban areas, yet school enrollees as a percentage of population 5-34 years of age appear somewhat lower in the manufacturing belt area than in the corn belt or even the western grazing and wheat areas.

Public school facilities are believed to be available on a comparable basis across the area with perhaps some difference in quality in lower income areas. There are two colleges of one type or another along the pipeline route in the western grazing and wheat areas, 19 in the corn belt area and 24 in the manufacturing belt area.

The availability of health care facilities is probably lower in the more sparsely inhabited western grazing and wheat area, although measures differ. In terms of hospitals, the western grazing and wheat area and the corn belt area appear fairly consistently in the 500 beds per 100,000 civilian population range compared to the national mean of 420. Indiana and Ohio appear below this national mean. These are statewide figures and how the generally less prosperous counties along the pipeline would fare is unknown although it can be assumed that the level of facilities would be lower. The Northern Great Plains Study notes that the ratio of medical doctors to patients in eastern Montana in 1970 was 1:1,962, compared to a statewide ratio of 1:910 and a national ratio of 1:627.

The description of the existing environment in terms of solid waste management is represented by the following description that is typical for most rural and sparsely populated areas of the United States. Even though there are some portions of the project that pass through or near some urban or suburban areas, where formally structured solid waste collection and disposal systems are used, the vast majority of the project will traverse areas where the following situations apply in terms of solid waste management:

- Solid wastes generated by the living patterns of people in such low density areas are much smaller on a per capita per day basis than for typical urban situation. Generation rates of 2-3 pounds per capita per day are common in rural settings.

- Solid wastes generated by industrial activities are virtually nonexistent in the predominantly rural setting of the majority of this project.

- Solid waste collection systems in terms of the mechanical packer-type collection trucks are virtually nonexistent in most of the rural areas along the project's route. Some areas near small communities will have limited commercial collection services as a spin-off of services being rendered in the community.

- The majority of the collection and transportation activities that will occur in such a rural setting will be by the generator himself in his own private conveyance.

- Land disposal facilities used in conjunction with open burning is the most common means of solid waste disposal. The land disposal facility in most cases is not a sanitary landfill that meets Federal, state and local regulations, but rather will more than likely be a facility better described as an "open dump."

- Substantial amounts of solid waste disposed of in this rural setting will be by the owner-generator on his own land. The situation of a farmer or rancher burning the bulk of his paper waste in a 55 gallon drum in his backyard followed by dumping the ashes with other unburnable wastes in a ravine someplace on his own property is common.

- Because of the massive dilution capability of large blocks of land when few people are involved, there are quite often very few identified environmental degradation problems associated with such an informal system.

- Hazardous and toxic wastes will be virtually nonexistent in the rural setting of this project.

- The biggest solid waste management problems that exist in an area that is primarily rural but that does contain a few small communities will be in the areas surrounding the small communities, and not in the rural areas themselves.

Area Trends

All three economic areas along the pipeline are relatively well established, stable areas. Six of the 10 states in which these areas lie, for example, are in the top half of the Nation in terms of population size, but only two are in the upper half in terms of population change in the 1960-70 period. The rate of change in both urban and rural populations was typically below the national average in the 1960 decade in almost all counties of the area. The decline in population seen in the western grazing and wheat area during the past decade was due almost entirely to the decline in farm population and this trend can be expected to level off in the near future. The number of movers (people who lived in a different house in 1970 than in 1965) was lower than the national average of 47 percent in all the 10 pipeline states except Montana.

It is true that the manufacturing belt area produces a declining share of the Nation's manufactures but this is more the result of expanding activity elsewhere in the Nation than actual declining activity here. Thus with the exception of a few localized developments such as coal mining and coal gasification in the Montana and North Dakota portions of the western grazing and wheat area, little change in the population level of the pipeline counties or the type and nature of their economic and social structure is foreseen for the near future.

2.1.3.11 Land Use

Historic Land Use Trends

The land has changed dramatically during the past 100 years. Prior to the mid-1800's the prairies were a sea of grass supporting vast herds of buffalo and other grazing animals. In the Ohio Valley and the eastern deciduous forest regions of Pennsylvania and West Virginia, the virgin forests were relatively untouched.

Following the Revolutionary War the United States acquired about 1.9 billion acres of public domain through purchase or treaty, and the distribution of public land began. The Land Law Act of 1820 allowed purchase of 80-acre tracts for $1.25 an acre. Many settlers who could not raise the necessary $100 farmed the land without benefit of title. The Homestead Act of 1862 permitted citizens, or persons in the process of becoming naturalized, to obtain 160 acres of public land by paying a registration fee, living on the land for 5 years and beginning its cultivation.

As westward migration proceeded, the virgin timber stands were cut; the tall grass prairies were plowed or grazed by livestock.

Following the Civil War the livestock industry of the southwest moved north and east until it met the tide of livestock coming from the east. Ten million longhorns were driven from Texas to the midwest during the period 1865-1887. Cattle worth $4 a head in Texas brought $40 in northern and eastern markets and $150 in California. Cattle could be fattened on corn from the plowed prairie of Iowa and Illinois.

The white hunter destroyed the buffalo herds of the western Indian; the way was open for the advancing farmers. The cattle baron moved north to establish the western cattle empires. Control of strategic water holes meant free access to millions of acres of public land. Overgrazing soon killed the climax grasses in both the mixed and tall grass prairies and created dust beds over large areas.

In the northern great plains of Montana and the Dakotas the rangelands with better soils were converted to dry croplands which in favorable years produced bumper crops of dry land wheat. Some areas were reseeded to tame pastures utilizing introduced species.

The magnitude of the conversion of the land from one of natural plant communities to another of artificial character through intensive agriculture is illustrated by the present land use categories through which the proposed route passes (Table 2.1.3.11-1). Of the approximately 1,600 miles of the pipeline, 1,470 miles or 92 percent will cross agricultural land.

Only 357 miles will cross areas containing remnants of the original natural vegetation. Most of these areas (253 miles) are in the mixed grass prairie region in Montana, North Dakota and South Dakota. About 76 miles traverse remnants of the eastern deciduous forests and 25 miles cross natural waterways and flood plains along the entire route.

Present Land Use

Agricultural-Forestry

The U.S. Soil Conservation Service compiled in 1965 a land resource map of the United States which depicts resource regions and areas based on soils, climate and the resulting types of agricultural usage.

Since land use patterns have changed very little since 1965 in those states traversed by the proposed pipeline route this inventory adequately describes present land use conditions.

The only irrigated lands along the proposed route lie within two irrigation projects constructed by the U.S. Bureau of Reclamation. Both projects are in North Dakota. One is the Buford-Trenton Project on the Missouri River near the North Dakota-Montana border. This 10,000-acre

Table 2.1.3.11-1 APPROXIMATE MILES BY LAND USE TRAVERSED BY PROPOSED PIPELINE

Land Use	Mont.	N.Dak.	S.Dak.	Minn.	Iowa	Ill.	Ind.	Ohio	W.Va.	Pa.	Total Miles
URBAN (Residential, Industrial, Commercial)	0	0	0	0	0	0	0	0	0	4	4
AGRICULTURE											
Cultivated	82	125	149	120	231	150	137	182	3	35	1,214
Range	96	135	22	3	0	0	0	0	0	0	256
WOODLAND	0	0	0	0	0	2	7	40	4	20	73
RIGHTS-OF-WAY (Roads, RR, Utility Corridor, etc.)	1	3	3	1	6	4	2	5	1	1	27
WATERWAYS & FLOOD PLAINS	1	3	2	1	4	4	2	4	1	2	24
Total Mileage	180	266	176	125	241	160	148	231	9	62	1,598

project was constructed between 1940 and 1943. The proposed route crosses the main canal, three laterals, an open drain twice and about 4 miles of irrigated lands. The other project is the Heart Butte Unit of the Missouri River Basin Project in south-central North Dakota. The principal project facilities were constructed in 1948 and 1949. Only a portion of the irrigable lands, about 2,400 acres, have been developed to date.

The following descriptions relate to those delineations shown on the map in Figure 2.1.3.11-1.

(F) Northern Great Plains Spring Wheat Region

The fertile soils and the dominantly smooth topography of this region are favorable for agriculture, but the low rainfall and short growing season severely restrict the crops that can be grown.

The production of spring wheat dominates the agriculture of the region. Other spring grains, flax and hay are also grown. Potatoes are grown in many places and sugar beets and corn are important in the Red River valley in the east.

52 - Brown Glaciated Plain (Montana)

Almost all the land is in farms and ranches. Level areas, mostly in the west and amounting to almost one-half of the total area, are cropped. Spring wheat is the major cash crop, but feed grains and hay are also grown on most farms.

In the east, most of the land is in range, although the gentle slopes are dry farmed to wheat. Narrow discontinuous strips along the Missouri River are irrigated. Feed grains (including corn), hay and tame pasture occupy much of the irrigated land, and sugar beets are an important cash crop.

53 - Dark Brown Glaciated Plain (North Dakota, Montana and South Dakota)

Nearly all this area is in farms and ranches and slightly more than half is cropland. Spring wheat is the most important crop, but feed grains and forage are also important. Flax is grown on some farms; sugar beets are grown on irrigated land in the west. About two-fifths of the area, the more sloping land, is in native grasses.

54 - Rolling Soft Shale Plain (North Dakota and South Dakota)

Nearly all the land is in farms and ranches. In most of the area agriculture is a combination of livestock production and cash-grain farming. About three-fifths of the area is in native grasses and shrubs used for range. The less sloping land, amounting to about one-third of the total area, is dry farmed. Spring wheat, feed grains, some flax and hay are the principal crops. Cottonwood and elm trees grow on the narrow bands of wet soils along the large rivers.

55 - Black Glaciated Plains (North Dakota and South Dakota)

Nearly all the area is in farms and ranches, and nearly three-fourths is cropland. Cash-grain wheat production is the principal enterprise on many farms. Other small grains, feed grains and hay for livestock also occupy moderate acreages.

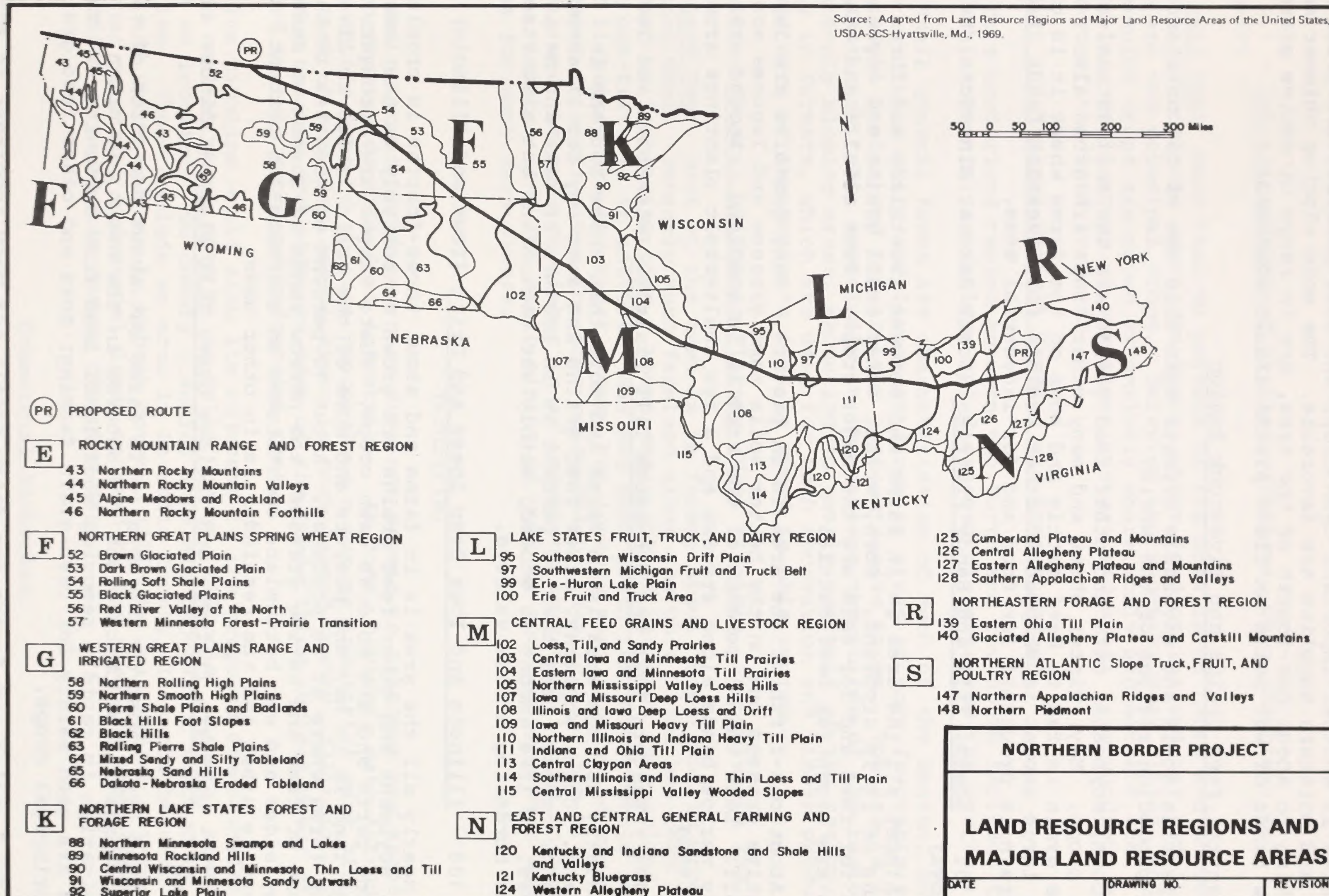


Figure 2.1.3.11-1 Land resource regions and major land resource areas

Flax is another important cash crop, and seed potatoes are grown where soils and moisture supplies are favorable. The more sloping thinner soils, amounting to about one-fourth of the area, are in range of native grasses. Narrow bands of wet soils on flood plains are in woodland.

(M) <u>Central Feed Grains and Livestock Region</u>

Fertile soils and favorable climate make this one of the outstanding grain-producing regions of the world.

Corn, soybeans, oats and other feed grains are the most extensively grown crops. Hay, winter wheat and many other crops are grown also. Much of the grain is fed to beef cattle and hogs on the farms where it is grown, but a large amount is shipped to other regions for livestock feed. Part of the grain is processed for food and for industrial uses.

102 - <u>Loess, Till and Sandy Prairies</u> (South Dakota, Minnesota, Nebraska and Iowa)

Almost all the area is in farms and between two-thirds and three-fourths of it is cropland. Corn, wheat, other small grains and soybeans grown for feed and for sale are the major crops. Some alfalfa and other hay crops are grown for beef cattle.

About one-fifth of the area is in pasture. Many pastures are largely of native grasses but on the better soils tame grasses and legumes are grown as well. Less than 1 percent of the area is in woodland. Wooded areas are mainly narrow bands along streams and a few shelterbelt plantings around farmsteads.

104 - <u>Eastern Iowa and Minnesota Till Prairies</u> (Minnesota and Iowa)

Nearly all the area is in farms and more than three-fourths is cropland. Corn, soybeans, other feed grains and some hay for livestock are the major crops. Less than 10 percent is in pasture of tame and native grasses. A like amount is wooded, mainly wet bottomland but also steep slopes bordering stream valleys.

108 - <u>Illinois and Iowa Deep Loess and Drift</u> (Iowa and Illinois)

Nearly all the area is in farms and about three-fourths is cropland. Corn, soybeans and other feed grains are grown extensively on the less sloping parts and are sold as cash crops. Where slopes are stronger, more of the land is in hay and pasture and more of the grain is fed to livestock on the farms where it is produced. About 10 percent of the area is in pasture of tame and native grasses; the narrow bands of forest on steep valley sides and wet bottomland constitutes an additional 5 percent. Five percent is urban and the remainder is in other uses.

110 - <u>Northern Illinois and Indiana Heavy Till Plain</u> (Illinois and Indiana)

<u>Land Use</u>: Most of the area is in farms but about one-fifth of the area, consisting of Chicago and its suburbs in the north, is urban. Urbanization is rapidly removing additional land from agriculture. Farmed areas are used mainly for cash-grain farming; corn and other feed grains are the principal crops.

Feed grains and forage for dairy cattle are very important in some places. Woodland occupies less than 5 percent of the area and is confined mainly to wet flood plains, steeply sloping valley sides and morainic ridges.

111 - Indiana and Ohio Till Plain (Indiana, Ohio, Michigan and Illinois)

Land Use: More than 90 percent of the area is in farms and about 80 percent is cropland. Corn, soybeans, other feed grains and hay for livestock are the principal crops. Dairying is important near cities, and truck and canning crops are grown extensively where soils and markets are favorable. Small areas of permanent pasture and small farm woodlots make up the rest of the land in farms.

(N) East and Central General Farming and Forest Region

This borderland region between the North and the South includes the Appalachian Mountains, valleys and dissected plateaus and the Ozarks.

Small general farms are characteristics of much of the region, but there are large dairy and livestock farms in areas of more favorable soils. Corn, small grains and hay are the most extensive crops. Tobacco is an important cash crop, especially in the eastern two-thirds of the region. The steeply sloping areas, amounting to nearly one-half of the region, are mainly in forests, which are used for both recreation and timber production. A large part of the Nation's coal is mined in this region.

126 - Central Allegheny Plateau (West Virginia, Pennsylvania and Ohio)

Land Use: Most of the area is in farms; about 10 percent is urban or in other uses. Recently much farmland along the Ohio River has been diverted to industrial uses. About one-sixth of the area is cropland and about one-fifth is in pasture. Hay and some grain for dairy cattle and other livestock are the major crops, but locally many fruits and vegetables are grown in small areas for home consumption. Nearly half the area is in forest, and the sale of timber is an important source of income on some farms. Leasing land for strip mining of coal is another important source of income for many farm owners.

Industrial

The proposed pipeline route does not appear to transect any areas that are currently identified as industrial. It does, however, pass through about 15,000 feet of an area proposed as a future industrial park along the east bank of the Mississippi River in Rock Island County, Illinois. The corridor touches the southern edge of the Quad-Cities nuclear power station located in this proposed industrial park.

The pipeline would also lie adjacent to the proposed Commonwealth Edison nuclear power site in La Salle County, Illinois. Several areas proposed as industrial on county planning maps are crossed or touched by the pipeline. These include an area in La Salle County, Illinois between La Salle and Utica and one in Wabash County, Illinois near Wabash. There may be other potential industrial lands crossed by the pipeline that are not identified on available county planning maps.

Commercial Fisheries

Commercial fishing in Montana is limited to larger bodies of water such as Fort Peck Reservoir. Along the proposed route only some baitfish seining of minor economic importance may take place. In North Dakota the route crosses Oahe Reservoir and the Missouri River in areas open to commercial fishing. Smallmouth and bigmouth buffalo, black bullhead, carp and goldeye are major species in the catch. While the Missouri River and its tributaries are fished commercially in South Dakota the route here does not cross commercial fishing waters. No active commercial fishing areas in Minnesota are crossed by the route although carp, buffaloes and other rough fishes are taken commercially in the upper Mississippi system. Iowa allows commercial fishing in the Mississippi for many of these same rough fishes. There was extensive mussel shell fishing in the Mississippi near the route crossing but staining of the shell from pollution has reportedly eliminated the demand by the Japanese cultured pearl industry. In Illinois the Mississipi and the Illinois Rivers also yield commercial catches of rough fish species. Pollution has had a similar effect here on the mussel shell fisheries. The Wabash River in Indiana has an active commercial fishery for rough fish and still has a significant mussel shell fishery. In Ohio the commercial fishing is mainly in the Ohio River which yields a variety of rough fish, carp, buffaloes and catfishes with an occasional paddlefish or shovelnose sturgeon turning up in the nets.

Here also the formerly valuable mussel shell resource has been affected by pollution problems. West Virginia shares these Ohio River commercial fisheries. No commercial fishing takes place along the Pennsylvania portion of the route.

Residential

The proposed pipeline route passes through several areas identified as residential or so near to existing residential areas as to be in the path of likely expansion of residential areas. These include about 1,000 feet of a proposed development area of the small town of West Bedford, Coshocton County, Ohio; about 1,000 feet of a proposed residential development area along the Ohio River in Brooke County, West Virginia; several potential urban areas as the pipeline winds its way through numerous suburban communities within the Pittsburgh metropolitan area such as a mile or so stretch between Houston and McGovern and again between Wickerham Manor and Victory Hills along the Monongahela River; a number of other communities such as Baines Hill, Mount Vernon, Jeannette and Penn, Pennsylvania appear to be similarly affected.

Planned residential areas transected by the proposed pipeline that appear on county land use planning maps include: a 7-mile stretch near Aberdeen, Brown County, South Dakota; 1/2-mile near Springville, Bureau County, Illinois; 9 miles near Coshocton, Coshocton County, Ohio; about 1,000 feet near Dillonvale, Jefferson County, Ohio.

Minerals

Only one area identified as a mine is transected by the proposed pipeline. This is a proposed quarry area on the west bank of the Illinois River, La Salle County, Illinois.

The pipeline would also pass over an area of underground mine workings in eastern Illinois, as discussed in the mineral resources section (Section 2.1.3.3). The possibility of future surface subsidence makes this area a potential hazard to the proposed pipeline.

One of the major potential coal producing areas lies in the Northern Rocky Mountain Region. Nearly half of the recoverable coal reserves of the western states lies in Montana and North Dakota. Due to the abundance of these relatively low sulfur reserves, synthetic gas manufactured from coal is a potentially large source of supplemental gas. Several coal gasification projects have been announced. Recent attention has been given to a project in the Dunn Center Reserve in the State of North Dakota. The proposed pipeline route traverses the center of these strippable coal reserves. The strip mining of large quantities of coal which will be required to support future energy needs may create serious environmental problems. Figure 2.1.3.11-2 illustrates major coal resources along the proposed route.

Recreation

Recreation use of land along the route is related to the differences in recreation between the eastern and western parts of the Nation. From the Montana border to Minnesota recreation is characterized by such factors as the rural nature of the small resident population, availability of game birds and big game for hunters and the opportunities to hunt without having other hunters in the immediate vicinity. In other words, the extensive use of land for hunting is an important recreational activity for the residents of the northern plains, and, because of its reputation as a hunting region, there is a positive economic impact to the communities and the states.

Designated recreation areas are of two types. They either serve local population or they serve tourists who must cross the high plains that lie between their homes in the East and the Rocky Mountains. The major recreation areas are those serving tourists and residents on a regional basis. These major regional recreation areas are generally associated with streams and reservoirs, and are managed by Federal and State governments. The best examples near the pipeline corridor in the Dakotas are the large and popular recreation areas along the reservoirs, such as the Oahe, on the Missouri River. Where possible these areas have been located at or near major river highway crossings for maximum tourist use.

Local recreation areas are primarily town parks. Most are activity-oriented to swimming or picnicking. Therefore, land acreage is usually not large. Where possible these parks are located near streams or occasionally lakes, to take advantage of the water, shade and green shrubs and grass. In recent years trails have become more important at all levels of government. No designated park areas are directly crossed by the pipeline west from Minnesota.

As one enters the cornbelt of Minnesota and continuing to eastern Ohio, a much larger population, smaller farms and intensive cultivation practices all influence recreation use of land. Because of large urban centers from the Mississippi River east, demand for public recreation land is most critical with most quality areas experiencing overuse. State parks and regional parks, like city recreation areas are much more oriented to serve local residents and generally are activity oriented.

Water for swimming, boating and fishing is a very important feature of many of these areas. Reservoirs serve as popular recreation areas. Hunting has not kept up with population growth in popularity mostly because of increasing closure of private lands, low game populations and probably devaluation of hunting experience to urban dwellers. Fishing on the other hand is growing in popularity in all the states along the pipeline corridor.

Trails for biking, horseback riding and walking are becoming popular with a growing segment of the population, especially those living in the large urban areas. They usually follow scenic areas, utility rights-of-way

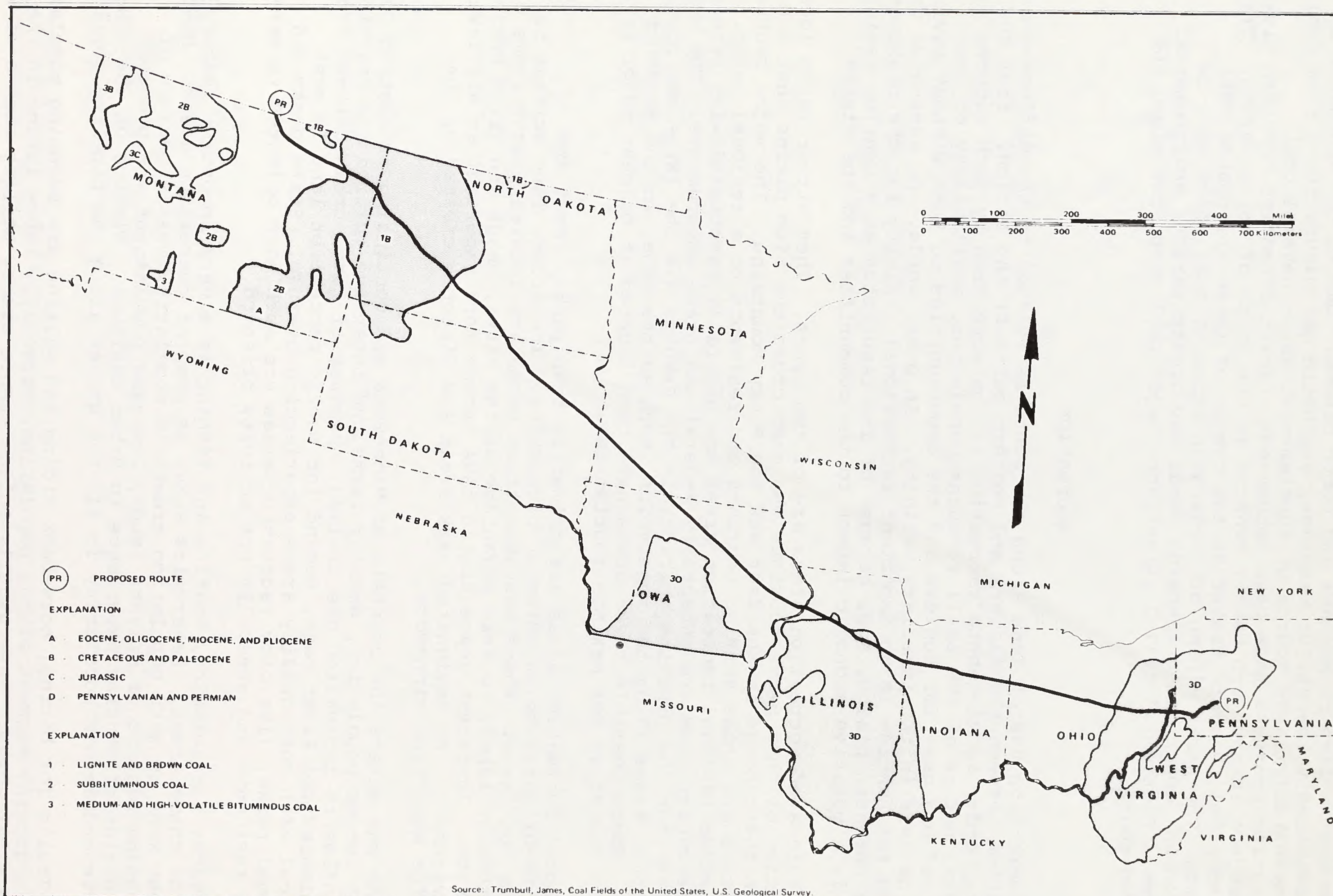


Figure 2.1.3.11-2 Coal resources of known or potential commercial value within the 10-State Area

or historical routes. Nine trails are crossed by the pipeline. The linear aspect of these kinds of recreation areas has resulted in recreation site designation becoming a much more important aspect of comprehensive planning as well as recreation planning in recent years. The growing trend to maintain flood plains in open space has also provided an increasing emphasis for establishment of trails within the flood plain. Several stream corridors along the pipeline have been delineated although planning is generally in preliminary stages. People living along the entire route have become aware of the importance of their relatively rare and unspoiled riverways. The recreation value of both scenic and historic river resources are beginning to be better identified and used.

From eastern Ohio and the beginning of the Appalachian Plateau to the end of the pipeline corridor the ridge and valley terrain reduces the amount of land under cultivation.

This allows for recreation pursuits such as big game hunting and backpacking that require large areas of available land. Designated recreation areas largely consist of city parks, some of which are in reality regional parks on the urban fringe, state parks and those areas associated with bodies of water such as reservoirs. These areas may be administered by any level of government and have become the principal day use areas in the region. Two of the regional parks are crossed by the pipeline in Pennsylvania.

In the vicinity of the pipeline corridor from about 20 miles west of the Ohio River to Delmont the region is urbanized. Valley bottoms and adjacent lands suitable for building construction have been largely consumed by the residential and industrial fringes of Pittsburgh and the industrial region of the Ohio River Valley. The question of open space planning is very real and by looking at regional plans one can see large parks being established on the edges of the Pittsburgh metro area. Many of these are on the ridges in contrast to valley floors, although some flood plain open space exists. However, all indicate the rapid increase in lands being set aside for open space for the use and enjoyment of the public.

Federal and State Reserves

The Federal Government has the management responsibility over large tracts of land in national forests, grasslands, wildlife refuges, parks and reservoir sites throughout the West. In the east, the Federal land management area becomes less, while the amount of State owned and managed land increases. In addition, the Indian reservations are primarily located west of the Mississippi River divide.

Lands under the administration of the Forest Service along the corridor consist of approximately 1-1/2 miles of the Little Missouri River National Grasslands in North Dakota. No National Forests are crossed by the Northern Border segment of the project.

The Fish and Wildlife Service administers several wildlife management areas. They have acquired many easements having significant waterfowl production areas on private land. About 30 miles of the proposed pipeline route encroaches on Federal management areas. Only a few state fish and game areas are crossed in this area.

The Bureau of Land Management has the managing responsibility for nearly 8.5 million acres of national resource lands in the states of Montana and North and South Dakota. The route crosses about 19 miles of these BLM lands. There is also a significant acreage of land in private ownership under which in addition the Federal Government retains title to about 115 miles of subsurface mineral deposits lying on private land. This includes, but is not limited to, the coal, gas and/or oil ownership rights.

The Bureau of Indian Affairs, acting as a service organization, assists in the management of the 931,223-acre Fort Peck Indian Reservation. The pipeline route traverses the Reservation from the west to east boundary, a distance of nearly 88 miles. Most of the present-day Indian land is in tribal estates; that is, reserves held in common under Federal trusteeship. In some cases, tribal members also hold individual allotments acquired by their families.

Recreational lands along the corridor consist of a number of reservoir projects and major river crossings under the jurisdiction of the Corps of Engineers but often managed by states. Many of these sites also include a lease agreement with the respective state fish and game agencies for wildlife management areas. Although the number of state and local recreation areas increase significantly as the population density increases, only about 6 miles of the route crosses state managed lands.

The Federal land ownership in the eastern sector is primarily national forests of which none is crossed. This is primarily due to the rugged, forested nature of most of this area. The National Park Service manages a number of historic parks, battlefields and historic sites near the proposed corridor.

Transportation Facilities

Highways, Roads and Railroads

The proposed route will cross 138 state and national highways, 15 interstate highways and many country roads.

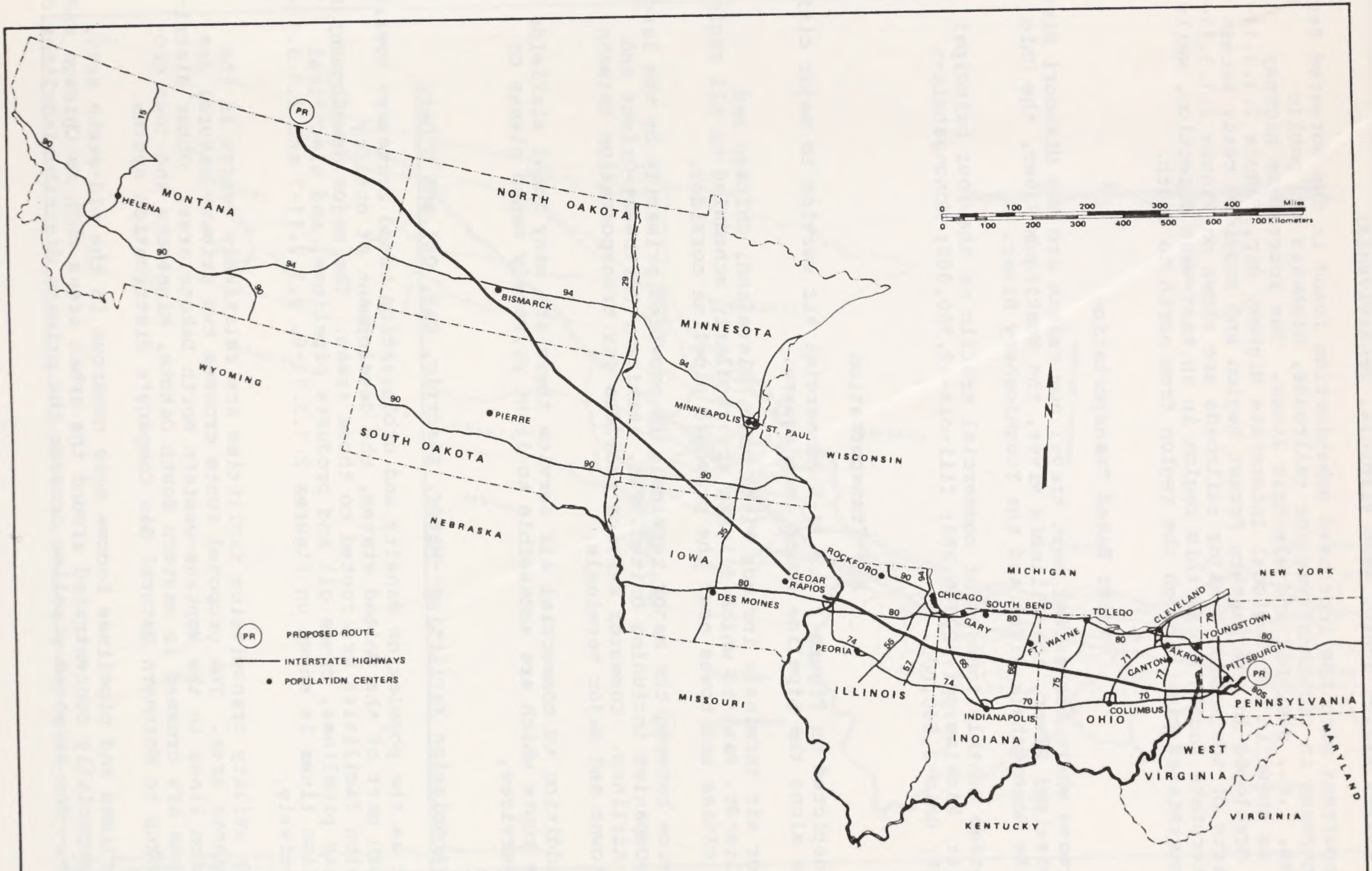
In general, the number of railroads, road and highway crossings increases from west to east.

Upper Missouri River Basin (Montana, North Dakota, South Dakota)

Only three interstate highways cross the Upper Missouri region. I-29 connects Fargo, Grand Forks, Sioux Falls and other cities in the eastern ends of North and South Dakota with points south. I-90, which crosses the United States from Washington State to New York, connects cities in Montana and South Dakota with points east and west. I-94 begins in Billings, Montana, connecting that city with Fargo, North Dakota and points east. State and local highway systems are relatively few in number and generally lightly traveled.

Cornbelt (Minnesota, Iowa, Illinois, Indiana)

Accompanying the increase in the number and size of urban areas in the cornbelt region is an increase in the number of interstate highways, railroad tracks and public utility lines. Many of the transportation and utility routes emanate from Chicago. Access to the region by interstate highway is generally good, as shown on Figure 2.1.3.11-3. Eight interstates cross the region in an east-west direction, while six interstates traverse the region from north to south. All major cities are serviced by one or more interstates; most are concentrated around Chicago and Indianapolis.



Source: Adapted from *The National Atlas of the United States of America*, United States Department of Interior, Geological Survey, Washington, D.C., 1970, p. 229.

Figure 2.1.3.11-3 Interstate highways in proximity to the proposed route

Eastern Forest Region (Ohio, West Virginia, Pennsylvania)

Concurrent with the increased urbanization found in the Forested Region is an increase in rights-of-way for railroads, highways and public utilities, i.e., gas, oil and electric lines. The interstate highway system, as shown in the Regional Interstate Highway Map, Figure 2.1.3.11-3, is well developed in the Eastern Forest Region and provides ready access to other parts of the Nation. Major railroads are shown on Figure 2.1.3.11-4. Nine interstate routes cross this region in an east-west direction, while eight interstates pass through the region from north to south.

Water Based Transportation

Streams where commercial boat travel now exists are the Missouri River, the Mississippi River, the Illinois River, the Muskingum River, the Ohio River, the Monongahela River and the Youghiogheny River.

Average monthly tonnage of commercial traffic on the four principal rivers is: Mississippi--2,000,000; Illinois--2,500,000; Monongahela--1,700,000; Ohio-2,500,000.

Air Transportation

As depicted on Figure 2.1.3.11-5 commercial air service to major cities and towns along the pipeline route is adequate.

Major air terminals include Pittsburgh, Cleveland, Chicago and Minneapolis-St. Paul to which flights are regularly scheduled to all regions of major cities and towns near the proposed pipeline corridor.

Service between the major terminals is provided primarily by the larger airline companies including United, TWA, American, Northwest-Orient and Frontier Airlines. Commuter service provides air transportation between smaller towns and major terminals.

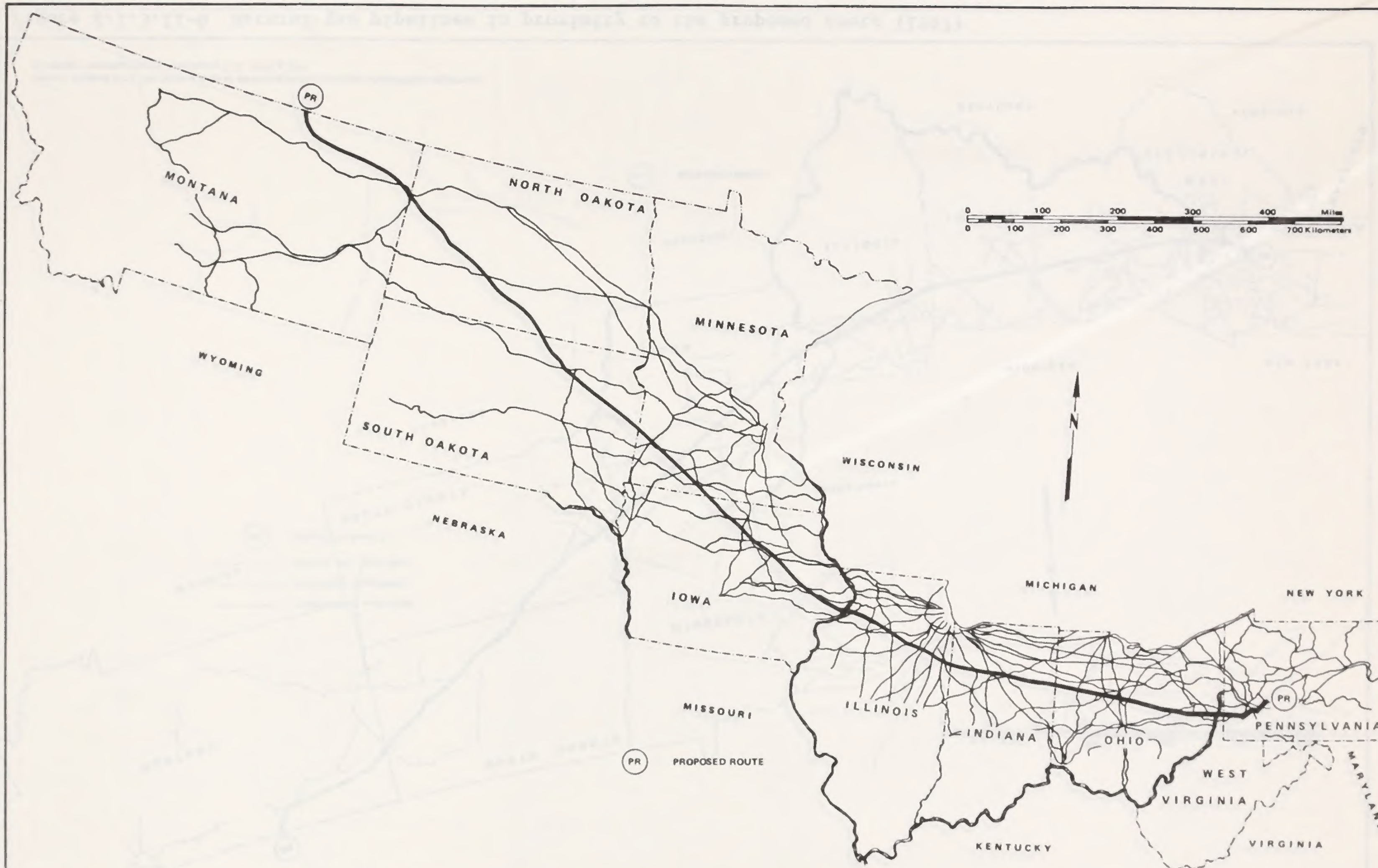
In addition to commercial air service there are many local airfields along the route which are accessible to light privately owned planes or charter services.

Transmission Facilities--Water, Electric, Gas, Oil and Others

Just as the population density and urbanization trend increases toward the eastern part of the United States, the development of utility transmission facilities are routed to those areas. The major development of natural gas pipelines, crude oil and products pipelines, and electrical transmission lines is shown on Figures 2.1.3.11-6, 2.1.3.11-7 and 2.1.3.11-8, respectively.

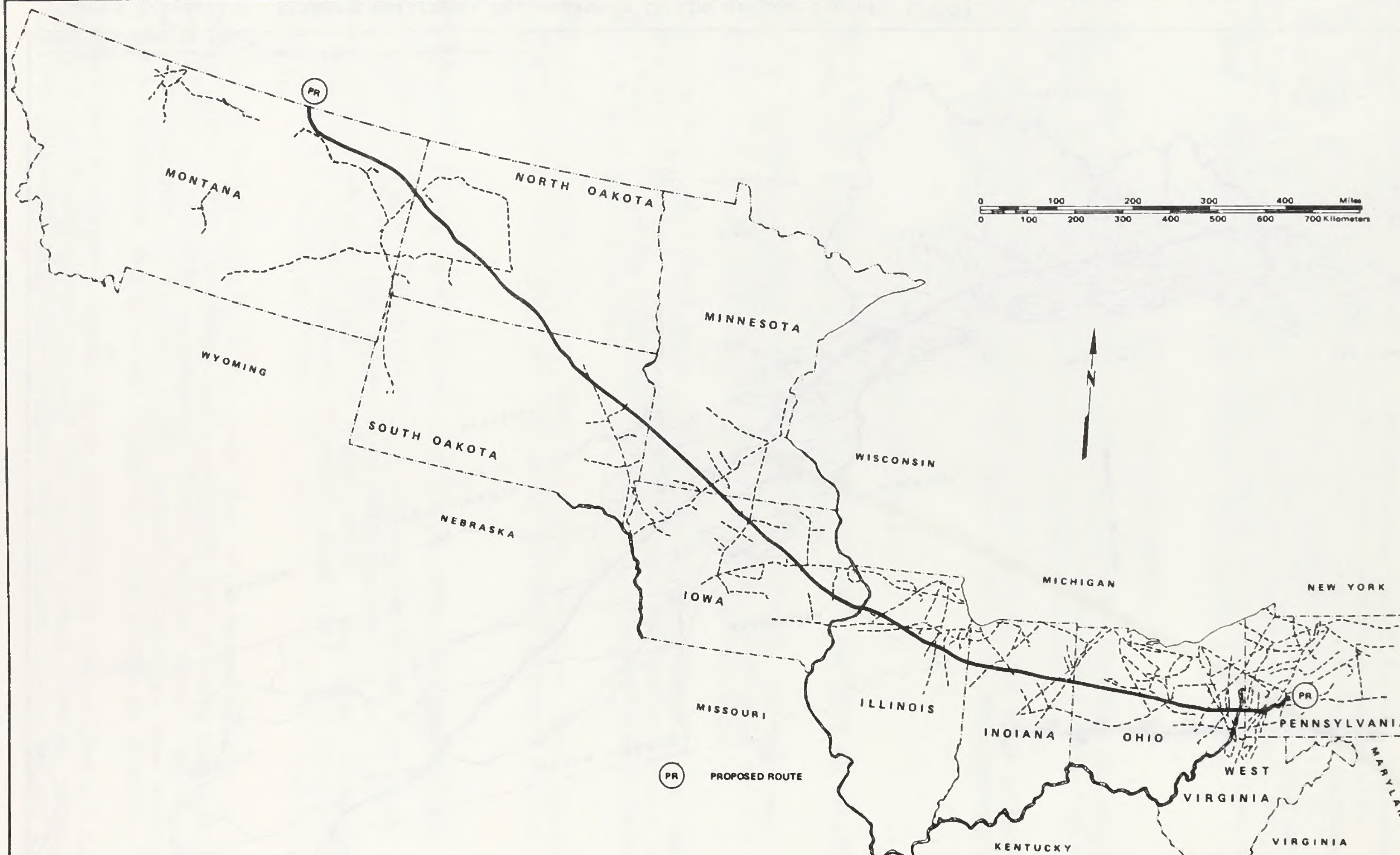
Major utility transmission facilities are relatively scarce in the Montana-Dakota area. The proposed route crosses two primary natural gas distribution lines in the Montana-western North Dakota area. Other distribution lines are crossed in eastern South Dakota, Minnesota and Iowa providing hookup to Northern Natural Gas Company's distribution system.

Powerlines and pipelines become more numerous in the mid-state area. They are especially concentrated around the urban areas such as Chicago and Fort Wayne. The proposed pipeline crosses the primary distributing lines of



Source: Adapted from *The National Atlas of the United States of America*, United States Department of Interior, Geological Survey, Washington, D.C., 1970, p. 231.

Figure 2.1.3.11-4 Primary railroads in proximity to the proposed route (1966)



Source: Adapted from *The National Atlas of the United States of America*, United States Department of Interior, Geological Survey, Washington, D.C., 1970, p. 237.

Figure 2.1.3.11-6 Natural gas pipelines in proximity to the proposed route (1967)

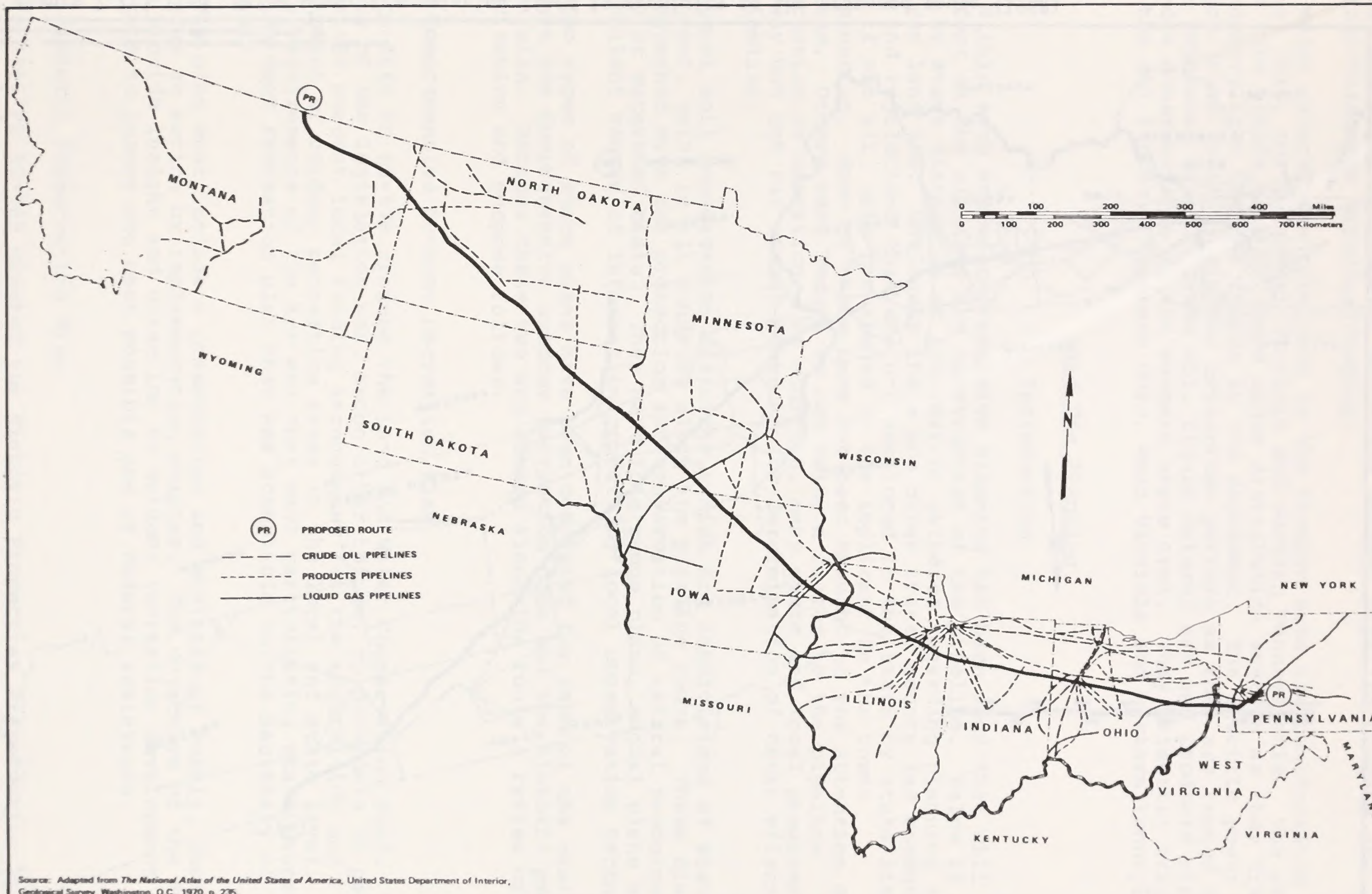
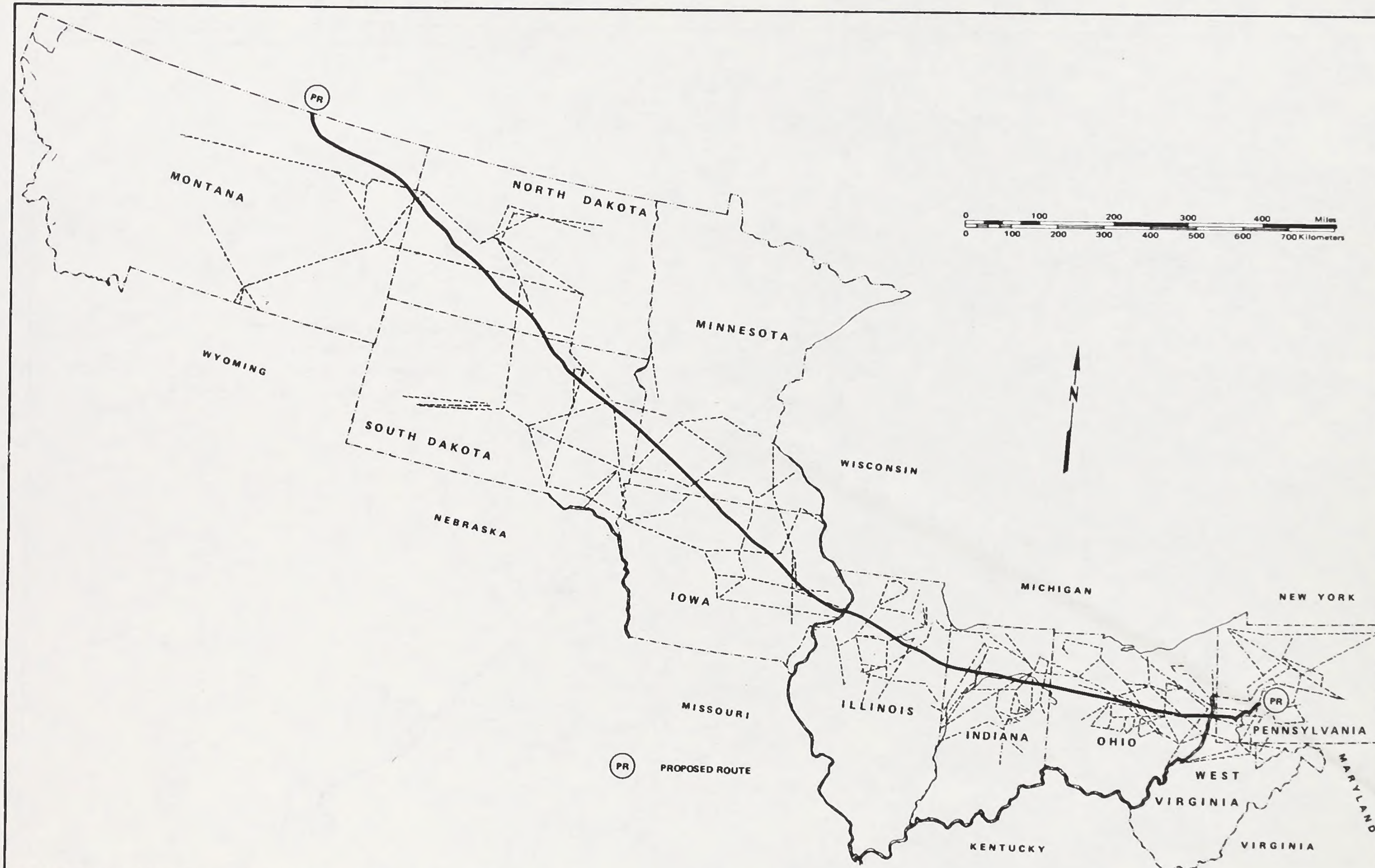


Figure 2.1.3.11-7 Crude oil, LNG, and products pipelines in proximity to the proposed route (1966)



Source: Adapted from *The National Atlas of the United States of America*, United States Department of Interior, Geological Survey, Washington, D.C., 1970, p. 191.

Figure 2.1.3.11-8 Major power transmission lines in proximity to the proposed route (1968)

Natural Gas Pipeline Company, Panhandle Eastern Pipeline Company and Michigan-Wisconsin Pipeline Company.

Major natural gas pipelines in the eastern area are concentrated in central Ohio, northern West Virginia and western Pennsylvania. The proposed route cuts across many of these major distribution systems as they traverse the country from the gas fields in the Southwest. The electric power transmission lines follow a similar crisscross pattern as they are routed to the major populated areas. Crude oil, liquid natural gas and products pipelines are more numerous than in the western state area. They primarily originate from the oil fields of eastern Ohio, West Virginia and western Pennsylvania.

Land Use Planning

Introduction

Within each state comprehensive planning has been done that will have an effect on the planning and construction of the pipeline. Below is a state by state discussion of information gathered regarding planning that involves land use. Obviously there are other state, county and community plans and regulations that are not mentioned in the state by state listing. Most, if not all, were researched by the applicant in the route determination. Some of these have not been brought to the attention of the EIS team. Others were judged as not being a factor to the pipeline construction or operation. In addition, many state and local programs were underway but not far enough advanced for determination of their effect on the pipeline.

Local soil conservation districts, which are subdivisions of state government, exist in all counties along the pipeline route. These districts are concerned with the protection and conservation of natural resources on a county or watershed basis. They have long range plans, annual plans and are an excellent source of information concerning local conservation techniques.

Two types of state plans have been completed for each of the states. They are the comprehensive outdoor recreation plan and the historic preservation plan. Because these two are common along the route a review of their authorization and purpose follows:

State Comprehensive Outdoor Recreation Plan

In 1965 PL 88-578 created the Land and Water Conservation Fund. The purpose of the legislation was, among other things, to provide a 50 percent Federal-50 percent local funding arrangement for the acquisition and development of outdoor recreation areas at the local and state level. One of the requirements of the Act was that each participating state prepare a state outdoor recreation plan that was acceptable to the Secretary of the Interior.

The plan must include a presentation and analysis of supply, demand and need plus an action or implementation chapter. The objective of the SCORP is to provide insight and direction to outdoor recreation development within the state to insure the best possible use of Federal assistance.

State Historic Preservation Plan

In 1966 PL 89-665 created the Historic Properties Preservation Program. The Act includes Federal funds for the preparation of comprehensive statewide historic surveys and plans. The specific purpose of the State Historic Preservation Plan is to provide identification, establish priorities and to present an action or implementation plan for the preservation, acquisition and development of significant historical and archeological sites in each state. The plans are to be completed by each state with the leadership of the State Historic Preservation Officer and transmitted to the National Park Service. Upon acceptance of the plan by NPS, each state becomes eligible for Federal assistance through the National Park Service in the form of matching financial grants.

State by State Summaries

Montana

Local planning in Phillips, Valley and Roosevelt Counties are in the early stages of development. No zoning regulations exist outside of the incorporated communities. Some economic development planning has been done for the Fort Peck Reservation. There are four statewide plans in existence that could influence the pipeline. They are the State Water Plan, the State Historic Preservation Plan, the State Comprehensive Outdoor Recreation Plan and the overall State Economic Development Plan.

North Dakota

Maps indicating future land uses exist for Mercer, Morton and McIntosh Counties. Other counties have not completed similar planning maps. Two RC&D districts, Lewis and Clark and Roosevelt and Custer have done planning for their respective areas. There are also two additional planning efforts underway in western North Dakota. They are the West River Diversion Plan being done by the state and the Rolling Prairie Planning Unit of the U.S. Forest Service which is being done by the Custer National Forest. Because county level planning is a recent program, no resulting land use regulations such as zoning exist along the route in North Dakota.

Statewide planning includes the State Historic Preservation Plan, the State Comprehensive Outdoor Recreation Plan and a statewide development plan.

South Dakota

Planning on the County level is of limited scale, but county land use maps are available for McPherson, Brown, Day, Codington, Hamlin and Brookings Counties. No countywide zoning is now in existence.

South Dakota is presently preparing a State Water Plan. A State Historic Preservation Plan and a State Comprehensive Outdoor Recreation Plan have been completed. A State Economic Development Plan has also been prepared.

Minnesota

While only Murray County has a completed future land use map, all of the counties in Minnesota which lie in the path of the pipeline have a planning staff and program. Lyon, Murray, Cottonwood, Jackson and Martin Counties have established county zoning. Lincoln County has not enacted zoning controls but has, along with the other five, established shoreland management ordinances for the lakes within their borders.

Minnesota is a national leader in outdoor recreation planning as their SCORP is evidence. The state also has a State Historic Preservation Plan but no statewide land use plan nor water plan has been prepared so far.

Iowa

The county conservation boards must have completed county plans in order to meet state level requirements for certain Federal financial assistance programs. Only five counties presently have land use planning maps; however, it is likely all will have land use plans shortly along with land use regulations such as county zoning. As in Minnesota, there is a possibility that because of advanced county planning, additional county ordinances may influence the pipeline.

Several state plans also have been completed that affect Iowa's land use. The principal ones are the Comprehensive Outdoor Recreation Plan, the State Water Plan, the State Historic Preservation Plan and a statewide development plan.

Illinois

Statewide the Historic Preservation Plan, the State Outdoor Recreation Plan and the State Water Plan are the primary plans that may influence the pipeline. There is no state economic development plan at the present time.

Future land use plans for Rock Island, Whiteside, Bureau and La Salle Counties have been completed in recent years. In addition, Kankakee and Iroquois have active planning programs. No county zoning is in effect.

Indiana

Three state plans are completed that may influence decisions regarding the pipeline. They are the State Water Plan, the State Comprehensive Outdoor Recreation Plan and the State Historic Preservation Plan. There is no State Development Plan at the present time.

Available information indicates that land use planning maps have been completed for White, Miami, Wabash, Wells and Adams Counties. A comprehensive plan is presently being prepared for Huntington County. No county zoning regulations are presently in effect. In Indiana special plans such as the one for the Wabash River are likely to affect the pipeline.

Ohio

Counties in Ohio do not have authorization to impose county zoning. Instead, a township-by-township vote of the people is needed to institute zoning. Agricultural land and public utilities land is exempt from zoning and is considered only as a land use. All counties along the pipeline route, however, have established planning offices.

Ohio has a State Transportation Plan, a State Water Plan as well as the SCORP and SHPP that all the preceding states have. There is no economic development plan at the state level.

Pennsylvania

Washington, Allegheny and Westmoreland Counties have active planning programs. None have adopted countywide zoning regulations. With the large number of communities in this part of Pennsylvania, it is likely that city zoning regulations may become relevant to the pipeline. This is especially true of subdivision regulations.

At the state level the State Comprehensive Outdoor Recreation Plan and the State Historic Preservation Plan have been adopted by the state. A State Land Use Plan is now being prepared as is the State Water Plan. An Economic-Development Plan has been completed. The state has existing sedimentation and erosion regulations in effect which will likely be an important factor in pipeline construction.

Expected and Potential Trends

Upper Missouri River (Montana, North Dakota, South Dakota, Minnesota)

In the sparsely populated states of the Upper Missouri River Basin agriculture is by far the major land use.

Future land use is predicted to remain very similar to present land use. Federal emphasis on all out food production to meet world-wide food shortages will probably result in more marginal land being farmed in the spring wheat areas.

West of the Missouri River water is in very short supply and will be a limiting factor in any future industrial development.

The current energy crises and recent advances in coal gasification technology could lead to significant future land use changes in areas where coal deposits occur and in nearby communities. The proposed pipeline route crosses the vast coal reserves of the Ft. Union formation in eastern Montana and western North Dakota.

Commercial gasification plants are presently under consideration in Dunn and Mercer Counties in North Dakota. Emmons, Morton, Oliver and Sioux Counties, North Dakota are also potential impact counties should full coal gasification development occur.

With this development populations in the effected counties might double by the year 2000. Significant areas of grazing lands would be permanently converted to plant sites and expanded communities while large areas would be temporarily used as mining sites.

In Brown and Spink Counties, South Dakota, a proposed irrigation project by the U.S. Bureau of Reclamation might convert 190,000 acres of nonirrigated range and cropland to irrigated cropland by 1988. If the project is further developed to its potential 495,000 acres of land could be irrigated.

The Cornbelt (Iowa, Illinois, Indiana, western Ohio)

Agriculture is the primary land use in the cornbelt states and is likely to remain so in the foreseeable future. All of these states through which the pipeline route passes are expected to grow in population with resulting demands on agricultural lands near population centers.

Because the pipeline route has been located to avoid population centers, very little change in land use is anticipated along the route.

Ohio River Basin (eastern Ohio, West Virginia, Pennsylvania)

The pipeline route through this region traverses lands predominantly in agricultural or forestry use. However, it is in this region that significant areas of urban use occur. Future land use is expected to follow the existing pattern with some increase in urban usage as cities and towns grow. Pressures for recreation by urban populations may also accelerate the use of flood plains for recreation.

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2.1.3.12 Cultural Resources

Archeology

The General Area and Possible Future Discoveries

The pipeline corridor has not been surveyed for archeological or historic resources. The information presented is an accumulation of known facts gathered essentially from the environmental assessment provided by the applicant. Additional sites will undoubtedly be found along streams and in flood plains. For known sites, size, age, cultural affiliations and present state of preservation are frequently unknown. Thus, no effort is made in this description to place a value on the site to determine its significance. Usually historical sites are more readily identifiable because they are more often surface structures than archeological sites.

Following is a resume that describes the setting for known sites and indicates the likelihood of additional sites of the pipeline corridor. The route has been divided into the Missouri River Basin, the Upper Mississippi River Basin and the Ohio River Basin for purpose of this discussion.

The Missouri River Basin

To make the description more manageable, this segment will be divided into the Northwestern Plains, the Middle Missouri and the Northeastern Periphery.

The Northwestern Plains subregion includes the Yellowstone and Upper Missouri River drainage, where rainfall averages less than 15 inches annually and agriculture was not generally feasible in prehistoric times. For many years it was believed that this area was uninhabited prior to the introduction of the horse, but recent studies have shown that most of the area was continuously inhabited by nomadic hunters and gatherers through the prehistoric era.

The remains of the earliest inhabitants of the Missouri Basin have been discovered in the Northwestern Plains. These people are called Paleo-Indians or Big Game Hunters and probably arrived in the area over 12,000 years ago. The latter name derives from the frequent association of early projectile points with now-extinct Late Pleistocene megafauna, such as the Columbiana mammoth (*Mammuthus* [*Parelephus*] *columbis*) and *Bison antiquus*.

Remains of these early hunters are rare and widely distributed over most of the North American continent. It has been hypothesized that the Paleo-Indians traveled in small, migratory family groups which rarely remained in one location for an extended period of time.

Clovis points, which are large, lanceolate spear points with short basal flutes, are diagnostic of the Paleo-Indian Period to 9000 B.C. in most of the U.S. and are found with mammoth remains. Dating from 9000-8000 B.C., the subsequent Folsom points were limited mainly to the Plains, where they have been found with remains of now-extinct bison.

During the Late Paleo-Indian Period, Plano points, which are long, lanceolate points with fine parallel flaking, were common in the Plains area. The Agate Basin, Cody and Angostura complexes, which contain Plano points, have been found in early stratified sites in Wyoming and Montana. The Eden and Scottsbluff Plano points, which have a fairly wide distribution, are part of the Cody complex. Grinding tools are found on Late Paleo Period sites, and perhaps indicate a more intensive use of the area's resources. The Plains Paleo tradition ends about 5000 B.C.

Paleo-Indian sites are often found covered by layers of accumulated soil in caves or alluvial soils near streams. Artifacts are sometimes on the ground surface, where they have been exposed by wind erosion. Areas near Late Pleistocene lakes and streams are potential site locations.

Few campsites from the Paleo Period have been discovered, and most of the knowledge of this period has come from special-use sites such as "kill sites" or from isolated artifacts. Thus, little more is known about Paleo-Indians other than the location of these sites, which have been recorded in Montana and South Dakota but have not been officially listed in North Dakota.

Following the Paleo-Indian Period, a drier climatic period, the Altithermal, caused a redistribution of the population in the Northwestern Plains during the Early Archaic. This period is known from several Wyoming sites, but very few sites in Montana have been examined. It has been hypothesized that larger game was more abundant in the north, where the population density was somewhat greater. The return of more favorable climatic conditions is indicated by the increase of bison remains in the Northwestern Plains region. Large, lanceolate projectile points continued in use, but other side-notched points were introduced during this period. The tool kits from these sites are typologically similar to those of other areas for the Archaic Period. Sites were probably reoccupied seasonally.

Climatic limitations prevented the expansion of the Woodland pattern into the Northwestern Plains. Modifications were made in the tool kit, but pottery, agriculture and mounds were never significant in this area. Dentalium shells and pottery fragments found in eastern sections of the area indicate increased contact with Middle Missouri groups after A.D. 500. Semi-permanent habitations have been found at the Hagen and Ash Coulee sites near Glendive, Montana. It has been suggested that these are early Crow sites, related to the Middle Missouri Hidatsa.

Archeological sites which may be found in the Northwestern Plains are tepee rings, bison kills, boulder effigies, aboriginal trails, wooden structures and vision quest sites. Areas along river banks may have supported semi-permanent villages, and caves were inhabited. In addition, workshop stations of various kinds, some of them situated far from present water or otherwise favored stopping points have been found in the Northwestern Plains.

To the east of the Northwestern Plains lies the Middle Missouri Trench, which has been more extensively studied by archeologists. Much of this work has been coordinated by the Smithsonian Institution River Basin Survey in connection with the construction of major flood control projects along the Missouri River from the Yellowstone to the southern South Dakota border. These surveys were usually confined to areas where flooding would be most extensive.

Evidence of pre-Woodland groups in the Middle Missouri region is almost nonexistent. The people probably had a hunting and gathering subsistence pattern. Deer, antelope and smaller game were more important during the Archaic than in the Paleo-Indian Period. This may reflect the Altithermal conditions in this region.

The Woodland Period is characterized by the use of pottery and the construction of burial mounds and dates from about 250 B.C. to A.D. 900 in the Middle Missouri region. Although very similar to the Eastern Woodland culture, there is no evidence of incipient agriculture in this area. The Woodland culture developed in the eastern forest, and its influence was slow to spread into the Plains. The wooded bottomlands along the smaller streams were intensively exploited, and it is here that the small, poorly defined sites from this period have been found. The eastern influence is reflected in the Middle Missouri region's pottery, which resembles that of the Mississippi and Ohio Valleys. From the Garrison Dam north, thick, cord-roughened sherds and large, stemmed projectile points are sometimes found on buttes and other high points. Along the Oahe Reservoir, Woodland Period sites underlie much more extensive alter sites.

It is hypothesized that during the Early Woodland Period, small family groups built temporary houses and subsisted by hunting bison and other game and by gathering wild plant resources. Slightly later sites in South Dakota appear to have been reoccupied frequently for extended periods of time, a fact indicative of a more settled lifestyle. Corn and beans may have been introduced into the area sometime after A.D. 200, and venison was more important in the diet. Clamshell ornaments and mounds are associated with later Woodland sites in the Middle Missouri region.

Few Woodland villages were excavated as part of the Missouri Basin Project, and many of the recorded sites dating to this period now lie under water. There is some evidence that Woodland sites may be found near the Knife, Heart and Cannonball Rivers in North Dakota.

During the subsequent Plains Village Period, A.D. 900-1860, agriculture became increasingly important in the subsistence pattern. Large permanent villages accessible to tillable land were built along the Missouri. During the winter the village broke into smaller groups which lived in sheltered areas, often in the smaller stream valleys. This allowed for maximum exploitation of limited winter resources. Within this cultural pattern several subdivisions have been defined which reflect changes through time and the growing contrast between cultures in North and South Dakota.

In South Dakota, the Initial Middle Missouri phase lasted from about A.D. 950 to A.D. 1400 and was followed by the Coalescent Period. The Extended Middle Missouri phase, A.D. 1100-1550, was essentially a North Dakota cultural development with a period of expansion into South Dakota. It was followed by the Terminal Middle Missouri phase in North Dakota, which lasted until the historic period.

Most of the Initial Middle Missouri phase sites have been found south of the Cheyenne River in South Dakota. It has been hypothesized that these sites were left by a horticultural group from southeastern South Dakota which migrated to the Missouri River. During this period the pattern of large, summer farm villages and scattered winter camps developed.

Extended Middle Missouri sites are found south of the Knife River in North Dakota and in the vicinity of the Bad and Cheyenne Rivers in South Dakota. The southern sites do not overlie Initial Middle Missouri sites, and it is hypothesized that an Extended Middle Missouri group invaded Initial Middle Missouri territory, forcing the latter to increase their fortifications and move to the south. These southern Extended Middle Missouri sites were abandoned around A.D. 1250. After A.D. 1450 this group once again settled in South Dakota.

Extended Middle Missouri sites in North Dakota were frequently small and lacked fortifications. The southern sites of this phase were similar to Initial Middle Missouri sites in size and were frequently fortified by ditches and palisades with bastions.

The Coalescent Period received its name because there seemed to be a fusion of Central Plains, Oneota and Middle Missouri traits in South Dakota after A.D. 1450. A variety of village layouts and methods of house construction were used.

In North Dakota, the Terminal Middle Missouri cultural pattern is contemporary with the Coalescent Period. Most of these sites have been found between the Knife and Cannonball Rivers along the Missouri and consist of large villages containing long, rectangular houses. Strong fortifications distinguish these sites from Extended Middle Missouri sites in this area. There is evidence of conflict between the Coalescent and the Extended Middle Missouri groups in the border area between North and South Dakota.

The differences between North and South Dakota lessened during the Post-Contact Coalescent Period from the late 1600's to the 1780's. During this period, these three villages' tribes reached a peak of prosperity due to intertribal trade. The villages were large and well stockaded, and houses were the circular earth lodges reported by early travelers.

After the first recorded small pox epidemic of the late 18th century, the village tribes slowly declined. Population declined, villages showed signs of neglect and after 1845 the Mandan, Hidatsa and Arikara all lived in one village on the present Fort Berthold Reservation.

The Northeastern Periphery region of the Plains lies east of the Middle Missouri region and northeast of the Coteau du Missouri. The James River Valley is within this region. This area, which is covered with tall grass and dotted with lakes, encompasses the eastern Dakotas, extreme western Minnesota and a corner of northwestern Iowa. Unfortunately, the early record of this area is poorly documented.

A few Paleo-Indian Period projectile points have been found west of the Red River in North Dakota, and several sites have been excavated in Browns Valley, Minnesota. There is almost no information on the Archaic Period in this region. It is assumed that the cultural pattern was similar to that of better known areas to the east. Small family groups probably followed a cyclical pattern of nomadism within a large territory.

The earliest known sites along the Big Sioux and James Rivers belong to the Woodland Period and have cultural traits intermediate between contemporary Mississippi Valley and Missouri Valley groups. In southeastern South Dakota, semi-sedentary villages of the Woodland Period were built on stream terraces and partially surrounded by ditches. Also found were bison scapula hoes, a distinctive Plains artifact. The presence of hoes may suggest that agriculture was practiced by these people.

After about A.D. 1000 the Northeastern Periphery was influenced by the Mississippian culture. The Over focus in southeastern South Dakota and the Mill Creek focus in northwestern Iowa reflect this influence. Agriculture probably assumed an increased importance, and population seems to have concentrated along the major rivers. Mounds were still being constructed.

During the first half of the 18th century, the Dakota (Sioux) moved west. The Santees lived near Mille Lacs, Minnesota; the Teton settled near the Missouri River and the other Dakota bands lived around lakes and rivers in the area between the first two groups. The Assiniboin, a Dakota offshoot, seem to have been in the vanguard of the move to the northwest.

During early recorded history the Cheyenne lived along the Cheyenne River in North Dakota, and were influenced by the cultural developments in the Upper Mississippi Basin and by the Middle Missouri cultures. About 1750 they were being pushed west by the Chippewa, and by 1804 they had completed the transition from horticulturalists to nomadic bison hunters.

Burial mounds are found scattered throughout the Northeastern Periphery region, but the highest concentration is along the eastern edge of the area. Conical mounds are frequently clustered in groups of from 2 to 50, often situated on bluffs overlooking stream valleys and eminences near lakes or creeks. Linear mounds have been found along the upper James River in North Dakota. From Jamestown, North Dakota, to Saskatchewan, a special funeral pottery is found in many mounds. Marine shell gorgets resembling artifacts from Ohio and Tennessee have been discovered in some mounds. These mounds may date from 100 B.C., but many may be of more recent origin.

Other types of sites found in the Northeastern Periphery include boulder outline figures, circles and effigies found in association with cairns or mounds, and mounds connected by pathways paved with bison leg bones. In addition, a bone-covered conical hill which was used as a lookout by the Cheyenne has been found.

The Upper Mississippi River Basin

The Upper Mississippi Basin, including Minnesota, Iowa and Illinois, forms one sub-area of the prehistoric Eastern Woodlands cultural area. Four basic cultural traditions developed during the long prehistoric era. Sequentially there are the Big Game Hunting or Paleo-Indian, the Archaic, the Woodland and the Mississippian. These traditions correlate roughly with time periods for which the same names may be used.

The earliest inhabitants of the Upper Mississippi Basin were big game hunters who followed large herd mammals into the area as the Wisconsin glacier retreated. This theory is partially based on the fact that the large diagnostic spear points of this period have been found in association with the remains of mammoth and large, now-extinct bisons. It is hypothesized that these early hunters lived in small nomadic families during the Paleo-Indian Period. In more forested areas, such as Illinois, it is probable that smaller animals formed a large portion of the diet.

The earliest spear points found in the Upper Mississippi Basin are Clovis points. In Minnesota and Iowa, Folsom points followed, while in Illinois a related form, the Cumberland point, is found as are some later adaptations.

Because most Paleo-Indian Period artifacts are not found in sites, little else can be said about the culture of these people. Browns Valley, Minnesota, is one area where in situ sites from this period have been studied.

During the subsequent Archaic Period (6750-1000 B.C.), regional differences became more obvious. The resource potential of the area was more intensively exploited through time by the Archaic people. They probably lived in family groups of from 20 to 60 people and wandered in a pattern of cyclical nomadism. Some campsites from this period contain evidence of reoccupation by people with similar cultural patterns. Knolls near streams were frequently occupied. A few scattered post holes have been discovered in Archaic sites, but there is no good evidence of permanent structures. The more numerous Archaic sites may indicate an increase of population. Among the artifacts which may be found on sites after 5000 B.C. are implements made of copper from the Lake Superior area and traded throughout the Upper Mississippi and Ohio Basins. A new method of working stone, i.e., pecking, grinding and polishing, was also introduced during this period and was used to manufacture atlatl weights and bola stones. By the end of the Archaic Period, there was a significant increase in the number of tools used in processing edible seeds. Although Archaic spear points had regional variants, they were usually large and crudely flaked, with side notches near the base for hafting. Burial was frequently in a shallow grave on a hillside, or glacial knoll, perhaps near a stream.

Starved Rock, one of the few northern Illinois Archaic sites, has a similarity to Plains sites because of the presence of lanceolate points and a lack of polished stone artifacts. Evidence from these sites indicates that the inhabitants had adapted to a basically Plains environment and relied heavily on bison.

Burials from later pre-pottery sites in Iowa contain quantities of red ochre, probably influenced by the development of the Red Ochre complex to the north and east. Due to its proximity, the southern part of Minnesota was probably more heavily influenced than the rest of the region by the Old Copper culture of the Lake Superior area. Thus, Archaic sites in Minnesota may contain the copper spear points and knives typical of that culture.

The appearance of pottery, mounds and incipient agriculture separates the Woodland Period from the preceding Archaic. These developments appear in Illinois prior to their appearance in Iowa and Minnesota.

During the Early Woodland Period (1000 B.C.-500 B.C.), several local burial patterns developed within the Upper Mississippi Basin. The subsistence pattern was probably very similar to that of the Late Archaic, with the increased emphasis on seeds allowing a more stable residence pattern to develop. In the central Illinois prairie and extending along the Illinois River were small scattered villages containing pottery and associated with burials covered with layers of black sand.

Heavy, cord-marked pottery and large, stemmed projectile points are characteristic of the Early Woodland Period in Minnesota. Some associated early mounds contain secondary bundle burials covered by burned logs.

Burial mounds have been found in Iowa, but because Early Woodland pottery is rare, it is difficult to correlate village sites and mounds. The prairie inhibited the spread of the Woodland culture into Iowa and most sites from this early period are located on high ground near streams in northeastern Iowa.

The Middle Woodland Period is characterized by the spread of Hopewell influence. This culture, which began to develop around 300 B.C. in the vicinity of the Illinois River Valley, is typified by elaborate grave goods, often made of exotic material. Log tombs containing extended or bundle burials were covered by earthen mounds and located on the bottomland or occasionally on the tops of ridges. Most adults were buried with few grave goods on bluff tops, while children were buried in the village.

Small, permanent Hopewell villages have been found along the major Illinois rivers and were usually somewhat sheltered by hills. These villages were well-drained and were located near springs and tillable soil where corn, beans and squash were grown. The importance of rivers to the Hopewell is demonstrated by the fact that villages along a river, though far apart, resembled one another more than they resembled villages in adjacent watersheds. Except for the absence of corn, beans and squash, the Hopewell sites in Iowa and Minnesota are similar to those in Illinois.

The Mississippian Period in the Upper Mississippi began after A.D. 1000 and lasted until the historic period. This was a time when new life styles and cultural traits were fused with the general Woodland pattern. The impetus for this change came from the Central Mississippi area from St. Louis, Missouri, south to the Arkansas River.

The Mississippian culture, which began to develop around A.D. 700, exhibits many traits which are probably of Mesoamerican origin. In the Central Mississippi area, large permanent towns with temple mounds were built and agriculture assumed increased importance for these people. Mississippian traits entered the Upper Mississippi area by indirect contact and by colonization of that area by Mississippian people. The northernmost colony of these people was at Aztalan in southern Wisconsin.

Northern Illinois cultures are distinguished from those of the Central Mississippi area during this period by scapula hoes, antler and bone projectile points, harpoons, a limited range of vessel forms and stone disc pipes. It has been hypothesized that a new cultural center was developing in the northern Illinois area in the late prehistoric period.

The most widespread of these late cultures developing from a mixed Mississippian-Woodland base was the Oneota. Adapted to an environment intermediate between prairie and forest, the Oneota combined cultural traits from both areas. In western Illinois, Iowa and southern Minnesota, their villages are almost always found along the major rivers, and their cemeteries are often on nearby ridges. The entrance of the Oneota culture into Iowa is dated to about A.D. 1300, and it slowly spread west across the state. Although remains of this culture are found over a large area, it appears that Oneota population density was low. The historic Iowa, Oto, Missouri, Osage, Sioux and Winnebago may be descendents of this late prehistoric culture.

The Ohio River Basin

The Ohio River Basin is one sub-area of the Eastern Woodlands cultural area during the prehistoric era. The long period of cultural development during this era can be divided into four basic cultural traditions. From earliest to latest there are: the Big Game Hunting or Paleo-Indian, the Archaic, the Woodland and the Mississippian. The cultural traditions correlate with four time periods.

The Big Game Hunting Tradition or Paleo-Indian Period within the Ohio Valley sub-area is very similar to contemporary developments in the Upper Mississippi sub-area. As the Wisconsin glacier retreated from the Ohio Basin, small nomadic family groups followed the larger herd mammals into the region. These groups advanced in a generally northeasterly direction, but seem to have avoided the unglaciated section of the eastern Ohio Valley, except for areas with unusual resources.

Spear points are the most diagnostic traits of the Paleo Period and often indicate cultural and temporal change. The earliest Clovis points were followed by a regionally distinct form, Cumberland points. Both were large, fluted, lanceolate-shaped projectile points. Towards the end of the period, long narrow points with fine parallel flaking similar to the Plains Plano points are found associated with modern faunal remains. Local variations begin to appear at this stage. Gravers, drills, scrapers and knives may also be found on a Paleo Period site.

Most of the evidence for Paleo occupation of the Ohio River Basin comes from scattered surface finds. Several lithic workshop sites have been found in eastern Ohio near outcroppings of Mercer flint. Because most Paleo artifacts are not found in datable context, estimates as to when the period ended range from 8000 to 6000 B.C.

During the subsequent Archaic Period, which ended about 1000 B.C., small groups of nomads hunted and gathered in the Ohio Valley region. These descendants of the Paleo Indians probably followed a seasonal pattern of migration within a large, poorly defined territory. Local patterns developed as the people slowly increased their utilization of regional resources. This pattern of "settling in" was distinctive of the Archaic, which is divided into three sub-periods.

The Early Archaic Period is tentatively dated 8000 to 5500 B.C. A strong similarity to Plains traditions remained but local styles were developing. Points tended to be more crudely chipped and crude grinding stones were utilized.

The introduction of a new stone-working technique separates the Early and Middle Archaic Periods. During the Middle Archaic, tubular pipes, celts, axes and atlatl weights were all made by pecking, grinding and polishing stone instead of by flaking it. Projectile points were slightly shorter and often stemmed. Increased use of riverine resources in the Ohio

Valley is indicated by small shell middens dating to this period. The hill country of the eastern Ohio Valley, which seems to have been ignored during preceding periods, became heavily utilized. Sites within the proposed route may contain artifacts and cultural patterns influenced by several local Middle Archaic traditions such as the Laurentian in western New York and northwestern Pennsylvania, the Panhandle Archaic in northern West Virginia and an early burial complex in Ohio.

The Late Archaic Period in the Ohio Valley is characterized by larger villages and increased ceremonialism. Chipped flint hoes and steatite vessels are two of the distinctive artifacts which may be found on a Late Archaic site.

In Ohio, southern Ontario, southern Michigan, Indiana, Illinois and southeastern Wisconsin, the Glacial Kame burial complex appeared during the Late Archaic. Burials were often placed in the tops of gravel kames and contained grave goods. Birdstones, Gulf Coast shell gorgets, copper beads and awls and timber wolf masks are distinctive of this culture and indicate an increase in trade relations with other regions.

The increased population size, emphasis on burials and wider trade relations during the Late Archaic Period provided the foundation for the subsequent Woodland Period.

The introduction of pottery and mound building are the diagnostic traits of the Woodland Period, separating it from the Archaic. The three sub-periods of the Woodland Period are characterized by the Adena, Hopewell and Intrusive Mound cultural phases, from earliest to latest.

The Early Woodland Period, which lasted from 1000 B.C. to 100 B.C., is characterized by the Adena culture, which appears to have been an indigenous development in the Ohio Valley area centering near Chillicothe, Ohio. The small, scattered villages of the Adena were often located along streams which provided both transportation and food resources. Amaranths, march elder and chenopodris were probably partially domesticated and are the first indicators of incipient agriculture in the northeastern U.S. Much less is known about the Early Woodland Period in the region north of the Ohio River. It is hypothesized that except for the addition of pottery, the life style there was very similar to that of the Late Archaic.

Some of the later changes in the Adena culture of Ohio may have been influenced by the Hopewell culture of Illinois. Developing around 300 B.C. in the Illinois area, Hopewell cultural traits soon dominated the entire Ohio Valley and marked the start of the Middle Woodland Period. Whether this was a spread of people or ideas is debatable, but regional patterns developed within the overall Hopewell sphere of influence. Distinctive of the Hopewell cultural phase were the large quantities of exotic trade goods associated with burials. These goods included copper from Michigan, mica from the Carolinas, shells and alligator teeth from the Gulf of Mexico, obsidian and grizzly bear teeth from the Rocky Mountains, Ohio flint and large quantities of fresh water pearls.

Few village sites have been studied, but they seem to contain several large rectangular houses, each probably providing shelter for an extended family. Grit-tempered pottery, corner-notched projectile points and utilized blades would be found on most Hopewell sites. Tubular pipes were replaced by platform pipes, often with realistic animal effigies. The basic subsistence pattern was probably similar to that of the Adena, with hunting and gathering wild plant resources supplementing horticulture. Corn has been found at several Hopewell sites. The elaborate grave goods and burial mounds have caused some to refer to the Hopewell culture as the Cult of the

Dead. Large geometric earthworks constructed in river flood plains or adjacent hilltops enclosed charnel houses. Within the charnel house most people were cremated, but a few presumably higher status individuals were buried under low mounds. After a time, a charnel house would be dismantled and earth piled over the area to form a large mound. The most elaborate of these earthworks are found in southern and central Ohio along the Scioto and Miami Rivers, but Hopewell influence spread over an extremely large territory.

Late Woodland sites in West Virginia are part of a local development called the Watson Farm culture. Small burial mounds practically devoid of grave goods were constructed. Compact villages were located near tillable soil where corn, beans and squash were grown. A distinctive cord-marked and limestone-tempered pottery is associated with these sites.

Another group which may have been ancestral to the Shawnee were the Monongahela of western Pennsylvania. This group received only very slight Mississippian influence. Small circular huts probably similar to historic wigwams were enclosed in stockades containing only 1 or 2 acres. Shell-tempered pottery, triangular projectile points and pottery elbow pipes have been found on Monongahela sites. Small stone mounds were constructed fairly late in the period.

The Late Woodland and Mississippian developments in northern Indiana and Ohio are poorly understood. Some agriculture was practiced wherever possible, but the subsistence pattern relied heavily on hunting and gathering. Built on promontories near streams and rivers, their fortified villages were comprised of several relatively small circular houses.

Existing Sites Along the Corridor

Following is a state-by-state presentation of known sites, if any, as well as likely site locations that lie within the pipeline corridor.

Montana

There are no identified sites. Although not limited entirely to the vicinity of streams, sites may be encountered near the following streams crossed by the route: Frenchman Creek, Willow Creek, Rock Creek, Cottonwood Creek, Shotgun Creek, Popular River, Big Muddy Creek and Little Muddy Creek.

North Dakota

Three sites have been identified in the close vicinity of the corridor:

Flint Quarry--Dunn County N 1/2, Section 29 Township 145 North, Range 93 West.

Flint Quarry--Dunn County SW 1/4, Section 21 and SE 1/4, Section 20, Township 145 North, Range 93 West.

Both of these sites are about 3 miles east of Dunn Center on the north bank of Spring Creek.

North Cannonball Site--Morton County SE 1/4, Section 10, Township 134 North, Range 92 West.

This site is on the north bank of the mouth of the Cannonball River.

The Killdeer Mountains, especially the pass in the northern mountains is a likely area for undiscovered sites. Also Beaver Creek, the Missouri, tributaries of the Little Heart River, the Heart River, Sweet Briar Creek, Knife River, Spring Creek, the Little Missouri River and Cherry Creek are likely locations for sites.

South Dakota

There are no identified sites. Mounds and villages can be expected to be found especially in the vicinity of the larger lakes and rivers such as Long Lake, Pelican Lake, Sioux River, Hidewood Creek, the James River and Mud Creek. Sites where suitable stone for tools occurs are likely areas for campsites.

Minnesota

There are no identified sites. Ten archeological sites have been located in the general area which give reason to believe that other sites will be located along the route. Mound clusters on high ground near lakes and villages or campsites along lakes make up known sites. Islands or promontories extending into lakes are likely areas for new discoveries. Rivers to be crossed with significant potential for unknown sites are the Lac Qui Parle River, Yellow Medicine River, Redwood River, Cottonwood River, South Fork Watonwan River and Elm Creek.

Iowa

There are no identified sites. The only known areas close to the route are in Hancock County northwest of Crystal Lake. Lakes, some of which have dried up or have been drained are possible locations of campsites and villages. Streams to be crossed that may be important are West Fork Blue Earth River, Buffalo Creek, East Branch Iowa River, Shell Rock River, Cedar River, Wapsipinicon River and the Mississippi River.

Illinois

Five sites have been located in the study corridor.

Utica Mounds--Sections 17 and 18 of Utica Township at Illinois River pipeline crossing. Two groups of 14 and 6 mounds.

Little Beaver Site--NE 1/4, SE1/4, SW 1/4 of Section 20 in Utica Township. This site has been designated a high priority by the Illinois Archeological Survey.

Barney Erickson Site--SE 1/4, NE 1/4, SW 1/4 of Section 20 in Utica Township.

Alexander Site I--NE 1/2, NE 1/4, SW 1/4 of Section 21 in Papineau Township, Iroquois County.

Alexander Site II--just east of Alexander Site I.

In addition to the five known sites others may be encountered along the route. Most will likely be clustered along rivers and streams with the following streams the most likely areas: Little Beaver Creek, Big Bureau Creek, Masters Fork, East Bureau Creek, East and West Branches of Horse Creek, East and West Forks of the Mazon River, tributaries of Covel Creek, Brush Creek, Tomahawk Creek, Little Vermilion River, Green River, Big Slough Ditch, Rock River, Iroquois River and Illinois River.

Indiana

There are no identified sites. There are 14 identified sites in the vicinity of the study area but none in the corridor. Sites tend to be located near lakes, springs and rivers. Hilltops, especially in marshy terrain were favorite campsites. Unrecorded sites may cluster near the larger streams to be crossed such as the Eel River, Twelvemile Creek, Wabash River, Salamonie River, Treaty Creek, Little Indian Creek, Tippecanoe River, Beaver Creek and Iroquois River.

Ohio

Three identified sites are in close proximity to the proposed route. They are:

Richardson Kame--in Hale Township, Township 5 South, Range 11 East about 2-1/3 miles southwest of Mt. Victory in Hardin County.

William Alexander Kame--is on the east bank of Wildcat Creek in Hale Township, Township 5 South, Range 12 East, about 1 mile southwest of Mt. Victory, Hardin County.

Unnamed village site--Township 5 North, Range 12 West, Knox County in the proposed Utica Reservoir.

It is likely that additional sites are present along the route. Thirty-seven sites are known within the general study area. Most are to be found along streams or on bluffs overlooking streams. There may also be work shop areas near outcroppings of fine chipping stone such as along Licking Creek, Flint Run and the Walhonding River. In addition several rivers and streams offer promise for undiscovered locations. They are St. Mary's River, Anglaize River, Scioto River, North Fork Miami, Rush Creek, Olentangy River, West Branch Alum Creek, Big Walnut Creek, Muskingum River, Mohawk Creek, Birds Run, Johnson Fork, Stillwater Creek, South Fork, Piney Fork, Dry Fork and the Ohio River.

West Virginia

There are no identified sites. Because camps usually were located on level ground and because the pipeline avoids rough terrain it can be expected that unknown sites will be encountered. Level areas near the Ohio

River and Buffalo Creek north of Bethany are the most likely areas. Hukill Run, Mingo Run and Camp Run also have possibilities for new discovery of sites.

Pennsylvania

There are four identified sites. Woodruff Farm Site--1 mile southeast of Cannonsburg where U.S. 19 and pipeline cross, Washington County, Pennsylvania.

Boyles Site--1/4 mile south of the Woodruff Farm Site, Washington County, Pennsylvania.

Cut or Neal Site--2 1/4 miles southeast of the Boyles Site. It is located in North Strabane Township, just east of Little Chartiers Creek northeast of Gambles in Washington County, Pennsylvania.

Robbins Site--just east of the mouth of Crawford Run on the northeast bank of the Youghiogheny River in North Huntingdon Township in Westmoreland County, Pennsylvania.

While these four sites are the only ones known to occur in the study corridor evidence of the archeological importance of the area is evident in that 115 recorded sites have been identified in the general study area. Further, as in West Virginia, the pipeline route tends to follow the same level ground that archeological sites are usually located on. Because of these facts additional sites may be discovered during construction of the pipeline. Areas where additional sites may be found are along Brashears Run, Indian Camp Run, Chartiers Creek, Little Chartiers Creek, Mingo Creek, Monongahela River, Youghiogheny River and Bushy Run.

History

Summary of History Through the Study Area

The following discussion like that for the archeological section will be presented by river basin. They are the Missouri River Basin, the Upper Mississippi River Basin and the Ohio River Basin.

The Missouri River Basin

The first white men to visit the Missouri Basin were French-Canadian traders in 1738. Traders and trappers were the dominant European influence in the Northern Plains for over a century. When the first white traders visited the Mandan at their Heart River villages in North Dakota, they observed a well-established trade pattern. The nomadic Indians came to the Missouri River Indian settlements to trade meat and hides for agricultural produce.

Toward the end of the 18th century, regular contacts were established between the Canadians and the Mandan and Hidatsa of North Dakota, while the Arikara traded more frequently with Spanish traders from St. Louis. In contrast to the forested areas to the north and east, furs were not the mainstay of this early trading system.

In 1804-1805, the Lewis and Clark party spent the first winter of their historic trip with the friendly Mandan. The neighboring Hidatsa were already strongly influenced by British traders who posed a threat to U.S. possession of the Northern Plains. Encouraged by Lewis and Clark's report of more abundant beaver up river from the confluence of the Yellowstone and Missouri River, American fur companies began to establish posts along the Missouri River. One of the first was built by the Missouri Fur Company at the mouth of the Knife River, North Dakota, in 1809. However, competition from such firms as the British Hudson's Bay and Northwest Companies bankrupted most of the American companies. Astor's American Fur Company was the first to effectively meet this competition and soon controlled the trade on the Missouri.

The American Fur Company built Fort Union near the confluence of the Yellowstone and Missouri Rivers in 1828. The desire for fast, dependable transportation prompted the American Fur Company to use steamboats, and in 1832 the first one arrived at Fort Union. After the demand for beaver decreased in the 1830's, the fort survived on the trade in buffalo hides. Fort Union was finally abandoned in the late 1860's.

There was very little U.S. military involvement in the Missouri Basin prior to the war with the Sioux in 1862. General Sully campaigned on the north and east bank of the Missouri, and in 1864 Fort Rice was built. That same year an expedition from the fort battled the Sioux in the Killdeer Mountain area in North Dakota.

Most settlers considered the Northern Plains an obstacle on the way to California and Oregon. After the traders, the first Americans to settle in Montana were miners. Soon, farmers and ranchers, attracted by the high prices their goods could bring, settled in mining areas.

Large-scale agricultural settlement of the Plains was dependent on the development of new farm equipment and farming techniques. The railroads and the Homestead Act of 1862 also contributed to the settlement of the Dakotas.

Pushing west across the Plains, the railroads sold large blocks of land to creditors. These "bonanza" farms were run like big businesses and helped promote the agricultural potential of the Dakotas. Low rates and cheap land were part of the vigorous railroad campaign to lure settlers to the Plains. Due partially to the efforts of the Northern Pacific Railroad Company, the population of the Dakotas boomed from 1868 to 1873 and again from 1878 to 1885. In 1889, North Dakota, South Dakota and Montana became states. The speculative boom of the 1880's was brought to an end by the 10 years of bad weather which followed the terrible winter of 1886-1887, and many marginal farmers were forced to leave the area. Since the 1920's, large-scale farming and increased crop specialization have characterized the economy of the region.

Because the rivers provided a convenient mode of transportation, many of the historical sites in the Missouri Basin are located near the major rivers. Sites associated with the historic period include fur posts, historic Indian villages and camps, military forts, battlefields, dugouts, sod houses, train depots and civic buildings. The proposed route may encounter some previously unrecorded historic sites.

The Upper Mississippi River Basin

When the 17th century French traders and explorers entered the Upper Mississippi Basin, they discovered a large native population with a mixed agricultural and hunting subsistence pattern. To the east, after years of turbulence, characterized by shifting alliances and frequent changes of residency, the Illinois Indians turned to the French for protection against the Iroquois. The French planned a series of forts on the Illinois River after they had determined that the return route taken by Father Jacques Marquette and Louis Joliet was important in any effort to maintain French control of the Upper Mississippi Basin. The first fort was built in 1682 at Starved Rock on the Illinois River near present-day La Salle. About 20,000 Indians were soon living in the area to trade with the French and take advantage of their protection. Most of the Illinois tribes inhabited this area at some time or another in the next 50 years. French missions were eventually located along the river, and towns were established at Cahokia and Kaskaskia near the Mississippi.

During the French and Indian War, most of the natives in Illinois allied with the French. When the English won, several tribes crossed the Mississippi into southern Iowa and Missouri to take advantage of Spain's lenient land policy and to trade at St. Louis. Spanish influence kept English trade to a minimum in Illinois.

By 1807 most of Illinois was opened to settlement and Illinois became a state in 1818. The Sioux ceded parts of Minnesota, and in 1819 the U.S. began construction of Fort Snelling to protect early settlers in the St. Paul area. New settlers were drawn to northwestern Illinois by the lead mines at Galena. Government attempts to reserve the land west of the Mississippi for the Indians were partially frustrated by miners attracted to lead deposits on Dubuque's Spanish land grant across the river from Galena.

Indians trying to reoccupy Illinois from their treaty lands in Iowa precipitated Black Hawk's War, which resulted in the opening of a strip of land in eastern Iowa to settlement. As pioneers continued to push west into Iowa, most of the Indians who had been given land in Iowa were moved to Oklahoma.

In 1833 Chicago was founded, and by 1850 the only part of Illinois not heavily populated was the Central Prairie District. The unfamiliar prairie was bypassed as farmers sought forested lands to the west. The first U.S. land rush was in 1843 on the Des Moines River, and in 1846 Iowa became a state.

Railroads, improved farm tools and a new wave of European settlers opened the prairies in the 1850's. Federal and state governments actively promoted the railroad boom, and by 1867 four lines crossed Iowa towards Council Bluffs. Rock Island became an important railroad center.

Westward expansion in Minnesota was temporarily halted by the Sioux uprising in 1862. General Sibley pursued the rebellious Indians across North Dakota the following year. Settlers, many of whom were immigrants from northern Europe, soon moved back into southwestern Minnesota, and by 1869 it was fairly well settled.

Transportation facilities often determined the pattern of settlement in the Upper Mississippi Basin. After an initial dependency on rivers, roads, canals and railroads assumed greater importance. Some of the sites which are associated with the historic period in this area are early forts, historic Indian camps, battlefields, canals, train depots and civic buildings. The Galena, Illinois, mining district and Dubuque's land grant in Iowa are two of the more unusual areas of historic interest.

Ohio River Basin

Prior to permanent white settlement of the Ohio Valley region, several problems had to be resolved. Indian occupation, rival French and English claims and transportation difficulties were barriers to early pioneers.

Even before explorers had crossed the Appalachians, the natives of the Ohio Valley had acquired some trade goods, had felt the effects of European diseases and had come under attack from eastern tribes seeking new territory in the West. The most hostile of the eastern tribes were the Iroquois. Protecting strong trade ties established by the Dutch and continued by the British in Albany, the Iroquois raided as far west as the Mississippi from their New York homeland.

The French were the first to explore the Ohio Valley country as they searched for the "Northwest Passage" and fur-rich areas in which to establish trading centers. Several forts were built and French trade in the Ohio Valley region concentrated on the Wabash and Illinois Rivers. Small towns were founded at Lafayette and Vincennes in what is now Indiana. This left the Ohio area vulnerable to British-backed Iroquois attack during the 1680's and forced the native population to move west of the Wabash leaving Ohio a no-man's land. English traders entered the area in the late 1730's. In an effort to control the Ohio Valley and to keep the English east of the Allegheny Mountains, Duquesne built a series of French forts along the Upper Ohio in the 1750's. Except for the new French towns, there was little settlement west of the Pittsburgh area prior to the American Revolution.

The Treaty of Paris in 1763 awarded to the English the disputed Ohio country. Although the king declared settlement west of the Appalachians illegal, English companies continued to speculate on Ohio Valley land. Settlers were already filling the Monongahela and Cumberland Valleys, while military roads provided easy access to the Pittsburgh coal fields.

Before the new nation could provide for orderly settlement of the Ohio Valley area, the claims of the various colonies had to be settled. The township and range method of surveying and dividing the government land for sale was embodied in the Ordinance of 1785. The first land office was opened in Steubenville, Ohio, and subsequently the Ordinance of 1787 provided for an orderly governmental system for the Northwest Territory.

The Treaty of Greenville, following General Anthony Wayne's defeat of the Indians at Fallen Timbers in 1795, opened the western half of Ohio and eastern Indiana to settlers.

Western Pennsylvania was bypassed as settlers moved down the Ohio River and up its tributaries into southern Ohio and Indiana. The opening of the first road across Ohio, Zane's Trace, in 1796 influenced the settlement of Cleveland. By 1803 Ohio was a state and Indiana had become a separate territory.

Transportation arteries greatly influenced the settlement pattern of the Old Northwest Territory. Access by river, canal, road or railroad often determined the fate of a newly founded town.

Indian and game trails along river valleys and over the Appalachian passes were often followed by early settlers. Military roads to Forts Duquesne and Pitt encouraged settlement of the Pittsburgh area, as did the advent of coal mining there in the late 1700's.

The National Road, which was opened to Columbus in 1833, stimulated settlement of central Ohio. While the opening of the Erie Canal in 1825 led to a dramatic increase in the settlement of northern Ohio and Indiana by New Englanders, land speculators drew attention to the prospects of large-scale farming in the Wabash and Kankakee areas. As the northern area became more populous, the Indiana capital was moved to Indianapolis.

The development of canals and railroads was encouraged by states who considered them panaceas for their marketing woes. The Ohio, Miami and Erie and Wabash and Erie Canals were authorized prior to 1845. In Illinois the Illinois-Michigan and Illinois-Mississippi Canals were built. These improvements were usually part of extensive state internal development programs. The canals did benefit the northern section of the area but were subsequently replaced by the railroad boom.

The Federal Government substantially aided the railroads by granting them free rights-of-way and adjacent sections of land. Whereas canals had been oriented north-south, the railroads strengthened east-west ties. The railroads were primarily responsible for encouraging foreign immigrants to settle in previously sparsely populated areas such as central Indiana.

There are many sites in the Ohio River Basin associated with the historic period. These may include historic Indian campsites, trading posts, early forts, canals, homesteads and civic buildings. Although many of these sites have been recorded in urban areas and along the major watercourses, they may also occur in other areas. The possibility exists that the proposed route may encounter some unrecorded historic sites.

Specific Sites Along the Corridor

Following is a state-by-state presentation of known sites, if any, as well as likely site locations that lie along the route.

Montana

There are no identified sites. Because the pipeline is entirely north of the Missouri and Milk Rivers, known historic sites have been avoided.

North Dakota

There is one known site--<u>Fort Bouis Fur Post</u>--located on the east bank of the Missouri River at the mouth of the Cannonball River.

Five other sites occur near the corridor. The farthest from the pipeline route is Fort Union on the Missouri River at the Montana-North Dakota border. Across the Missouri and to the east, near the mouth of the Yellowstone is the site of Camp Barbour. Warren's Bank Station in Morton County is located in the NE 1/4, Section 29, Township 139 North, Range 84 West. This site appears to be about 1 mile from the route. Two other sites in Morton County are within about 1/2 mile of the pipeline. One is a dugout between NW and SW quarters of Section 7, Township 137 North, Range 82 West. The other site, Custer Camp, is about 1 mile south along Buck Creek.

Historic sites in North Dakota are rarely associated with standing structures. Because sites have been recorded only since 1930, there may be unrecorded sites in the state and near the pipeline route.

South Dakota

There are no identified sites. Like North Dakota many historic sites in South Dakota do not have associated standing structures. Some sites are listed by the state without providing locations. This is because research has not been done and partially to protect sites which are located on private property. As a result there may be unrecorded historic sites along the proposed route.

Minnesota

There are no identified sites. No sites appear threatened by the pipeline. However, a state survey was conducted in the summer of 1973, the results of which are not yet available. It is likely that this new survey will turn up additional sites.

Iowa

There are no identified sites. No sites appear threatened by the pipeline. Most sites in Iowa are standing structures and are usually to be found in communities.

Illinois

There is one identified site--The Illinois-Michigan Canal--The pipeline crosses the canal between La Salle and Utica on the north side of the Illinois River in La Salle. The canal in this area is now part of the Illinois State Park system and is eligible for inclusion into the National Register of Historic Places as part of the Illinois-Michigan Canal National Historic Landmark. The exact boundaries of this canal are not yet established and remaining segments of the canal are considered eligible for landmark status. While the area in the vicinity of the Illinois River pipeline crossing has many sites of historical interest, only this one appears to be directly threatened by the pipeline.

Indiana

There are no identified sites. No known sites are within a mile of the right-of-way. Most historic sites in Indiana are structures located in towns.

Ohio

There is one identified site--Miami and Erie Canal--The canal is crossed by the pipeline 4 miles north of St. Marys, Ohio in Auglaize County.

Ohio's historical surveys have concentrated on urban areas and that is where most of the known sites are to be found. However, unrecorded sites may be found along the proposed route.

West Virginia

There are no identified sites. Three sites have been identified within the study area but over 1 mile from the route. Two are on the Bethany

College Campus in the town of Bethany and the third is Beech Bottom Mound 1-1/2 miles north of the pipeline near the Ohio River.

Pennsylvania

There are no identified sites. While no known historic site will be crossed by the pipeline, it is evident that because the study area is so rich in history that unknown sites are likely to be discovered. Only the North Buena Vista site less than 1/2 mile south of the route near the Youghiogheny River appears to be in the vicinity of the pipeline.

2.1.3.13 Recreational and Aesthetic Resources

Recreational Facilities, Areas and Resources

Introduction

Recreation areas that exist within the 5 mile-wide study corridor are administered by state or county land managing agencies. Because the route avoids towns, no city recreation agency will be involved. However, some county park agencies such as those managing Round Hill and Mingo Creek Parks near Pittsburgh, Pennsylvania are in reality urban recreation agencies. Some of the recreation areas in the corridor are linear in shape and primarily used for trails or natural areas that can take advantage of railroad rights-of-way, flood plains, etc. These areas are generally new areas and some are presently being studied and the others have only been proposed. State agencies are now carrying out the necessary planning studies needed to fully establish these new areas. In the future many flood plains will be used extensively for trail and open space oriented recreation, however, not all of the counties along the route have identified flood plain areas, let alone taken steps to protect them or to use them for park and recreation use.

Some Federal agencies manage lands that are available for public recreation along the pipeline corridor. None of these lands presently receive significant recreation use although those in the North Dakota Badlands may become better known as the years pass. The Little Missouri Grasslands of the USFS occur in scattered tracts in McKenzie County while a few BLM tracts are along the corridor in Dunn County. BLM also manages land along the pipeline in Montana. The other Federal lands with recreation use are the Corps of Engineer's Oahe Reservoir in North Dakota at the Mississippi River south of Clinton, Iowa, Salamonie Reservoir, Indiana and Delaware Reservoir, Ohio. The USF&WS manages the island and shore areas at the Mississippi for wildlife enhancement. The recreation facilities on Corps lands along the corridor are operated by states.

Uses and Facilities

Table 2.1.3.13-1 shows primary information regarding existing parks and recreation areas that are directly in the path of the pipeline right-of-way or will otherwise be directly impacted by the construction or operations and maintenance of the pipeline.

In addition to the recreation areas presented there are 12 additional areas that either are presently providing recreational opportunities or have been delineated and studies are underway or planned that will result in establishment as recreation use areas. For example, two rivers listed are on the 5(d) list of PL 90-542 requiring study as part of any Federal

Table 2.1.3.13-1 -- Parks and Recreational Areas

Name of Area	County and State	Managing Agency	Acres	Primary Facilities	Visitation	Potential For Expansion
West Fork River* Greenbelt	Black Hawk, IA	County Conservation Board	218	Nature Trails	New Area	Good
Big Bend State* Conservation Area	Whiteside, IL	State Dept. of Conservation	1,188	Nature Trails Hunting	New Area	Excellent
Starved Rock* State Nature Preserve and State Park	La Salle, IL	State Dept. of Conservation	2,524	Picnicking Lodge Campers Trails	604,211 (1973)	Good
Matthessen State Park	La Salle, IL	State Dept. of Conservation	1,628	Picnicking Trails	198,629 (1972)	Good
Lake Shafer	White, IN	Private	1,291	Amusement Park	Unknown	Poor
Salamonie State* Recreation Area	Huntington, IN	State Dept. of Resources	8,551 (2,855 water)	Camping Picnicking Swimming Boating	717,817 (1974)	Poor
Delaware Reservoir* State Park	Marion and Delaware, OH	Ohio Dept. of Natural Resources	7,673 (1,300 water)	Camping Boating Facilities Picnicking	1,125,486 (FY 1974)	Poor
Lake Clendening	Harrison, OH	Maskingum Watershed Conservancy District	6,580 (1,800 water)	Boating Camping	217,000 (1974)	Poor
Mingo Creek Park*	Washington, PA	Washington County Dept. of Parks and Recreation	2,500	Picnicking Trails	600,000 (1973)	Poor
Round Hill Regional Park	Allegheny, PA	Allegheny Dept. of Parks and Conservation	963	Picnicking Trails	300,000 est. (1973)	Good

* Land and Water Conservation Fund money has been used for acquisition and/or development facilities.

planning involving the use of water and related land resources in the river areas. Pipeline projects do not require studies be done. Two canals are listed for their potential as trails, a railroad right-of-way that has been identified as being desirable for a trail route, two delineated trails, two river corridors and two marked routes--the Lewis and Clark Trail and the Great River Road now undergoing study.

Parks and Recreation Areas

What follows is a description of each of the nine parks and recreation areas that lie in the 5 mile pipeline study corridor.

<u>West Fork River Greenbelt</u>--This 218-acre area in the extreme northwest corner of Black Hawk County, Iowa was acquired by the state with a 50 percent match from the Department of the Interior's Land and Water Conservation Fund. The location, at the confluence of the West Fork River and the Shell Rock, and only a mile from the confluence of the Cedar River with the Shell Rock, is in a tree-covered flood plain. Oxbows, meanders and a few open fields in the wooded bottomland provide the predominant features for the recreation area. A branch line of the Chicago and Rock Island Railroad passes through the area from north to south and a narrow strip of land along the railroad right-of-way has been included in the purchase as an access to the area.

The area is new and no visitation count is available but use has been very light. The plans for the area are for it to largely remain as a natural area with walking for pleasure and picnicking expected to be the primary activities. The opportunity for enlargement of the area is excellent as similar terrain and vegetation occur in the immediate vicinity. With protection of the vegetation one can expect the natural values of the area to improve in future years.

The proposed pipeline construction corridor crosses the access route to the north of the main area and through the northeast quadrant of the main area. Aerial photos of the area indicate the strip to be crossed is wooded, some of which is closed-canopy hardwood forest.

<u>Big Bend State Conservation Area</u>--This area consists of 1,188 acres of flood plain lands along the east side of Rock River in Whiteside County, Illinois. The site is one of oxbow lakes that are now essentially dry and scattered stands of trees which includes some closed-canopy hardwood forest. The bottomland vegetation of open grass areas and groves of trees provides an important habitat for wildlife. In fact, at the present time hunting is the principal activity in the area. The Illinois State Department of Conservation expects to maintain the area as a natural area with planned facilities to include picnicking, trails and perhaps primitive campsites in the future. No visitation figures are available.

Because of the occurrence of similar bottomland areas adjacent to the Big Bend site, there is an opportunity to expand the area. This, of course, will depend on opportunities in the future.

With no change of present use of the area, the natural values of the setting and vegetation can be enhanced by proper management.

<u>Starved Rock State Nature Preserve and State Park</u>--The combined State Park and Nature Preserve consists of 2,524 acres along the bluffs of the

Illinois River. The park is on the south bank across from the communities of La Salle and Utica. The Illinois River, through the central part of the state, is rich in scenery, archeology and history. Starved Rock is one of a cluster of important areas in the vicinity of La Salle. The Park and Preserve recorded 604,211 visitors in 1973. A great many outdoor recreation activities occur throughout the area. Some, especially in the Preserve, provide opportunities to enjoy the natural values of the woodland river bluffs such as nature trails and picnicking. In the main park segment a lodge is the principal facility although a great variety of other traditional outdoor recreation activities occur.

Until very recently a gap existed in the State's holdings at Starved Rock. It was through this gap that the proposed pipeline has been routed. Within the last year the parcel has been acquired by the State and added to the Nature Preserve; thereby providing a continuous state park along the bluffs. There is a possibility that other parcels in the proximity of Starved Rock will be added to the existing area.

The presence of three towns on the north shore and quarry activity for many years on both sides of the river has had a significant impact on the region. The unique wooded bluffs, much of which is covered with closed-canopy hardwood forest, along with the known cultural sites has led to the creation of Starved Rock State Park.

Matthiessen State Park--This state park has recently been expanded to adjoin the southern edge of Starved Rock State Park. The park consisted of 175 acres until 1974, when it was increased to 1,628 acres. It is primarily used for day use recreation. Picnicking is the principal activity of park visitors, who numbered 198,629 in 1972.

The route passes through the northeastern tip of the park through land that has been used in recent years as farmland. The park, which is roughly half wooded, lies along the east side of the Vermilion River. It is those areas of the park closest to the river that contain most of the wooded land. Near the middle of the park some deep ravines provide topographic relief and significant scenic qualities for the visitor.

Lake Shafer--This lake is the result of a dam on the Tippecanoe River just north of Monticello, Indiana in White County. The pipeline is expected to cross the lake at its extreme upper end. The route will pass north of the designated recreational areas through largely agricultural lands that exist around the lake. Houses, mostly with boat ramps, line the lake.

The park on the lake is very popular with local residents and with Purdue University students from West Lafayette, 30 miles to the south. As one would expect, boating, swimming, sunbathing and picnicking are important recreation activities which occur at the park. Perhaps as important, however, is an amusement park. Visitation figures were not available for this study.

White County's future land use plan shows a residential zone around the lake except for the location of the recreation area. This narrow zone around the lake takes advantage of the tree-lined banks along the river. The countryside in the vicinity of the Tippecanoe River is typical of the lower Great Lakes Region. The streams are tree-lined and occasionally are cut deep enough to have picturesque bluffs along the course. The uplands are used for agriculture although a few groves of trees are scattered over the landscape.

Salamonie State Recreation Area--This reservoir was constructed by the U.S. Army Corps of Engineers. The recreation facilities are operated by the Indiana Department of Natural Resources. While the State has given name designations to each highly developed recreation complex, the facilities and activities are about the same at each. Camping, picnicking, swimming and boating are the principal activities. Overall visitation at the reservoir was 717,817 for 1974.

The pipeline corridor crosses the reservoir boundaries at its extreme upper end. Recreation use in this area is limited to some boating, fishing and hunting. Most of the area is open grassland with some brushy areas. Scattered stands of trees also occur within the study corridor.

Delaware Reservoir State Park--Delaware Reservoir is a Corps of Engineers project located on the Olentangy River in Delaware, Morrow and Marion Counties in central Ohio, north of the city of Delaware. Total acreage of the reservoir is 7,673 of which 1,300 acres is water. The Ohio Department of Natural Resources is the managing agency. Both wildlife management and recreation are important activities. Fiscal Year 1974 records show 1,125,486 recreation visitors at the reservoir. With Columbus only 35 miles away, the heavy use is understandable. Major outdoor recreation activities consist of camping, picnicking and boating. The principal recreation facilities are located on the west side of the lake, a short distance north of the dam. The Corps has two leases with Ohio's Department of Natural Resources, one for the recreation development and one for the wildlife area.

The east side of the reservoir, as well as the upper end, are wildlife areas. The state has established several large wildlife test plots in this area. The pipeline crosses that part of the wildlife area in Marion County. Recreation use of this area is limited to walking for pleasure, bird watching and similar activities. The route bends to the southeast after crossing the Olentangy Valley and shortly after entering Delaware County it crosses another major arm of the Delaware Reservoir on Whetstone Creek. Unlike the Olentangy Valley, the Whetstone does not show the signs of reservoir water fluctuations. Instead its wooded streamway remains largely undisturbed.

There is little possibility that the Delaware Reservoir boundary will be expanded in the future. The river bottom has been acquired and any additions would consist mostly of land now under cultivation.

Lake Clendening--The Muskingum Watershed Conservancy District is the administering agency for the 6,580-acre Lake Clendening area of which 1,800 acres are water. The facilities are being operated by concessionaire arrangements. Boating, camping and picnicking are the most popular activities at Lake Clendening. In 1974 the lake had 217,000 visitors.

The Conservancy District's land is mostly heavily wooded with frequently steep slopes along the bluffs overlooking the lake. Harrison County's future land use map has designated a large buffer zone around the lake as an open space or a conservation area for varied use such as outdoor recreation. This buffer zone results from arrangements made by the Conservancy District to allow access to the lake to adjacent landowners who agree to manage their lands in a compatible manner with the District's holdings. This policy has resulted in several large parcels being acquired by semi-public groups such as the Girl and Boy Scouts who have been granted use of the lake. Partly because of this policy it is unlikely that the

Muskingum Watershed Conservancy District will acquire more land to add to the existing area.

The pipeline crosses just south of the District's land but well into the conservation zone which is adjacent. The area crossed is owned by the Boy Scouts of America organization of Cleveland, Ohio. Much of the area has been stripped for coal and acquired from a coal company.

Mingo Creek Park--Mingo Creek Park, a large regional park consisting of 2,500 acres is managed by Washington County and Pennsylvania's Department of Parks and Recreation. It is located about 12 miles east of Washington, north of PA 136 near the small community of Kammerer. The park received 600,000 visitors in 1973. Despite the heavy use and the proximity to Greater Pittsburgh, the park is and will be managed primarily for extensive recreation. Picnicking and hiking and walking for pleasure are the principal activities and are expected to be in the future. No additions to the park are presently anticipated.

The countryside is rolling almost to the point of being rough. About two-thirds of the 2,500 acres are presently wooded. The major drainage through the area is Mingo Creek which flows through the northern half of the park in an east-west direction.

Round Hill Regional Park--This area is owned and managed by the Allegheny County, Pennsylvania Department of Parks and Conservation. Like Mingo Creek it receives day use from Greater Pittsburgh including McKeesport and Donora. The park consists of 963 acres which may be expanded in the future.

In 1973 an estimated 300,000 visitors participated in recreational activities at the park. Most of the area is managed for extensive recreation with trails and picnicking activities being the most popular. The attraction that brings the majority of visitors to Round Hill is an exhibit farm. Nearly all of those coming to the park visit the farm.

Round Hill is in rolling countryside that is more than half wooded. The farm is located at the southern end of the park and is near the path of the pipeline. A utility corridor crosses the area of the park and the pipeline is expected to be adjacent to the existing right-of-way.

Trails and Waterways

Table 2.1.3.13-2 presents a list of 13 linear type areas or sites related to outdoor recreation that will be crossed by the pipeline. The reader will note that seven are actually existing areas and meeting recreation needs of their region. Most have either been recently acquired and/or are only in the planning stage. Others, notably the Little Missouri and the Wapsipinicon Rivers are to be studied by the Department of the Interior for possible inclusion into the National Wild and Scenic River System should Federal projects affect the water or land resources.

In addition to this short list there are many more stream corridors and rights-of-way such as those associated with canals and railroads that offer potential for designated recreation areas. Because none have reached more than the hopeful stage, they have not been included in the study. Probably the best example is the Miami-Erie Canal in Auglaize County, Ohio.

Considering only the 13 routes shown in Table 2.1.3.13-2, all have been identified for recreation use because of the scenic setting in which they

Table 2.1.3.13-2 -- Trails and Waterways

Name of Area	County and State (within study area)	Managing Agency	Present Status	Potential for Expansion
Lewis and Clark Trail	Williams, Morton, Emmons, ND	PVT	Designated	Studied for National Trail
Little Missouri River	Dunn, ND	PVT	(1) 5(d) list of PL 90-542 (2) Designated	To be studied for National Wild and Scenic Rivers designation State Scenic River
Railroad Right-of-Way (no name)	Codington, SD	State Game, Fish and Parks	Designated	
Wapsipinicon River (twice)	Clinton, Scott IA	PVT	5(d) list of PL 90-542	To be studied for National Wild and Scenic Rivers designation
Great River Road	Rock Island, IL	PVT	Proposed	Future study has been funded
Rock River Canoe Route	Whiteside, IL	PVT	Designated	
Illinois and Mississippi Feeder Canal	Bureau and Whiteside, IL	State Dept. of Conservation	Proposed	
Illinois and Michigan Canal	LaSalle, IL	State Dept. of Conservation	Designated	
Wabash River Environmental Corridor (twice)	Wabash and Adams, IN	PVT	Study Planned	
Upper Wabash Trail	Wabash, IN	Div. of Outdoor Recreation	Proposed	
Buckeye Trail (twice)	Harrison and Auglaize, OH	PVT	Segments designated	
Muskingum River Corridor	Coshocton, OH	Muskingum Watershed Conservancy	Designated	
Youghiogheny River	Allegheny and Westmoreland, PA	PVT	Proposed	"A" priority for inclusion in State Wild and Scenic River System

occur. In some cases this has been no more than a tree-lined corridor while others such as the Great River Road offers vistas of the Mississippi River Valley while the Little Missouri River provides the solitude in an area, the North Dakota Badlands, with little impact by man. The key point is that these areas have been chosen for scenic and aesthetic reasons and offer the promise of significant outdoor recreation value.

Esthetic, Scenic and Cultural Features

Nowhere along the 1,619 miles of the pipeline are there the kind of scenic wonders that have traditionally attracted tourists in any great numbers. The topography of the route consists of a variety of plains types until the Appalachian Plateau is reached in central Ohio. Nevertheless scattered features exist that have significance as attractions. A list of the most striking, including some with national values are:

1.	The breaks along Frenchmen Creek	(Montana)
2.	Lake Sakakawea	(North Dakota)
3.	Little Missouri Badlands	(North Dakota)
4.	Little Missouri River	(North Dakota)
5.	Killdeer Mountains	(North Dakota)
6.	Medicine Butte	(North Dakota)
7.	Oahe Reservoir	(North Dakota)
8.	Pot Hole Region	(South Dakota)
9.	Wapsipinicon River	(Iowa)
10.	Mississippi River	(Illinois-Iowa)
11.	Rock River	(Illinois)
12.	Illinois River Valley	(Illinois)
13.	Tippecanoe River	(Indiana)
14.	Wabash River Valley	(Indiana)
15.	Delaware Reservoir	(Ohio)
16.	Eastern Knox County and Western Coshocton County	(Ohio)
17.	Clendening Lake	(Ohio)
18.	Ohio River	(Ohio-W. Virginia)
19.	Mingo Creek Area	(Pennsylvania)
20.	Round Hill Regional Park	(Pennsylvania)

These areas are singled out because they provide contrast to the countryside or, in the case of Knox and Coshocton County, Ohio and the Mingo Creek and Round Hill of Pennsylvania, provide some of the most attractive although typical areas of their respective regions along the pipeline corridor.

There are factors other than topographical characteristics that provide scenic and aesthetic quality to the corridor route. In the prairie regions blue sky and clean air are striking and readily noticeable features. The rolling prairie itself is often picturesque. Through eastern South Dakota, Minnesota and northern Iowa the scattered lakes give an added dimension to the generally flat agricultural prairie. The agricultural patterns themselves result in the well known and attractive midwestern checkerboard appearance to the countryside. This region begins in Minnesota and continues into Knox County in central Ohio. This is the bread basket of the Nation with its green and golden crops set against attractive farmsteads. The atmosphere with its frequent haze also helps to give a distinctive setting to the region.

From central Ohio east to Delmont, Pennsylvania, the pipeline passes through typical eastern countryside. The rugged, forested hills with valleys containing string towns are industrial in character. The strip mined areas and large industrial plants help to create the environmental setting for the region. The oak and maples that are common on the Lower Great Lakes countryside provide beautiful fall colors, which add beauty and character to the region and are cherished by its inhabitants.

2.1.3.14 Ambient Air Quality

Level of Air Pollutants

Air quality measurements over the affected region, as reported by the various states, are given in Table 2.1.3.14-1 for the 15-year period 1958-1972. The pollutants of interest to the national ambient air quality standards program include the following:

- sulfur oxides
- suspended particulate matter (including dust and artificially produced solid materials)
- carbon monoxide
- photochemical oxidants
- hydrocarbons
- nitrogen oxides

Of the pollutants listed, only particulates have been measured by all the states in the affected area.

The usual measure of air pollution intensity is mass-per-volume, and the accepted unit is micrograms per cubic meter ($\mu g/m^3$) or 10^6 grams per cubic meter. Another widely used concentration unit is parts per million (PPM), which expresses the ratio of pollutant volume to air volume.

In the case of gaseous pollutants whose level is relatively high, e.g., carbon monoxide (CO), it is more convenient to use concentrations expressed as milligrams per cubic meter (mg/m^3) or 10^{-3} grams per cubic meter.

The proposed route passes through 20 air quality control regions (AQCR's). The emission densities of five principal air pollutants are shown in Table 2.1.3.14-2 for all 20 of the AQCR's, along with other air pollution factors.

No other measurements of ambient air quality for regions along the proposed route are available.

The climate west of Indiana is highly favorable for dispersion of air pollution. By contrast, the climate to the east of Indiana is conducive to stagnant inversion layers because of generally lower wind speeds in combination with mountainous terrain.

The characteristics of the western portion of the proposed route include relatively smooth surfaces combined with few obstacles to wind passage. The predominant vegetation in the far western portion is native, but agriculture is steadily more intensive toward the east, principally wheat and corn. In the east, the presence of forests and mountains offers major damping mechanisms to high winds.

Table 2.1.3.14-1 Summary of air quality data

AIR QUALITY REGION AND STATION	POLLUTANT	PERIOD OF RECORD	NUMBER OF SAMPLES	MAXIMUM OBSERVATIONS (μg/m^3)	MAXIMUM ANNUAL ARITHMETIC MEAN (μg/m^3)	MAXIMUM ANNUAL GEOMETRIC MEAN (μg/m^3)
MILES CITY, MONTANA						
GLACIER NATIONAL PARK	PARTICULATE	1958–72	310	225	22	---
	SULFUR DIOXIDE	1969–72	64	59	---	---
	NITROGEN DIOXIDE	1969–72	67	173	---	---
NORTH DAKOTA						
WARD COUNTY (FOXHOLM)	PARTICULATE	1958–72	644	843	73	38
SOUTH DAKOTA						
BLACK HILLS NATIONAL FOREST	PARTICULATE	1958–72	288	124	37	---
	SULFUR DIOXIDE	1968–72	101	19	8	---
	NITROGEN DIOXIDE	1968–72	102	160	46	---
SOUTHWEST MINNESOTA						
WORTHINGTON	PARTICULATE	1968–72	133	162	---	---
MARSHALL	PARTICULATE	1968–72	79	503	---	---
SOUTHEAST MINNESOTA–LACROSSE						
AUSTIN	PARTICULATE	1972	34	124	---	---
MANKATO	PARTICULATE	1968–72	115	257	---	---
NORTH CENTRAL IOWA						
WEBSTER CITY	PARTICULATE	1972–73	22	79	---	39*
NORTHEAST IOWA						
DELAWARE COUNTY	PARTICULATE	1959–66	197	461	70	---
METROPOLITAN QUAD CITIES, IOWA						
CLINTON	PARTICULATE	1970–72	98	178	78	58*
DAVENPORT	PARTICULATE	1961–73	266	1,128	170	273*

*MAXIMUM QUARTERLY GEOMETRIC MEAN.

AIR QUALITY REGION AND STATION	POLLUTANT	PERIOD OF RECORD	NUMBER OF SAMPLES	MAXIMUM OBSERVATIONS (μg/m^3)	MAXIMUM ANNUAL ARITHMETIC MEAN (μg/m^3)	MAXIMUM ANNUAL GEOMETRIC MEAN (μg/m^3)
METROPOLITAN QUAD CITIES, ILLINOIS						
WHITESIDE COUNTY	PARTICULATE	1967–69	73	234	76	---
ROCK ISLAND	PARTICULATE	1964–72	111	438	153	---
ROCK ISLAND COUNTY	PARTICULATE	1967–69	149	904	130	---
MOLINE	PARTICULATE	1964–72	91	418	132	---
METROPOLITAN CHICAGO						
KANKAKEE COUNTY	PARTICULATE	1967- 69	85	256	87	---
JOLIET	PARTICULATE	1963–72	150	480	136	---
WILL COUNTY	PARTICULATE	1967–69	325	377	---	---
	SULFUR DIOXIDE	1966–67	495	105	52	---
NORTH CENTRAL ILLINOIS						
BUREAU COUNTY	PARTICULATE	1967–69	121	412	98	---
	SULFUR DIOXIDE	1966–67	95	262	---	---
PUTNAM COUNTY	PARTICULATE	1967–69	220	559	174	---
	SULFUR DIOXIDE	1966–67	167	105	26	---
EAST CENTRAL ILLINOIS						
MC LEAN COUNTY	PARTICULATE	1967–69	79	319	79	---
	SULFUR DIOXIDE	1966–67	23	26	---	---
CHAMPAIGN COUNTY	PARTICULATE	1967–69	75	274	108	---
WABASH VALLEY, INDIANA						
KOKOMO	PARTICULATE	1970–72	44	101	6	---
LAFAYETTE	PARTICULATE	1970–72	32	120	---	---
VALPARAISO	PARTICULATE	1972	26	227	---	---
	SULFUR DIOXIDE	1972	23	42	---	---
	NITROGEN DIOXIDE	1972	24	215	---	---

AIR QUALITY REGION AND STATION	POLLUTANT	PERIOD OF RECORD	NUMBER OF SAMPLES	MAXIMUM OBSERVATIONS (μg/m³)	MAXIMUM ANNUAL ARITHMETIC MEAN (μg/m³)	MAXIMUM ANNUAL GEOMETRIC MEAN (μg/m³)
NORTHEAST INDIANA						
FORT WAYNE	PARTICULATE	1957–72	214	304	135	---
	SULFUR DIOXIDE	1970–72	33	38	---	---
	NITROGEN DIOXIDE	1970–72	32	127	---	---
MARION	PARTICULATE	1970–72	32	119	---	---
MUNCIE	PARTICULATE	1963–72	120	239	99	---
NORTHWEST OHIO						
CELINA	PARTICULATE	1964	25	190	91	---
MANSFIELD–MARION						
WOOSTER	PARTICULATE	1966–67	52	261	106	---
WAYNE COUNTY	PARTICULATE	1968–72	207	167	73	---
	SULFUR DIOXIDE	1970–72	64	184	68	---
	NITROGEN DIOXIDE	1970–72	60	224	---	---
METROPOLITAN COLUMBUS						
MARYSVILLE	PARTICULATE	1966–67	51	207	102	---
NEWARK	PARTICULATE	1966–67	49	305	156	---
ZANESVILLE–CAMBRIDGE						
CADIZ	PARTICULATE	1964	25	167	87	---
COSHOCTON	PARTICULATE	1964	25	388	159	---
DOVER	PARTICULATE	1964	25	207	99	---
STEUBENVILLE–WEIRTON–WHEELING						
EAST LIVERPOOL	PARTICULATE	1966–67	46	428	179	---
SAINT CLAIRSVILLE	PARTICULATE	1966	25	190	103	---
STEUBENVILLE	PARTICULATE	1964–72	177	1,581	390	---
	SULFUR DIOXIDE	1971–72	30	10	---	---
	NITROGEN DIOXIDE	1971–72	28	103	---	---

AIR QUALITY REGION AND STATION	POLLUTANT	PERIOD OF RECORD	NUMBER OF SAMPLES	MAXIMUM OBSERVATIONS (μg/m^3)	MAXIMUM ANNUAL ARITHMETIC MEAN (μg/m^3)	MAXIMUM ANNUAL GEOMETRIC MEAN (μg/m^3)
WEST VIRGINIA STEUBENVILLE–WEIRTON–WHEELING						
FOLLANSBEE	PARTICULATE	1970–71	46	---	---	228
	SULFUR OXIDES	1970–71	44	440	125	---
NEW MANCHESTER	SULFUR OXIDES	1970–71	22	236	79	---
NEW CUMBERLAND	SULFUR OXIDES	1970–71	45	223	83	---
WELLSBURG	SULFUR OXIDES	1970–71	46	545	102	---
MOUNDSVILLE	SULFUR OXIDES	1970–71	44	660	107	---
SOUTHWEST PENNSYLVANIA						
INDIANA COUNTY	PARTICULATE	1969–72	111	113	56	---
	SULFUR DIOXIDE	1969–72	129	62	24	---
	NITROGEN DIOXIDE	1969–72	131	224	75	---
CLARION COUNTY	PARTICULATE	1958–72	350	150	57	---

Source: Northern Border Project Supportive Report, Atmospheric Environment Study; Northern Border Pipeline Company, 1974.

Table 2.1.3.14-2 Emission densities and population densities for the air quality control regions traversed by the proposed route

AIR QUALITY CONTROL REGION NAME AND NUMBER		EMISSION DENSITY (TONS/SQ. MI./YEAR)					POPULATION DENSITY (PERSONS/SQ. MILE)	AREA (SQ. MILE)	ANNUAL HIGH AIR POLLUTION POTENTIAL DAYS
		PART.	SO_2	CO	HC	NO_X			
MILES CITY	143	0.30	0.13	1.63	0.28	0.34	2	48,000	0
NORTH DAKOTA	172	1.42	1.22	7.60	1.53	2.00	8	68,916	0
SOUTH DAKOTA	206	0.39	0.12	6.39	1.18	0.85	7	60,337	0
SOUTHWEST MINNESOTA	133	3.10	2.63	24.08	6.23	3.05	25	12,000	0
SOUTHEAST MINNESOTA-LACROSSE (MINNESOTA PORTION ONLY)	128	8.49	9.51	38.29	7.24	6.14	51	12,011	0
NORTH CENTRAL IOWA	089	4.22	1.66	25.01	4.02	3.96	36	8,445	0
NORTHEAST IOWA	088	4.72	8.33	42.75	6.38	4.38	68	7,195	0
SOUTHEAST IOWA	091	2.28	4.90	26.94	4.34	2.47	44	5,244	0
METROPOLITAN QUAD CITIES	069	14.46	19.95	75.10	11.19	14.78	115	4942	1
NORTH CENTRAL ILLINOIS	071	45.71	50.88	35.05	7.36	13.61	60	3,586	1
METROPOLITAN CHICAGO	067	154.4	281.2	588.4	156.9	130.0	1275	5,149	1
EAST CENTRAL ILLINOIS	066	11.32	7.26	34.05	7.36	7.48	64	10,045	2
WABASH VALLEY	084	14.69	32.35	9.33	3.95	8.83	78	10,267	3
NORTHEAST INDIANA	081	10.40	5.09	90.10	19.54	12.10	138	3,573	4
NORTHWEST OHIO	177	21.54	9.80	99.61	19.83	11.10	91	6,568	4
METROPOLITAN COLUMBUS	176	22.56	22.40	184.4	40.68	24.07	295	3,990	5
MANSFIELD-MARION	175	15.94	11.98	76.58	19.17	16.28	199	4,054	5
ZANESVILLE-CAMBRIDGE	183	59.52	59.06	55.66	13.46	22.15	78	3,544	5
STEUBENVILLE-WEIRTON-WHEELING	181	273.2	501.8	100.6	22.20	95.30	188	7,516	5
SOUTHWEST PENNSYLVANIA	197	119.4	273.9	187.5	49.05	75.38	429	6,700	5

Source: Northern Border Project Environmental Assessment; Northern Border Pipeline Company, 1974.

Air quality generally declines from west-to-east along the proposed route. This pattern correlates roughly with the degree of industrialization of the regions concerned and with the ability of the atmosphere to disperse pollutants. Table 2.1.3.14-1 shows that the zones of most intense air pollution are those of highest population density.

The EDR (Emission Density Ranking) yardstick defines ranking of 70-100 as "unpolluted," 37-69 as "moderately polluted," and 5-36 as "severely polluted." By this criterion, all portions of the proposed route west of the Iowa-Minnesota state line are unpolluted. Severely polluted areas along the proposed route include the regions around Chicago, Columbus, Wheeling and Pittsburgh.

The proposed route crosses several rivers where high population density and conditions favorable to strong inversions combine with already high pollution levels to create a sensitive air pollution situation. These crossings include:

Mississippi River, Iowa-Illinois	10,000 feet of pipe
Muskingum River, Ohio	500 feet of pipe
Ohio River, Ohio-West Virginia	4,500 feet of pipe
Monongahela River, Pennsylvania	2,400 feet of pipe
Youghiogheny River, Pennsylvania	400 feet of pipe

Sources of Pollution

The principal sources of air pollution along the proposed route are summarized in Table 2.1.3.14-3. The western one-half of the proposed route receives air pollution principally from natural sources and power plants, with some input from combustion sources other than power plants.

In general, the occurrence of sulfur dioxide and particulates correlates well with the presence of power plants and heavy industry, hydrocarbons and carbon monoxide correlate well with automotive traffic and nitrogen oxides (NOx) correlate well with total combustion sources (automotive, residential, power plants, industrial). In the farthest western portion of the proposed route, wind-generated dust is probably responsible for most of the observed particulate matter.

Only in the four extreme easternmost AQCR's does the proposed route pass through areas that are consistently populated by heavy industry. The Metropolitan Chicago AQCR (067), although it is the most severely polluted along the entire proposed route, is mostly farmland in the section traversed by the proposed route. The measurements from AQCR 067 reported by the counties along the route (Table 2.1.3.14-3) are generally lower than for AQCR's farther east.

2.1.3.15 Environmental Noise

Almost the entire pipeline route is rural where the lowest ambient sound levels in the United States are generally found. The sound levels are determined primarily by agricultural equipment during the day and insects in the evening, with occasional sound from distant vehicles, mostly trucks and overflying aircraft.

The two important factors related to environmental noise are the ambient sound levels at any point where noise impact is expected to occur and the transmission properties of the atmosphere and terrain from potential source to potential receiver.

Table 2.1.3.14-3 Pollution Sources and Emission Densities Along the Proposed Route

AQCR	AQCR Number	Dominant Pollution Sources*	Overall Emission Density Ranking**
Miles City	143	N	99
North Dakota	172	N,P(3)	96
South Dakota	206	N,U	90
Southwest Minnesota	133	P(1),U	78
Southeast Minnesota (intrastate)	128	P(1),U	60
North-Central Iowa	089	U	78
Northeast Iowa	088	P(4),U	63
Southeast Iowa	091	U	78
Metropolitan Quad Cities	069	P(3),U,I	42
North-Central Illinois	071	P(2),U,I	40
Metropolitan Chicago	067	P(8),U,I	7
East-Central Illinois	066	P(1),U	60
Wabash Valley	084	U	60
Northeast Indiana	081	U	57
Northwest Ohio	177	P(1),U,I	37
Metropolitan Columbus	176	P(2),U,I	23
Mansfield-Marion	175	P(4),U,I	37
Zanesville-Cambridge	182	P(2),U,I	30
Steubenville-Weirton-Wheeling	181	P(7),U,I	12
Southwest Pennsylvania	197	P(4),U,I	13

*N = Natural Sources
P = Power Plants (Number in parentheses is number of plants)
U = Urban
I = Industrial

$$\text{**Emission Density Ranking} = \frac{1200}{\text{Population Density} \times 0.7}$$

A rating of 70 - 100 is rated as non polluted.
A rating of 37 - 69 is rated as moderately polluted.
A rating of 5 - 36 is rated as severely polluted.

Ambient Sound Levels

Ambient sound is generally defined as the all-encompassing sound existing at the measurement point due to the sound emitted by all sources in the environment. It is, in essence, the sound heard by a receiver without regard for who caused the sound. The ear responds only from about 50 cycles per second to 15,000 cycles per second (the audio frequency range). The widely accepted scale for accommodating this fact is called "A-weighting" and it is referred to as db(A).

A more recent scale developed by the U.S. Environmental Protection Agency is called the Energy-Equivalent Sound Level (L_{eq}). It is the steady sound level in db(A) which has the same amount of energy as the actual fluctuating sound level when averaged over a specified time period. A further refinement of this scale has been developed; it is called the Day-Night Average Sound Level (L_{dn}). It is a special 24 hour average 06 L_{eq}. These measures will be used in this assessment. The use of the L_{dn} has been objected to as not being useful for assessing noise impact. EPA has incorporated L_{dn} into what is called the Fractional Impact Method which will soon become officially adopted by them to assess noise impact. While this method may not be sufficiently detailed to permit recognition of specific noise impacts, it is becoming recognized as an adequate tool for overall assessment of noise impact. At the stage of development for this project, it would not be considered possible to use more specific measures.

The applicant has furnished four ambient sound measurements which characterize the existing noise environment. Two were taken at the sites of compressor stations 10 and 18 in North Dakota and Minnesota respectively. Two others were obtained at unspecified locations near Erie, Illinois and in Allegheny County, Pennsylvania. These measurements are summarized as follows:

Ambient Sound Levels

Location	Day		Night		Approx.	Approx.	EPA Goal
	L_{10}	L_{90}	L_{10}	L_{90}	L_{eq} (24)	L_{dn}	L_{dn}
Morton County, N.D.	33	28	30	28	32	37	55
Murray County. Minn.	34	26	30	21	33	37	55
Near Erie, Ill.	39	28	42	28	37	39	55
Allegheny County, Pa.	56	45	56	42	56	61	55

The EPA long term goal for environmental noise level is L_{dn}-55. We can see that the average sound levels at three of the four locations are very low, representing an exceedingly quiet environment, while the Pennsylvania location represents that found in many urbanized communities.

Noise is a very local phenomenon, generally extending a mile or less from the source so it is difficult to generalize the above results to all compressor stations and to all points along the right-of-way. The nature of the pipeline route is such that it is highly likely that the rural levels of sound observed at three of the locations will generally extend over most of the route.

Transmission Properties

The ability of sound to propagate from a source to a distant receiver will depend upon the micrometeorological conditions along the path. In a perfect medium with no absorption or reflection, the sound level would decrease 6 db for every doubling of distance or 20 db for every tenfold increase in distance. For example, a sound level of 80 db(A) measured at 100 feet from a source, would be 74 db(A) at 200 feet and 60 db(A) at 1,000 feet. In the actual air, the micrometeorological and ground conditions will cause what is called "excess attenuation" so that the sound will attenuate more rapidly than 6 db per doubling of distance. These conditions are: (1) temperature gradients; (2) wind gradients; (3) wind direction; (4) humidity; (5) surface growth such as grass or trees and (6) ground level changes.

In the high plains part of the pipeline, Section 2.1.3.1 shows that the winds are generally along the route so that the effects of wind on sound propagation might be neglected. This effect is the creation of a shadow zone upwind where the sound may attenuate up to 26 db per distance doubling and concentration of sound downwind where it may attenuate at 9db per distance doubling. In other parts of the pipeline, there are farmlands and tree groupings which will have a greater effect on sound propagation than wind or temperature. Large stands of mature trees used as windbreaks can be expected to provide an excess attenuation of about 5-7 db provided the stand is 40-50 feet high and 100-200 feet in depth and the receiver is 200-400 feet behind the stand.

The condition for attenuation is assumed to be one with no wind, with propagation over grass-covered level fields for peak frequencies near 100 Hz. For this case the attenuation starting at 100 feet is expected to be as shown as given in the upper row of the table below:

Distance, feet	100	200	400	450	650	800	1000	1450	2000	4000
Estimated attenuation dB	0	6	13	-	-	19	23	-	32	44
Measured attenuation, dB (interpolated or extrapolated points shown in parentheses)	0	(6)	(12)	18	18	(20)	23	26	(32)	(41)

This attenuation characteristic was based on the equations of Korze and Beranek (Ref. 1). Private communication with Kurze indicates attenuation may be highly dependent on ground cover. Measured data were obtained to provide confidence in this estimate and the results are also shown in the table. The agreement is sufficiently good to warrant use of the estimated attenuation.

In much of the countryside traversed by the pipeline the contour is sufficiently gentle so little shadowing is afforded any residence nearby. In West Virginia and Pennsylvania, this is not necessarily true but the major impacts are expected to be closer so that acoustical shadowing will play only a minor role.

3 ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

3.1 ARCTIC GAS PIPELINE PROJECT

3.1.3 Northern Border Pipeline

Introduction

Determination of impacts on the environment that would result from construction and operation of the proposed project involves consideration of several variables that cannot be predicted with certainty. The exact pipeline route location, detailed engineering design specifications, and specific construction procedures and rehabilitation techniques are determinants of impact that are not fully known at this stage of project planning. In this section, impacts are specifically identified and quantified where available information permits. Where variables are involved, ranges of impacts are indicated. Detailed construction and rehabilitation plans for each segment of the pipeline should be prepared and evaluated before construction is authorized. Many of the impacts identified in this section are common to any project of this nature. Those that are unique or especially important for this project are identified below.

Summary of Major Impacts

Critical Features and Areas

Along the 1,619 miles of the proposed pipeline there are scattered critical features or areas that will be impacted. The most significant are:

Frenchman Creek Breaks	Montana
Missouri River (Lake Sakakawea)	North Dakota
Little Missouri Badlands	North Dakota
Little Missouri River	North Dakota
Killdeer Mountains	North Dakota
Heart River	North Dakota
Oahe Reservoir (Missouri River)	North Dakota
McIntosh County Pothole Region	North Dakota
Ordway Memorial Prairie	South Dakota
Northeastern South Dakota Lake and Pothole Region	South Dakota
West Fork River Green Belt	Iowa
Wapsipinicon River (2 crossings)	Iowa
Mississippi River and the Upper Mississippi River Wildlife and Fish Refuge	Iowa-Illinois
Big Bend State Conservation Area	Illinois
Illinois and Mississippi Feeder Canal	Illinois
Illinois and Michigan Canal Parkway	Illinois
Illinois River	Illinois
Starved Rock State Park and Nature Preserve	Illinois
Matthiessen State Park	Illinois
Lake Shafer	Indiana
Salamonie State Recreation Area	Indiana
Wabash River (2 crossings)	Indiana
Delaware Reservoir State Park	Ohio
Lake Clendening	Ohio
Ohio River	Ohio
Mingo Creek Park	Pennsylvania
Round Hill Regional Park	Pennsylvania

In addition, the following impacts may apply to the preceding list but generally relate to specific conflicts that are cited in the discussion.

1) Mixing of soil profiles will alter their structure and inhibit microbial activity. It will also contaminate topsoils, especially where substrates are toxic, acidic or basic. The result will be reduced food and fiber production. This impact will be especially critical in the wheat-growing areas of the Great Plains and the Corn Belt of the Midwest.

2) Pipeline construction will disrupt tile and open drainage systems, thus affecting the surface productivity of the lands drained. Tile lines may be crossed as often as every 100 feet in fields in the Corn Belt states of the Midwest.

3) Adverse impacts will occur during construction because of intense, short-term surges of demands for services and increased competition for housing, recreation, education, transportation and entertainment. These impacts will be exceptionally severe in the rural western states of Montana and North Dakota.

4) Mud flows or slides may be triggered during construction, especially in the eastern portion of the route. These slides may cause immediate damage with loss of life during construction.

5) The greatest impact on cultural resources will be the destruction of unknown archeological sites along the proposed right-of-way especially river and stream crossings such as the Illinois and Mississippi Rivers, lakeshores, as in southwestern Minnesota, and bluffs such as the one in North Dakota where the Cannonball Site is located.

6) The project crosses one of the prime waterfowl habitat areas in the United States; the pothole country of North and South Dakota and Minnesota. Several impacts will occur, such as loss of habitat through drainage of lakes and harassment of waterfowl from construction of project.

7) Straight line right-of-way cuts through forests and evidence of the pipeline ascending steep bluffs and cliffs will constitute long-term esthetic impacts. This impact will be especially severe in critical areas listed above, such as the Little Missouri Badlands and the Illinois River crossing.

8) Maintenance of a brush and tree-free corridor will alter the habitat for many wildlife species. This impact will be especially severe where wooded areas are few and scattered and where habitat loss would be incremental.

3.1.3.1 Climate

While most impacts related to climate will be by the climate on the pipeline, there will be project induced impacts on the climate. The macroclimate will be impacted little, if any. However, the microclimates will be significantly impacted. The principal impacts relate to air quality as discussed in Section 3.1.3.14; others include 1) soil temperature changes caused by soil-gas temperature differentials directly over the buried pipeline (Section 3.1.3.6); 2) suspension of soil particles in the air caused by wind (Section 3.1.3.4); 3) deposition of soil eroded by wind and water on nearby areas; and 4) accelerated runoff from disturbed areas. All will adversely affect the microclimate of soil organisms at or near the soil surface.

3.1.3.2 Topography

Impacts on topography will result directly from construction activities and indirectly from acceleration of natural processes that cause erosion, sedimentation, landslides, rock slides, rock falls and flood scour.

Development of Erosion Hazards

The construction process will affect the erosion potential in three areas: (1) along the trench; (2) outside the trench area but within the right of way; and (3) outside the right-of-way limits. Impacts can be expected from wind erosion, water erosion, and erosion caused by construction activities.

The wind will erode loose soil materials along the right-of-way. This material will be susceptible to wind erosion largely because of the destruction of the natural vegetation cover, partly because of the grinding and churning of equipment wheels and tracks during construction, and partly because the orientation of the proposed route is nearly parallel to the prevailing wind direction. The activity of equipment will break down the larger fragments of soil and earth materials to finer particle sizes that can be eroded by the wind. A Soil Conservation Service formula is used in Section 3.1.3.4 to estimate the tonnage of soil that could be eroded from the right-of-way by wind. It is estimated that 60,000 to 480,000 tons could constitute the total annual soil loss due to wind along the entire length of the pipeline, and that the greatest losses will occur in the 650 miles of spring wheat region and parts of the Midwest. However, the conclusion is reached that intensive protective measures could reduce this impact by 90 percent. (See Section 3.1.3.4 for more details.)

Despite the large tonnage of soil that could be eroded by the wind, the impact on the topography by soil erosion and its subsequent deposition will be negligible. The expectable damage to the topography probably will consist of slight drifting in ditches and along fences.

Those areas underlain by windblown sand can be significantly impacted. Sand dunes will be particularly susceptible to damage, especially those where the vegetative cover has been broken, and "blowouts" have developed. Areas of dunes that do not display blowouts can be equally susceptible to erosion if the vegetative cover is broken. Once broken, the cover is not easily reestablished.

Areas marked by dune topography are recognized in northeastern Montana, northern Illinois, and northern Indiana. The total length of the proposed route in such topography appears to be less than 5 miles.

In addition to those areas marked by sand dune topography, extensive additional areas in the vicinity of the dunes may be underlain by a few to several inches of patchy windblown sand lacking characteristic dune topography. The extent of such deposits is not determined. Surface disruption of these deposits also can lead to local wind erosion. The seriousness of wind erosion in these areas probably will not be as great as in dune areas.

Accelerated erosion by running water (runoff) will take place largely through the action of slopewash (sheetwash) and its concentration into small rills and rivulets. The concentration will be due, in part, to small irregularities on the ground surface caused by the equipment used in laying the pipeline and, in part, by the crown, or ridge of soil, to be left above the trench to compensate for natural settlement of the backfill and conversely, by the depression left where settlement exceeds the excess material provided. The normal rate of erosion will be increased along the right-of-way because of the absence of vegetation and the pulverized character of the surface soil caused by the wheels and tracks of equipment. Surface water will erode loose soil very readily and subsurface earth materials less readily because of their generally greater particle size.

A formula developed by the Agricultural Research Service and the Soil Conservation Service, U. S. Department of Agriculture, is used in Section 3.1.3.4 to estimate the tonnage of soil that could be eroded from the construction right-of-way by surface runoff. It is estimated that "over one-third of a million tons of soil could be lost," and that the areas of greatest potential loss are in parts of Montana, North Dakota, eastern Ohio, West Virginia, and Pennsylvania. (See Section 3.1.3.4 for more details.)

Accelerated erosion of earth materials beneath the soil by surface runoff will occur where the soil has been removed by erosion. The result will be gullying of slopes and increased cutting by small streams with accompanying reduction of vegetation and crop yield. Some of the eroded earth material will be deposited downslope, building alluvial fans that reduce production by their overwhelming of vegetation in the fan area.

In general, accelerated erosion will cause the greatest impact along the westernmost and easternmost segments of the proposed route. From the point of entry at the Canadian border to the second crossing of the Missouri River the impact will be highest, even though the annual precipitation is low. The earth materials are soft, weak, and have low permeability. High runoff, sparse vegetation and steep valley walls all contribute to high erosion hazards.

From the Missouri River crossing to eastern Ohio, the impact of accelerated erosion will be least. The rainfall is relatively moderate, the earth materials are generally weak and soft, permeability is moderate, vegetation is more dense and upland slopes are gentle. Precipitation is moderate and valley walls are relatively low and gentle to moderately steep.

In eastern Ohio, West Virginia, and Pennsylvania on the unglaciated Appalachian Plateau the impact of erosion will be moderate to great. Here some of the earth materials are soft and weak, but others are hard and strong. Permeability varies greatly as does runoff despite the generally steep slopes. Most of the area is sloping, runoff is quickly concentrated into streams, and drainage is thoroughly integrated.

The loose character of the trench backfill will increase its erodibility and with the lack of vegetative cover on relatively steep slopes, accelerated erosion is likely to occur along the right-of-way.

Erosion of the floor of stream channels can be initiated by uneven backfilling. Once erosion has started, it progresses in a headwater direction, and additional quantities of earth material are lost. It is impossible at this time to know on what streams this may occur or what additional tonnage of earth materials may be eroded.

Subsurface erosion by groundwater can occur within the backfilled trench. Erosion will be in part by solution and in part by the below-surface washing away of fine particles of earth materials (piping). The broken character of the backfill exposes more surface-to-ground water than the material originally had, so the erosion rate is somewhat faster in backfilled material. It is not possible at this time to estimate the amount of material that will be removed by subsurface erosion.

Inducement of Landslides and Rockfalls by Blasting and Trenching

Blasting to facilitate excavation will probably be necessary along that part of the proposed route lying in the Appalachian Plateau, particularly in the walls and floors of valleys and in places on the upland ridges. Blasting also will be needed in rock-walled or rock-floored valleys of the Central Lowland, in the well-cemented Flaxville gravel of northeastern Montana and for firm sandstone layers in Montana and western North Dakota.

1) Blasting probably will be negligible as a factor in causing new landslides or renewed movement of now stable landslide masses. It is possible that a mass of claystone, shale, or siltstone that is on the threshold of slope failure may slide because the shock waves of blasting overcame or reduced the shear strength of the bedrock material to the point of failure. Moreover, the kinds of landslides generally present along the route occur in weak rocks which are thoroughly fractured near the ground surface. The fracturing will tend to absorb the shock of the blast, reducing its effect.

Because the trench would be less than 10 feet deep at nearly all points, the shallow placement of blasting charges would presumably affect landsliding mainly by transfer of shock parallel to the ground surface. Vertical "jump" of the ground which might reduce the shear strength to zero would be acting almost wholly in a zone of loose or uncompacted material. This material would tend to absorb the shock or be blown upward and outward.

Blasting can induce rockfalls in two ways: (1) the shock can so jar loose pieces of loose rock that they would fall, or (2) the shock can weaken or cause the loss of support beneath a loose rock mass, permitting it to fall. The probability that blasting will cause rockfalls is moderate along the segment of the pipeline within the Appalachian Plateau, moderate in the rock-walled river valleys of the Central Lowlands, and small along that part of the route from the Canadian border to the second crossing of the Missouri River.

For information regarding the impact of the pipeline on rockfalls see Section 3.1.3.3.

2) Trenching probably will be a greater factor in the inducement of new landslides and renewing movement of now stable landslide masses than blasting. The trenching may act in one or both of two ways: (1) reduction of support to upslope materials, and (2) addition of weight plus reduction of shear strength by the introduction of water into the slope materials.

The reduction of support will depend on the location and orientation of the trench, and the length of time the trench is open. If the trench is parallel to the direction of maximum slope (up and down slope) there is little or no loss of slope support. The greatest loss of support is caused by an orientation perpendicular to the maximum slope. A trench located at any position up or down a slope may cause landsliding, but in general, a trench near the base of the slope is more likely to cause trouble than one high on the slope. If masses indicating former landsliding are present on a slope, the potential for additional landsliding is greater.

Whatever the location or orientation of a trench across a slope, the longer that trench is open the greater the risk that landsliding may occur. Delay between excavation and movement, if movement is to occur, may be a matter of days or weeks.

Trenching along or within the toe of a stable landslide that lies along the 145 miles of route within the Appalachian Plateau causes a serious risk of renewed movement. However, a trench across the scar (headwall) upslope of the deposit is very unlikely to cause damage.

For additional information regarding the impact of the pipeline on landslides and rockfalls, see Section 3.1.3.3.

Recontouring of Slopes

Cuts and fills to establish a level working surface for construction and maintenance activities on slopes crossed by the pipeline will result in recontouring. Because steep slopes traversed by the pipeline route are generally limited to stream valleys which are crossed perpendicularly, cuts and fills for right-of-way leveling will be largely restricted to the moderate slopes of the upland areas. Thus, recontouring for right-of-way leveling will be limited in degree and extent, depending upon the actual pipeline alignment. Such recontouring will be most prevalent in the 145 miles of the proposed route that lie within the Appalachian Plateau.

Disposal of surplus spoil from trenching and backfilling in centrally located piles scattered at strategic sites adjacent to the proposed route will also result in recontouring. The size of the piles depends on the volume of the spoil to be cast off and on the spacing of the piles and is impossible to estimate at the present time.

Permanent Changes in the Land Surface

Changes of permanent character in the form of the land surface will result from (1) the crown of spoil material over the trench backfill, (2) cuts and fills for foundations of structures, and (3) those situations where the trench cannot be fully backfilled.

1) Crown of spoil over the pipeline presumably will be the breadth of the trench in width, and the crest will stand several inches above the general surface of the land adjacent to the right-of-way. In profile the crown thus will be convex upward. With time this crown will essentially disappear, and may actually be replaced by a similar form that is concave. The change in profile from that of a crown is caused by the natural settlement of the loose backfill in the trench. As the presence of moisture is a significant factor in the rate of settlement, the process will be distinctly slower in that part of Montana, North Dakota, and South Dakota crossed by the proposed route. Considering the slow rate at which settlement takes place in that region, the crown may well last for many years. Further east, the rate of settling is more rapid and the crown probably will be destroyed within 5 years in the Central Lowland area and 3 years in the Appalachian Plateau.

2) Cuts and fills for foundations of structures are likely, especially in areas of high water table. Earth or gravel fills will be needed at some sites. Most sites will also require gravel or asphalt surfacing. These manmade features are not likely to introduce problems because of their small size.

3) Inadequately backfilled trenches may occur in a few situations. For example, a near vertical valley wall or highway cut with layers of hard rock exposed would presumably have a vertical trench cut into the wall to receive the pipeline. The trench would not be filled completely and so would be apparent for the life of the pipeline. Presumably it would serve as a drainage channel for surface water runoff along the surface of the backfill and for ground water flowing through the backfill.

Examples of stream valleys that can present this situation include those of Frenchman's Creek, both crossings of the Missouri River, the Little Missouri, Knife and Heart Rivers, all in Montana and North Dakota, plus adjacent badlands. A steeply walled valley in the Central Lowlands is that of the Illinois River. Need for an open pipeline trench can be encountered in any part of the route through the Appalachian Province, but the slope of the typical valley wall may permit complete backfilling; site analysis is required.

3.1.3.3 Geology

Construction of the proposed project will have impacts on both the bedrock and the surficial materials, and on the geologic processes within the backfilled trench, within the right-of-way, and within the vicinity of the right-of-way.

The significance of an impact can differ from one location to another, and at the same location in the opinion of different individuals. In general, the impacts on the geologic environment are minor within a geologic frame of reference. The same impacts may be far more significant if viewed in terms of wildlife or crop production.

Effect on Present and Future Mineral Resource Exploration and Production

The effect of construction and operation of the proposed pipeline on the exploration for and production of mineral resources along the proposed route will be negligible to small.

The kinds of mineral resources present and their general distribution is well known along the proposed route. Increased exploration to obtain better estimates of coal reserves is likely in the future, and some additional exploration for petroleum and natural gas is possible.

Exploration for those mineral resources that occur at depths of several hundred feet or more is conducted mainly by test drilling and geophysical methods. The right-of-way of the proposed pipeline generally will be 100 feet wide, with an unspecified but significantly greater width of the right-of-way necessary locally in hilly terrain, especially in the Appalachian Plateau. The width there commonly may be 200 feet, and perhaps can reach 300 feet in some places. Such right-of-way widths do not prevent exploration as modern techniques include drilling at controlled angles and remote geophysical sensing. The right-of-way can be an inconvenience to exploration in that it could serve as a deterrent to cross-country movement of drilling or geophysical equipment.

Production of mineral resources could be reduced slightly because of the proposed pipeline having to cross, or pass beneath, access roads to mines and wells, and petroleum or natural gas collection lines from wells. Construction of the pipeline and maintenance during its operations might cause a brief shutdown of such facilities until the passage or repair is completed. The proposed route is not known to cross open strip mines, pits or quarries, whether active or inactive, so no reduction in production of coal, clay or sand and gravel is foreseen.

Future production of mineral resources, notably coal, may be negatively affected by construction of the pipeline. The proposed route is known to cross identified areas of strippable coal in northeastern Montana, western North Dakota, Illinois, and the Appalachian Plateau area. Provision for leaving a raised berm through a strip mine, would (1) divide the mine area into two parts which would decrease operational efficiency; for example, it would perhaps require longer haulways from the mine face to processing equipment in order to circumvent the raised berm, (2) perhaps require construction of underpasses or ramps to permit passage of haulage equipment from one part of the mine to the other, and (3) eliminate from production the volume of the mineral resource that underlies the right-of-way and that must remain adjacent to it for support.

Eastern Montana and western North Dakota contain enormous quantities of lignite coal at shallow to moderately shallow depths. Coal gasification plants are contemplated or planned at various localities within this region, and some reportedly will be located adjacent to or in the vicinity of the proposed pipeline.

Coal deposits in northern Illinois, eastern Ohio, and southwestern Pennsylvania can also be used for coal gasification and reportedly are being studied. The proposed pipeline probably will have impacts on these deposits similar to, but lesser in degree than those on coal deposits in Montana and North Dakota, for the eastern coal resources are located in areas served by numerous existing natural gas transportation pipelines.

Other coal deposits are located in southcentral Iowa, a considerable distance from the proposed pipeline. Construction of the proposed pipeline will impact these deposits, but these resources are not considered in greater detail because they lie so far beyond the corridor of the proposed route.

Any loss of production of sand and gravel, or clay from known but presently unworked deposits of glacial origin because of the right-of-way may be compensated for by the recognition of poorly known deposits of similar character.

One potential effect on present and future mineral resource production that must be considered is the possible damage by blasting to underground and surface mines, quarries and pits; reservoirs supplying petrolem or natural gas or used for their storage; ground-water aquifers and springs; and walls and transmission or service pipelines. The potential hazard to springs, wells and pipelines perhaps is greatest and the probability that damage will occur is considered to be moderate. The potential for damage to the yield of springs or to rock fractures or aquifers that yield water to wells is similar. The likelihood of significant damage to mines, quarries, pits, petroleum or natural gas reservoirs or underground storage facilities is believed to be small.

Effects on Slope Stability

Construction of the proposed pipeline may affect slope stability to a moderate degree if: (1) the slope has previously undergone landsliding, (2) the slope is underlain by claystone, shale or siltstone, and especially if it contains swelling (bentonitic) clay (see Section 2.1.3.3), (3) the slope is steeper than 30 percent, and (4) the trench is perpendicular to the direction of maximum slope and is situated near the base of the slope or in the steepest part. Slope stability may be somewhat reduced if the slope is supported in part by massive, well fractured sandstone, limestone or dolomite, and blasting is needed for trenching.

A slope that has previously undergone landsliding may or may not now be stable. If it is stable now, it can become unstable again. Moreover, that part of a slope that has not failed may be unstable. If adjacent parts of the slope have failed, or if the soil surface is marked by small irregular steplike surfaces (soil ripples), the slope may be unstable.

The change of condition of a slope from stable to unstable is caused basically by (1) the loss of support of the slope, (2) the addition of weight to the slope, (3) the addition of water which reduces the shear strength by increasing the internal pore pressure, or (4) some combination thereof.

Construction of the pipeline could cause temporary loss of support of the slope because of the excavation of the trench. If the trench were open for a brief period before backfilling, landsliding might occur; the longer the trench remains open the greater the possibility. The possibility also exists that very minor landsliding could occur after the trench is backfilled because the backfill would be loose and uncompacted, thus allowing for some compaction through sliding. This is probably unlikely, as a mass, in a slope that is unstable, would probably slide shortly after the trench is opened. Blasting to permit excavation might cause loss of support by jarring earth materials from a position of support to overlying strata, or might cause a loose fragment to fall free.

It seems unlikely that construction of the pipeline will add enough weight to the slope to cause sliding except in slopes already unstable. The added weight will be greatest at the time of construction when the pipe perhaps will be resting on the slope, and equipment and excavated material are present. Once in place, the structural form of the pipeline will presumably carry a significant part of the pipe weight. The remaining weight will, in part, be compensated by the weight of the earth materials removed from the site after backfilling is completed.

The addition of water to an unstable slope may be hazardous because it adds weight, and because it reduces shear strength. Water may be introduced to a slope, or a former landslide mass, by the trench because the trench may act as a French drain to trap surface water runoff, or it may intersect the water table and receive ground-water discharge. If the gradient of the trench permits, the water can reach and enter permeable earth materials underlying the slope or an old landslide mass.

Four kinds of slope failure may be encountered: (a) landslides, (b) rockslides, (c) rockfalls, and (d) mud and debris flows. These have been described in Section 2.1.3.3.

Construction of the proposed project may trigger landslides, rockslides and rockfalls, and can be a significant factor in the occurrence of mud and debris flows.

A significant aspect of damage from landslides, rockslides, rockfalls, and mud and debris flows is the fact that these may have a very significant effect on the land, structures, and property values for a considerable distance beyond the right-of-way; a mud flow may block a variety of transmission and transportation routes.

Landslides can and probably do occur in all of the geologic materials along the proposed route and may be encountered during construction. Landslides probably are numerous in the swelling-clay, rich-shale bedrock exposed locally in the 140 miles between the Canadian border and Big Muddy Creek in northeastern Montana, and in the vicinity of the second crossing of the Missouri River Valley in western North Dakota. Slopes as low as 15 percent can slide in this geologic environment, and recognition of landslide areas can be difficult for an inexperienced observer.

Landslides are very numerous in the 160 miles of the route situated in the bedrock of the Appalachian Plateau and areas of much steeper slopes. Again, recognition of individual landslides is generally difficult for the inexperienced observer.

Along the other parts of the proposed route landslides most likely will be encountered along steeper slopes, especially those that form the walls of valleys. Landslide deposits will probably be less numerous in this area, but will be harder to recognize because of the considerable vegetative cover.

Rockslides are few in number along the route, scattered, and small. They most likely will be encountered or occur locally in the 730 miles of pipeline route in and to the east of eastern Iowa, particularly at places where local bending of bedrock strata has tilted the layers.

Rockfalls of as much as 50 cubic yards volume may occur during construction at scattered localities along the route. Rockfalls of from 50 to 100 cubic yards volume can occur, but are not likely. They may be expected to occur where layers of hard to moderately hard rock notably sandstone, limestone or dolomite, form ledges that crop out in steep faces or cuts. Conditions locally are favorable for rockfalls in (1) the 485 miles of proposed route between the Canadian border and the vicinity of the second crossing of the Missouri River, (2) crossings of steep rock-walled river valleys of the Central Lowland, notably the Illinois River, and (3) the 160 miles of the route through the Appalachian Plateau Province.

Mud and debris flows may occur locally along the proposed pipeline during the estimated 100 years of its life. Some of these will flow along or across the right-of-way but will have no direct impact on, and will not have been caused by the installation. Other flows can occur mainly as a result of the pipeline; these chiefly will involve the trench backfill. Such flows have occurred a short distance southeast of the pipeline terminus within the past 30 years.

If it is conservatively assumed that heavy soaking rains will occur along the pipeline route, the likelihood of flows happening is great. Moreover, the likelihood that such flows will involve trench backfill of the proposed pipeline to a degree that will cause loss of support is also great, and such a flow can threaten pipe integrity.

Small flows, perhaps 10 to 100 cubic yards in volume, can occur locally along the rest of the proposed route. Though the likelihood is small, they are most likely to happen in the 485 miles of the route between the Canadian border and the second crossing of the Missouri River. The likelihood of mud or debris flows in that part of the route between the second crossing of the Missouri River and the Appalachian Plateau is negligible.

Possible Discovery of Geologic Resources

The potential for construction of the proposed project to lead to the discovery of additional deposits of presently known resources along or in the vicinity of the proposed route is discussed in Section 2.1.3.3.

The initial discovery of economic deposits of previously unrecognized geologic resources along the proposed route as a result of the construction process is highly unlikely.

Trenching can lead to recognition of some local aquifers that will yield small supplies of ground water. The ground moraine, consisting mainly of till, encloses scattered lenses of small lateral extent composed of sand and gravel. Some of these can contain enough "hard" ground water with sufficient recharge to supply from one to several farms Similarly, in the Appalachian Plateau small subsurface flows of water may be intersected. These may be too shallow to last the year around, and their presence may be known already to local residents.

During the next 100 years, which may be the lifetime of the pipeline, increased scientific knowledge may lead to a new demand for geologic resources not now needed. In that case, it appears the then existing knowledge of geologic materials will serve as a guide to field searches for them. There seems to be no reason to believe that geologic knowledge or information produced by this project would be a contributive factor to the success of such searches.

Other Geologic Impacts

Faulting (ground displacement)

Construction of the project will not trigger faulting along the proposed route.

Earthquakes

Construction of the proposed project will not trigger natural earthquakes, but will cause seismic events strong enough to be felt in the immediate vicinity. These events may be the result of the activity of construction equipment and blasting necessary for trenching in hard bedrock and perhaps in stream crossings. The manmade events will be felt within a maximum distance of several yards to perhaps 1 mile, are of very brief duration, and locally will be numerous. Minor damage to structures, mainly the cracking of plaster can occur. Further discussion of blasting effects is contained in Section 3.1.3.2.

Landsliding

The proposed construction can reduce the stability of slopes in the area traversed, thus increasing the likelihood of landslides, rockslides, rockfalls, and mud and debris flows. The potential effect is discussed in Section 3.1.3.2, but the evaluation of the potential hazard that can result is discussed below.

The walls of some of the valleys to be crossed by the proposed route are marked locally by the distinctive topographic expression of landslide deposits. In the vicinity of the proposed route, many landslides have occurred in some valleys and very few or none in others. The presence of landslide deposits on a valley wall warrants consideration of slope stability nearby in non-landslide areas. Similarly, landslide deposits in one valley warrant the search for possible landslides in adjacent valleys of similar geologic character. These concerns are valid because of the potentially serious nature of landslide impacts.

One impact of landsliding is damage to both property and structures belonging to others and adjacent to the proposed route. The damage can be of great variety: (1) differential loss of support causing rupture or collapse or tilting of buildings, transmission lines, and transportation routes; (2) impact of sliding, falling, rolling, or bounding rock; (3) obstruction of the flow of traffic on roads and railroads by blockage, and of streams by temporary damming, and (4) possible loss of land use for crop production and perhaps for other yields or uses.

Another possible impact of landsliding is personal injury or death. The various kinds of landslides can cause both, but all except rockfalls generally move at a slow to moderate rate. This generally will permit a person to escape unless perhaps the event were to happen at night while one sleeps. Rockfalls happen very quickly, however, and sufficient time to escape may not be available.

The scarring of the land surface by landslides may be considered an undesirable impact by some persons. However, the bare headwall scarps are temporary and commonly are reduced or obliterated in a few to several years. Moreover, the process is a natural one and where landsliding exists in the vicinity, scarring probably can be expected to occur eventually at most, if not all, places in the vicinity provided the geologic environment is similar.

One impact of landsliding that increases its undesirability is that, once begun, landsliding can be difficult if not impossible to stop permanently and the work can be costly. In addition, most landsliding is progressive upslope. The downslope movement of one mass removes support from material upslope, and in some cases laterally, so that material in turn is subject to landsliding. Thus, a small landslide low on a slope can eventually affect structures or crop production on the upland adjacent to the slope crest.

A secondary impact of landsliding can be the associated loss of vegetation cover and increased erosion leading to greater sediment loads in streams and subsequent sedimentation.

The potential impact of the proposed pipeline on landsliding mainly will be: (1) the introduction of water into presently stable landslide deposits and into rock and earth materials underlying presently stable slopes; (2) loading of the upper parts of presently stable landslides and slopes with excavation materials, pipe, and equipment, and (3) undercutting by trenching of the toes of now stable landslide masses and the lower parts of presently stable slopes. Any or all of these can cause movement which, in turn, can affect the pipeline. If the trench has permitted the introduction of water to a landslide mass, movement of the mass increases the ease with which additional water can be introduced. The impact, thus, can be cyclical in character.

a. Landslides caused by the pipeline can occur at a given locality during construction and within the 100-year lifetime of the pipeline. They are more likely to occur during construction where the trench is situated in weak glacial-lake clays, at the base of a valley wall or at the toe of a presently stable landslide deposit.

b. Rockslides and rockfalls caused by the pipeline can occur at any time during construction or within the lifetime of the pipeline also. However, those occurring during construction are more likely to have been triggered by the work, even though their development may have begun earlier. Conversely, those that occur after construction could have developed mainly as a result of construction--but not necessarily--and probably were triggered by natural processes, perhaps enhanced by construction.

c. Mud and debris flows will occur after backfilling and subsequent to prolonged heavy rain. Those caused by the pipeline will involve trench backfill.

The impact of the pipeline on the various kinds of landsliding present along the route will occur in the same areas where the various kinds of landslides are present.

a. Landslides and rockslides are most likely in the 160 miles of the Appalachian Plateau Province, much less likely in the 145 miles between the Canadian border and Big Muddy Creek, and least likely in the remaining 1,300 miles of the proposed route.

b. Rockfalls are most likely along the 160 miles of the proposed route in the Appalachian Plateau and are much less likely along the remainder of the route; in the latter area they are most likely in river valleys with steep rock walls such as that of the Illinois River and perhaps locally in the 240 miles of the route from Big Muddy Creek to the second crossing of the Missouri River Valley.

c. Mud and debris flows are most likely to occur along the 160 miles of the proposed route in the Appalachian Plateau and much less likely along the 385 miles between the Canadian border and the second crossing of the Missouri River Valley.

Bedrock Fracturing

Construction and operation of the proposed pipeline will not damage the bedrock strata or the firm glacial deposits, except for minor fracturing of the material adjacent to the trench. This fracturing can be caused by either the excavation equipment, mainly backhoes and rippers, or the blasting required for rock excavation. Within 10 feet of the ground surface, the surficial materials and weaker kinds of bedrock generally are loose or well fractured now because of natural weathering processes. The effects of the construction processes will cause little additional fracturing of these materials. However, blasting in this fractured near-surface material can yield a trench wider at the top than planned. The additional fracturing will not cause significant impact on the geology or hydrology adjacent to the trench.

3.1.3.4 Soils

Of all the natural physical resources affected by the proposed project the disturbance of the soil profile will create the most significant impacts, either directly or indirectly, to the environment.

The destruction or reconstitution of the life supporting topsoil will interfere with the natural processes of the functional ecosystems through which the pipeline passes. The loss or dilution of topsoils on agricultural lands will cause lasting reductions in crop production. The exposure of topsoils by removal of the vegetation will allow erosion from wind and water. Eroding soil particles will provide particulates that will contaminate the air and sediments to pollute streams. Soluble salts and minerals will degrade the subsurface waters where trench excavation is below existing water table levels. In natural areas, soil disturbances will cause adverse effects to topographic features and changes to natural plant communities that will result in esthetic degradation. In addition, gas temperatures in the pipe could cause early or continued thawing of the frost causing drainage control problems (Section 3.1.3.6). The changes caused by soil disturbance to vegetation will also have indirect effects on wildlife species dependent on the original plant composition.

The planned construction operations include leveling of the 100-foot right-of-way for 1,600 miles, the excavation and backfilling of the pipeline trench to depths of 7 to 10 feet, and the disturbances necessary to construct operations facilities and access roads. In addition to impacts on the construction site there will be offsite disturbances from the excavation of bedding material and dispostion of surplus materials from the pipeline trench. The quantities of these materials cannot be assessed until construction begins or detailed surveys are made. Likewise, the quality of subsoils and substrata materials to be excavated are not known for specific areas to be crossed by the project.

This section discusses the soil related impacts that will occur as a result of implementing the proposed project. Although quantifications are not always possible, the relative impacts anticipated and the range of losses to be expected are discussed.

Descriptions of the soil series likely to be encountered along the pipeline route are contained in section 2.1.2.4. These descriptions have been interpreted in this section to determine the critical areas of soil related impacts that are likely to occur with project implementation (Figure 3.1.3.4-1).

Contamination of Topsoils by Excavation of Subsoils

As described in section 2.1.3.4 the proposed pipeline route will cross many diverse soils. While in some areas topsoil will be stockpiled and returned to the surface of the trench, the applicant proposes single trenching much of the pipeline route which will result in subsoils or mixtures of topsoils and subsoil on the surface.

Topsoils are the organically enriched layers that have received and accumulated the residues of native plants through many thousands of years of soil formation. In agricultural areas, they have received the fertilizers and manures applied by the farmer.

In most soils along the proposed route, topsoil layers vary from 6 to 24 inches in depth (see tables 2.1.3.4-1 through -9). It is the topsoil that supports the living soil micro-organisms so important to the nutrient cycle of the ecosystem.

Burying the topsoil under several feet of relatively sterile subsoil would prevent full restoration of the productive and ecological potentials until a new micro-organism community can be established and become functional.

The severity of impact to crops or native vegetation will depend to a large degree on the nature of subsoil material left on the surface. Plant establishment and growth may be inhibited by highly alkaline or acid subsoils. Heavy clay subsoils may reduce permeability to a critical point while sands and gravels may be so permeable that moisture and nutrients cannot be retained for plant use. The soil compaction caused by continued passage of heavy equipment will also have adverse effects on soil properties.

Listed below are soil series that will create special impact problems and the approximate distance of pipeline route along which they may be encountered. The quantity of each series crossed is not known. Maps of soil associations in which the series occur and more detailed descriptions of the soil series are contained in Section 2.1.3.4.

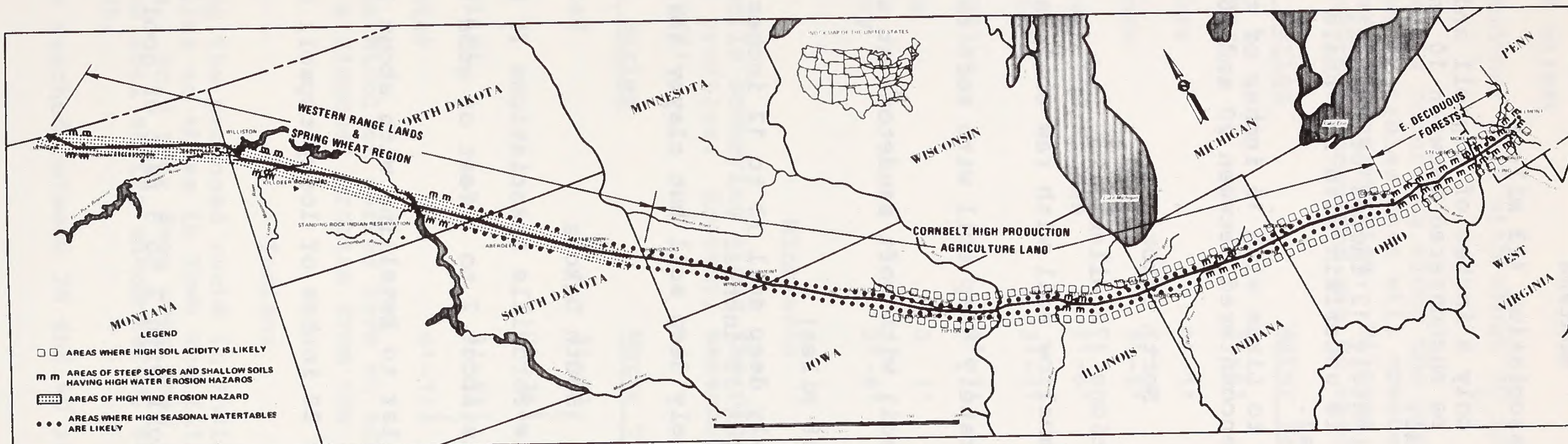

Figure 3.1.3.4-1 Pipeline segments where special soil related impacts are likely to occur

Montana

Lisam-Cabbart-Shale Outcrop Association (23 miles)

Cabbart Series--Contains only 4 inches of topsoil and very shallow subsoil. Soft sandstone will be encountered between 10 and 20 inches and is unsuitable for surface material.

Lisam Series--Has approximately 12 inches of topsoil with clay subsoils between 12 and 20 inches. It is underlain with raw shale which is unsuitable for surface material.

Thebo Series--Is similar to Lisam with 16 inches of topsoil over clay subsoil. Soft shale will be encountered between 20 and 30 inches.

North Dakota

Badland and Bainville Associations (72 miles)

Badlands Series--A very shallow soil with raw shale and sandstone at less than 12-inch depth.

Bainville Series--A moderately deep soil with soft raw shale at about 2 feet.

Flasher Series--Shallow soil with soft sandstone at about 50 inches.

Morton-Rhoades Associations (48 miles)

Morton Series--A moderately deep soil (3 to 12 inches of topsoil) with siltstone or soft shale at about 36 inches.

Rhoades Series--A relatively deep soil but clayey shale might be encountered below 5 feet.

South Dakota

Fordville-Estelline and Renshaw-Fordville Associations (6 miles)

Estelline Series--Contains about 2 to 3 feet of good topsoil over sand and gravel.

Fordville Series--Is similar to Estelline with about 2 feet of loamy topsoil over sand and gravel.

Renshaw Series--Has 10 to 20 inches of loamy topsoil over sand and gravel.

Lamoure Association (2 miles)

Lamoure Series--Another soil with 2 to 3 feet of good topsoil over sand and gravel.

Stady Association (4 miles)

Stady Series--Another soil with about 30 inches of loamy soil over sand and gravel.

The following soils occurring along the proposed route in South Dakota have high seasonal water tables that will create impacts due to water disposal problems during construction. Mileage along route refers to associations in which they occur and may be encountered:

Soil Series	Water Table Level	
Harmony	3'-6'	5 miles
Lamoure	0'-1'	4 miles
Lismore	3'-6'	2 miles
Niobell and Noonan	3'-6'	24 miles
Oak Lake	3'-6'	6 miles
Parnell	0'-1'	15 miles
Tonka	0 1'	15 miles
Waubay	3'-6'	18 miles

Minnesota

There are no soils occurring along the proposed route in Minnesota having shallow soil profiles. However, seasonal water tables may be encountered as follows:

Soil Series	Water Table Level	
Aastad	3'-6'	18 miles
Flom	0'-3'	
Nicollet	3'-6'	15 miles
Webster	0'-1'	

Subsoils of the Nicollet series have an acidic pH factor as low as 5.6 which might create a disposal problem from the standpoint of pollution.

Indiana

The soils along the proposed route in Indiana are in the glacial till plains and are similar to those in Iowa and Illinois. The rich organic topsoils range from 1 to 3 feet deep over deep glacial till materials. In all but a few of the soil series encountered, seasonal water tables occur between 0 and 6 feet.

Bedrock may be reached between 20 and 40 inches in the Millsdale and Randolph series.

Iowa

All of the soils occurring along the proposed route in Iowa are relatively deep with till or loess materials in the subsoils. Rich organic topsoils vary from 1 to 2 feet. High seasonal water tables are common, however, and may be encountered as follows:

Soil Series	Water Table Level	
Clyde	0'-1'	24 miles
Floyd	1'-3'	
Kenyon	3'-6'	
Muscatine	1'-3'	12 miles
Nicollet	3'-6'	60 miles
Webster	0'-1'	

Although Fayette Soil Series does not have a high water table level, it does have acidic pH factors as low as 4.6.

Illinois

Soils occurring in Illinois along the proposed route are similar to those in Iowa. Rich organic topsoils vary from 1 to 3 feet in depth over deep glacial till materials of varying textures.

In all of the soils that will be encountered high seasonal water tables are common and range up to 6 feet.

Ohio

The following soil series having undesirable subsoils will be encountered in eastern Ohio (70 miles).

Berks--A moderately deep soil with raw siltstone and shale between 20 and 40 inches.

Dekalb--A moderately deep soil with sandstone bedrock between 20 and 40 inches.

Guernsey--A slope and ridgetop soil with shale between 55 and 72 inches.

Keene--An upland soil with heavy clay and shale between 20 and 40 inches.

Loudonville--A shallow upland slope soil with sandstone bedrock between 20 and 40 inches.

Muskingum--A steep slope soil with siltstone and shale bedrock between 20 and 40 inches.

Westmore--A shallow upland soil with channery clay loams between 4 and 6 feet.

<u>Westmoreland</u>--A steep upland soil with sandstone, shale and limestone bedrock between 20 and 40 inches.

The following Ohio soils along the route have seasonal water tables. Approximately 150 miles of the route will traverse these soils.

Soil Series	Water Table Level
Bennington	1'-3'
Blount	1'-3'
Cardington	3'-6'
Dekalb	1'-3'
Del Rey	1'-3'
Guernsey	3'-6'
Keene	3'-6'
Montgomery	0'-1'
Morley	3'-6'
Pewamo	0'-1'

Subsoils are acidic with pH ranging from 4.5 to 6.0.

West Virginia and Pennsylvania

All of the soils encountered along the route in West Virginia and Pennsylvania are shallow with bedrock at depths of 2 to 6 feet.

High seasonal water tables may occur along 60 miles of the route in the following soils:

Soil Series	Water Table Level	
Cavode	1'-3'	4 miles
Wharton	3'-6'	
Guernsey	3'-6'	48 miles
Lindside	1'-3'	8 miles
Melvin	0'-1'	
Rainsboro	1'-3'	

All of the soils along the route in these two states are acidic with pH ranging from 5 to 6.

Summary

Impacts associated with the mixing or burying of topsoil will occur to some degree along the entire 1,600-mile pipeline route. If topsoils are not replaced, approximately 250 miles (3,000 acres) of the route will be left with relatively sterile erodible subsoils or parent materials on the surface.

Soils with high seasonal water tables will create impact problems along approximately 450 miles (5,400 acres) of the route. About half of these soils may contain acidic water that will present disposal problems.

Erosion hazards associated with shallow soils over bedrock will be created along approximately 250 miles (3,000 acres) of the proposed route.

The specific impacts include:

1) From mixing or burying topsoil--Low soil fertility, high rates of erosion, esthetic degradation, revegetation difficulties.

2) From high water tables--Trench flooding requiring pumping may cause erosion of outlet channels, siltation of streams, excessive groundwater drawdown, acidic pollution to aquatic plant and animal habitat.

3) From shallow soils over bedrock--High erosion rates, low fertility, landslide hazards, esthetic degradation, revegetation difficulties.

Exposure to Wind and Water Erosion

Most of the adverse soil impacts caused by wind or water erosion will occur during the construction period and the period during which new vegetation is being established.

All erosion impacts will be directly related to soil disturbances resulting from pipeline construction activities. Erosion hazards will be created each time the vegetative cover is removed for pipeline right-of-way, compressor stations, roads, and other facilities.

Factors affecting the degree of hazard include soil types, topography, weather phenomena, time of bare soil exposure and measures taken to protect exposed areas.

Wind Erosion

Wind erosion hazards will be most prevalent along 650 miles of the route in the spring wheat region of Montana and the Dakotas (Figure 3.1.3.4-1). This is primarily because precipitation is low and high wind velocities are common. Bare ground is especially susceptible to wind erosion during drought periods that cause prolonged low soil moisture.

Since the general direction of the pipeline route is Northwest to Southeast through the spring wheat region, it will be aligned with the prevailing winds. Where soils are left uncovered severe wind erosion may occur, especially during the spring months when wind velocities are likely to be high. Soils exposed to high winds may lose up to 53 tons of soil per acre per year as shown below.

The displaced soil particles will have an adverse effect on adjoining land and will cause local air pollution during and after construction until adequate vegetation cover is reestablished. Local wind velocities are unpredictable but when high winds occur and the land is bare, soil particles will become airborne. The degree of air pollution and the amount of soil deposited on adjoining lands is difficult to quantify; however, when high

Soil Losses from Wind (Potential) Tons/Acre/Year

Soil Texture Group	Susceptible Distance (Feet) 50	100	200	500	1,000	10,000
Sandy	5.0-18.0	11.0-27.0	15.5-24.5	23.0-44.5	29.0-51.0	34.5-53.5
Silty	0.5	1.5	3.0	6.0	9.6	15.0
Clayey	2.5	5.7	10.0	15.5	19.5	26.0

hazard conditions exist, it will be significant. In susceptible areas, annual losses due to wind erosion could range from 60 to 480 tons per mile of pipeline if successful revegetation or temporary protection is not successfully applied following disturbance. This could amount to a total annual loss of from 60,000 to 480,000 tons for the total pipeline length with the highest losses occurring in the 650 miles of the spring wheat region and parts of the midwest. Intensive protective measures could reduce this impact by 90 percent or reduce total annual losses to between 6,000 and 48,000 tons.

Actual losses will depend upon a number of variables including wind and moisture conditions during construction, especially as they relate to susceptible areas that might be exposed during dry windy periods. Although reseeding is planned as soon as practical after construction activities are completed, wind erosion losses exceeding 5 tons/acre/year would cause severe seedling damage and make revegetation very difficult. Mulching and intensive conservation practices will be needed to assure revegetation success.

As the pipeline proceeds east, wind erosion hazards will decrease because of higher precipitation and lower wind velocities common to the midwest and protection from wind in the rougher topography of the east. However, wind erosion is common during the spring months in the midwest where land surfaces are left unprotected, as they will be.

Water Erosion

The most serious erosion impacts will result from water erosion. The degree of water erosion will depend upon the steepness of the topography, the stability of the soil materials and the time period required for revegetation. The occurrence of intensive storms during the period of exposure could greatly increase erosion impacts.

Since intense rainstorms are common along the pipeline route during the spring to fall months some segments of the exposed right-of-way will undoubtedly incur significant soil losses. The single trenching method of excavation, if used, will leave sterile surface soils that will be difficult to revegetate, thus, causing prolonged periods of potential erosion.

Water erosion hazards are discussed below by State:

Montana

The Lisam-Cabbart-Shale Outcrop Association will be crossed for approximately 23 miles primarily in Phillips and Western Valley Counties where it crosses the Frenchman Creek, Rock Creek, Willow Creek and Bitter Creek drainages. This soil association will also be crossed for about 3 miles briefly near the Montana-North Dakota boundary at Little Muddy Creek.

This soil association occurs on steep unstable badlands where disturbance will greatly accelerate high natural erosion rates. Topsoils are extremely thin and the shale and sandstone bedrock, if left on the surface, will have a lasting effect as an erosion hazard and an area of reduced forage production.

About 15 miles of the pipeline will traverse soils of the Sunburst Association which have very thin topsoils and clay substrata. Slopes are moderately steep and the clays left on the surface will be erosive and difficult to revegetate.

The 17 miles crossing the flood plain soils (Harlem-Havre Association) will have only minor erosion impacts since the soils are deep and occur on flat terrain.

The remaining 125 miles will cross the better soils of the dry cropland areas where the topography is level to rolling. Erosion hazards on these soils will be minimal.

North Dakota

About 120 miles of the pipeline route through North Dakota will traverse soil associations containing Bainville, Flasher, Badlands, Morton, and Rhoades series intermingled with deeper more level soils.

The most rugged terrain along the route will be encountered where it crosses the Little Missouri Badlands and the Missouri River Escarpment. Here slopes range up to 60 percent with elevational differences of 400 feet.

Topsoils are extremely thin and substrata material is principally shale and sandstone. Erosion hazards will be extremely high in these areas and revegetation will be difficult.

The remaining 146 miles of the route through North Dakota will cross associations containing better substrata material on more moderate slopes. Here, erosion hazards will be minimal except where drainages are crossed. Sand and gravel will be exposed where encountered on flood plain areas.

South Dakota

The entire 182-mile route through South Dakota traverses the relatively flat glacial till plains and morrains. Slopes rarely exceed 10 percent and subsoil materials are deep. Where stream terraces and outwash plains are encountered, sand and gravel will be uncovered at shallow depths.

On many areas erosive clays may be left on the surface but because of the flat terrain erosion will be minimal. The most hazardous erosion conditions will occur at drainage crossings, especially where the James River and headwaters of the Big Sioux River are crossed.

Minnesota

The 131-mile route through Minnesota also traverses the glacial plains where subsoil materials are deep and the topography is nearly level. On some soils the erosive subsoil clays will be left on the surface but erosion will be minimal because of nearly level topography. This will be true throughout the Midwest. Disturbed embankments at drainage crossings and surface ditches will be the principal areas of erosion hazard.

Iowa

The 241 miles of the proposed route through Iowa traverses the glacial plains where conditions are similar to those in Minnesota.

Sediment suspended in trench water will create some adverse impacts if allowed to enter natural streams. This is a particular hazard in areas of high water tables from South Dakota to central Ohio (Figure 3.1.3.4-1); it may also be a problem in other segments of the pipe line if rainwater runs into the open trench.

Illinois

Most of the 161-mile pipeline route through Illinois will be on the glacial plains with conditions similar to those in Minnesota and Iowa.

Two areas along the route where soil stabilization may require special control are the south bluff area of the Illinois River and the small, deeply incised Pecumsaugan Creek area draining into the Illinois River from the north bluff. Construction in the Pecumsaugan Creek and Illinois River north bluff area will entail traversing approximately three-quarters of a mile of extremely thin and fragile bedrock controlled soils with severe erosion potentials. Construction up and along the south rim of the Illinois River will entail utilizing approximately two-thirds of a mile of shallow, steep-sloped, unstable soils. Slopes of 30 to 60 percent are encountered in both areas, and the thin soil mantle underlain with sandstone, shale, limestone and bedrock will be difficult to restore and restabilize once the protective forest cover is removed.

Topsoil imported to reestablish the slope soil profiles may have to be utilized to stabilize the erosion hazard. Small-scale landslides have been observed and documented 4 miles downstream from the Illinois River crossing point on terrain similar to that traversed by the proposed route. The evidence from these studies indicates that slopes greater than 20 degrees on clay rich soils will flow or fracture. Continued surveillance and maintenance should be performed in these areas.

Drilling and blasting will be required to construct through the resistant limestone formations in Pecumsaugan Creek and beneath the Illinois River. Within Grundy and Kankakee Counties, shallow rippable Pennsylvanian shales may be unearthed during trenching.

Indiana

As in the other prairie states, the pipeline route crosses deep glacial tills on nearly level topography throughout the 149 miles of Indiana.

Significant erosion is expected only in the 7 miles of moderately sloped escarpment along the Wabash River near Peru, Indiana. The erodible Miami silt loam terrace and slope phase and Crosby silt loam are located within this area on the interridge areas. Removing the protective forest cover will yield short-term rill and gully erosion lasting until these slopes become fully revegetated.

Ohio

Western Ohio, from the western border to approximately the western edge of Coshocton County, a distance of 131 miles, is in the glacial till region where soils are deep on nearly level topography. Erosion in this area will be moderate except where stream bottoms and surface drain ditches are crossed. Streambank erosion could be a significant problem during spring and summer when seasonally high ground-water levels increase soil plasticity.

For approximately 100 miles in eastern Ohio, the proposed route crosses the Appalachian Province where slopes are steep and soils are shallow over shale and sandstone. This will be an area of high erosion hazard.

In addition to soil and slope problems, high water tables in acidic soils and numerous small stream crossings will intensify erosion problems. Approximately 7 miles of surface mines will be crossed in the eastern counties where unstable acidic spoil piles already exist. These areas are not only erosion hazards but also potential pollution sources.

West Virginia and Pennsylvania

As in eastern Ohio, the 72-mile route through these States traverses steep topography with very shallow soils over shale, siltstone and sandstone bedrock. High water tables, frequent intense rainstorms and acidic conditions all add to the severe erosion hazards likely to be encountered. This area is also crossed by numerous stream channels that will present special erosion problems. It is also probable that borrow areas from which material is taken for pipeline bedding will add to the total erosion hazard area.

The segments of the pipeline requiring bedding material are not known specifically, but will occur primarily where bedrock or other rough materials are encountered in the bottom of the trench. Soil descriptions indicate that most bedding material will be required over about 40 miles in the West Virginia-Pennsylvania area. However, about 150 miles in other areas where soils are shallow may also require bedding material (Figure 3.1.3.4-1). Where practical, excess spoil material from the trench will be used for bedding. Where hauling distances prohibit this, offsite bedding material will be brought in from commercial gravel pits or acquired from other sources where it might be available. The offsite disturbances cannot be quantified since needs are not known at present. If presently stable areas are used to extract bedding material, they will present an erosion hazard.

As indicated above, severe water erosion may occur over approximately 325 miles (3,900 acres) of the route; 38 miles (456 acres) in Montana, 120 miles (1,440 acres) in North Dakota, 2 miles (24 acres) in Illinois, 100 miles (1,200 acres) in eastern Ohio, and 40 miles (480 acres) in West Virginia and Pennsylvania.

The remaining 1,275 miles (15,300 acres) of the route have moderate to low potential for water erosion because of the absence of steep slopes. Additional erosion potentials will exist at borrow sites and access roads which are unknown at present.

The degree of water erosion hazard will depend upon several variables including rainfall intensity during the construction period and the measures taken to prevent erosion.

Soil Losses from Water Erosion

Under natural conditions where the soil surface is protected by adequate natural vegetation and residues, soil losses from sheet and rill erosion are generally exceeded by soil development. This assures perpetuation of the soil resource and continued development of the surface horizon.

On croplands the soil resource is maintained through management practices and nutrient supplements.

Soil erosion is greatly accelerated when cover is removed and bare soil surfaces are exposed. The rate of accelerated erosion is dependent upon such factors as rainfall, soil type (erodibility), and length and percent of slope.

Along the 100-foot right-of-way of the proposed pipeline route, sheet and rill erosion will occur along and across the exposed right-of-way. The rates of erosion will vary according to local conditions along the route.

Normal acceptable soil losses where adequate cover or management exists range from 3 to 5 tons of soil loss per acre per year.

While exact quantities of soil loss along the pipeline cannot now be predicted because of unknown variables, Table 3.1.3.4-1 illustrates the range of rates of accelerated soil loss that can occur on unprotected soils.

Data in Table 3.1.3.4-1 were compiled by the Universal Soil Loss Equation method: A = RK (LS) CP

where A = Soil loss in tons/acres/year

R = Rainfall factor

K = Soil erodibility factor

L = Length of slope

S = Percent of slope

C & P = Management factors

The data are based on typical soil series through which the route will pass. They are not intended to quantify actual soil losses but to illustrate the rate at which soil loss occurs when cover is removed and to emphasize the importance of timely protection on disturbed surfaces. The data are also compiled as yearly averages. Rates of erosion could be much greater during periods of heavy rainfall. Forty to 50 percent of yearly soil losses frequently occur during the months of April, May, and June when rainfall is highest.

Soil loss quantities in Table 3.1.3.4-1 are based on no management practices applied, so C & P values of 1 were used. When permanent vegetation is established, soil loss rates above the acceptable rate will be reduced 98 or 99 percent.

Unless intensive conservation practices are applied such as mulching or matting, the bare ground rates of soil loss shown in Table 3.1.3.4-1 can be expected during the year of construction. Reduction in these rates will depend upon the success of revegetation efforts (section 3.1.3.6, Vegetation).

Table 3.1.3.4-1 . Water Erosion Soil Losses from Bare Ground (Sheet and Rill Erosion) in Tons Per Acre Per Year*

Soil	100-Foot Slope Length									300-Foot Slope Length									400-Foot Slope Length		
Textures**	2%	5%	8%	10%	15%	16%	20%	25%	50%	2%	5%	8%	10%	15%	16%	20%	25%	50%	2%	8%	15%
North Dakota																					
Sandy	2	--	--	12	--	24	--	50	150	2	--	--	20	--	41	--	87	238	--	--	--
Silty	3	--	--	20	--	40	--	78	248	4	--	--	34	--	64	--	157	392	--	--	--
Clayey	4	--	--	26	--	53	--	110	330	5	--	--	44	--	82	--	189	518	--	--	--
Rocky Shaly Subsoil	5	--	--	34	--	70	--	141	436	9	--	--	59	--	118	--	250	686	--	--	--
Illinois																					
Sandy	7	8	--	42	--	--	125	--	--	12	28	--	71	--	--	225	--	--	--	--	--
Silty	21	26	--	130	--	--	400	--	--	36	90	--	230	--	--	675	--	--	--	--	--
Clayey	13	23	--	80	--	--	240	--	--	22	52	--	135	--	--	410	--	--	--	--	--
Ohio																					
Sandy	8	--	--	50	--	100	--	221	--	13	--	--	83	--	167	--	387	--	--	--	--
Silty	11	--	--	71	--	155	--	318	--	19	--	--	118	--	250	--	551	--	--	--	--
Clayey	14	--	--	91	--	200	--	397	--	23	--	--	167	--	333	--	687	--	--	--	--
Residual Sandstone	15	--	--	100	--	200	--	452	--	27	--	--	167	--	333	--	783	--	--	--	--
Pennsylvania																					
Sandy	5	--	25	--	63	--	--	--	--	--	--	--	--	--	--	--	--	--	11	50	128
Silty	8	--	40	--	100	--	--	--	--	--	--	--	--	--	--	--	--	--	17	80	204
Clayey	6	--	30	--	75	--	--	--	--	--	--	--	--	--	--	--	--	--	13	60	153

*From data developed by USDA, Agricultural Research Service, and Soil Conservation Service using the Universal Soil Loss Equation.

**Based on common soil series through which the pipeline route passes.

It is estimated that over one-third of a million tons of soil may be lost from the construction right-of-way through water erosion. The highest losses will occur in the high hazard areas as shown below.

Potential Soil Losses From Water Erosion*

State	High Hazard Areas (Miles)	Estimated Soil Losses** (Tons)
Montana	38	20,520
North Dakota	120	64,800
Illinois	2	2,800
Ohio	100	114,000
West Virginia & Pennsylvania	40	26,500
Remaining 1,275 Miles	(Slight to Moderate Hazard)	153,000
TOTAL		381,520

*Estimated from anticipated soil, slope, and climatic conditions with normal protection efforts. Losses will increase with high intensity rainstorms and could be reduced 40 to 60 percent with intensive conservation practices, including topsoil replacement, mulching, etc.

**Over and above natural soil losses which amount to an additional 90,000 tons for the project area.

Disruption of Agricultural Activities

Grazing

The proposed pipeline route will cross approximately 253 miles of native grazing land in Montana, North Dakota, and South Dakota.

In this region livestock graze very large pasture units during the months when construction will occur. Construction activities will adversely affect grazing patterns since livestock will probably be reluctant to approach or cross the construction area. This will result in abnormal concentrations of animals and heavy grazing on portions of the pastures.

In addition, approximately 3,200 acres of grazing land will be out of production during the construction year and will produce at a reduced rate for several years until new vegetation can be established. This amounts to a loss of forage for approximately 800 animal unit months of grazing the first year and nearly that much the second year if reseeded rangeland is properly deferred from early grazing.

If sections of the pipeline route are fenced to protect new seedings during the period of establishment the fencing would be a temporary barrier that would disrupt grazing patterns.

In some areas temporary access roads with construction traffic will also adversely affect livestock movement.

There will be some danger of animals falling into the open trench during construction, especially at night.

Impacts on grazing east of the western range country are expected to be much less. However, some of the impacts described above might occur in the Midwest and East where pastures along the pipeline route total about 1,045 acres and grazeable woodlands 980 acres.

Croplands

The disturbance on croplands due to pipeline construction will cause two major adverse impacts; the loss of crops during the construction year, and the reduction of cropland productivity for a number of years. Crop losses during construction are covered in Section 3.1.3.11.

It is difficult to assess the crop reductions that will occur after construction operations are completed. As previously indicated, areas where topsoil replacement will take place have not been specifically identified. Topsoil will be replaced where required by the landowner or government agency stipulations.

On areas where topsoil is replaced and soil compaction is not severe, crop production should be nearly normal the year following construction. Where topsoil is not replaced and soil compaction is severe, continuing crop reduction will depend upon the kinds of subsoil or substrata material left on the surface and the intensity of rehabilitation by the farmer.

Even where subsoils have good textural qualities, they lack fertility. The section on topsoil contamination identifies some of the soils where special adverse conditions will occur if subsoils are left on the surface, and mentions some of the measures that might minimize the effects.

Projection of income losses due to the disruption of farming activities are covered in detail in Section 3.1.3.9, Economic Factors.

In addition to crop reductions, the pipeline construction activities will create a variety of inconveniences for the farmer. Movement of farm machinery and tillage and harvesting operations will be complicated by the trenching through established fields. Compaction or subsidence of fill areas along the trench and the exposure of cobbles or gravel on the surface will all contribute to more difficult farming operations.

Noise factors may also have an adverse impact on the production of farm animals such as milch cows, laying hens, and brood sows.

Irrigation Systems

The proposed route crosses two operating irrigation projects constructed by the U. S. Bureau of Reclamation and one authorized project.

The two operating irrigation projects crossed by the proposed route are in North Dakota. The first is the Buford-Trenton Project located on the Missouri River near the North Dakota-Montana border. This project was constructed by the Bureau of Reclamation between 1940 and 1943 and irrigates in excess of 10,000 acres. The project is operated by the Buford-Trenton Irrigation District headquartered in Trenton, North Dakota. The proposed route crosses the Main Canal, three laterals, an open drain twice, and about 4 miles of irrigated lands. Construction across these conveyance facilities will either have to be done during the nonirrigation season or in such a way as to not interfere with normal operation of the project. Pipeline crossings will have to be well marked at each location to prevent damage to the pipeline during irrigation maintenance activities. The disturbed areas from crossings of irrigation facilities should be contoured, smoothed, and reseeded following construction activities. The proposed route will encounter the rising ground-water table under the Buford-Trenton Project.

The other operating irrigation project crossed by the proposed route is the Heart Butte Unit of the Missouri River Basin Project, located in southcentral North Dakota. The principal project facilities were constructed by the Bureau of Reclamation in 1948 and 1949. However, only a portion of the irrigable lands (about 2,400 acres) have been developed to date. The proposed route across the unit does not appear to affect potentially irrigable lands nor proposed sites for future project facilities.

The proposed route crosses the West Lake Plain area of the authorized Initial Stage, 190,000-acre Oahe Unit, James Division, Pick-Sloan Missouri Basin Program. The geographic area of concern is located south of the city of Aberdeen, in the James River Valley, situated in the northcentral portion of eastern South Dakota.

It appears that construction of the Northern Border Pipeline through the affected West Lake Plain area will precede actual development and construction of affected Initial Stage Oahe Unit features. The proposed pipeline will therefore present a design and/or relocation problem at each point where an Oahe Unit feature (canal, lateral, surface drain or subsurface drain) crosses or intersects it.

Actual construction of the West Main Canal will depend upon future Congressional appropriation of funds; however, reasonable projections indicate that it will be constructed during the calendar years 1980 through 1984.

The pipeline route crosses the proposed West Main Canal approximately 3 miles west of Aberdeen, South Dakota. The design of this feature will have to be modified to provide a compatible crossing if conflicts in the profile location exist. The maximum depth of excavation will be about 23 feet with most of the canal length excavated to a depth of not more than 15 feet.

The distribution system laterals will generally be located in a rectangular pattern, with a few exceptions necessitated by the topography or culture at various locations. Construction of laterals is subject to the same funding as the main canal, but the laterals are projected to be constructed during calendar years 1985 through 1988 in the area traversed by the proposed route of the Northern Border Pipeline.

The proposed route will cross the distribution system laterals as many as 15 to 20 times as it traverses the area. The design of the pipeline and each lateral will have to be modified to provide a compatible situation at each crossing depending upon profile location conflicts that might exist.

The project drainage system will include all drains except the on-farm surface drains. The drainage system will consist of a combination of a system of subsurface (closed) pipe drains and a system of open drains, and provide a waterway to return excess waters to the James River.

The proposed route of the Northern Border Pipeline will cross Moccasin Creek Drain twice and will cross the smaller surface drains (open) as many as 15 to 20 times. The proposed pipeline will probably cross the closed subsurface drains several times per mile as it traverses the irrigable area.

The pipeline will have to be buried to considerably greater depths, or elevated and bridged across surface drains depending upon each particular intersection situation. All surface drains will require open channel flow conditions and cannot accommodate obstructions.

The pipeline, as it traverses the irrigable area, will present an obstacle to the normal location of the subsurface drains which vary in depth from 6 to 10 feet and the spacing in this area may vary from 500 to 1,000 feet. The normal layout of the relief pipe drains will have to be altered to avoid crossing the proposed Northern Border Pipeline, and any crossing of the collector pipe system will have to be jacked under at some location where adequate clearance is available. This will result in increased costs for the pipe drainage system.

Even if design conflicts between the applicant and the Bureau of Reclamation are resolved the pipeline project will have some adverse impacts on the land being irrigated. As on nonirrigated cropland, construction activities will take land out of production for one growing season and reduce production for several years if topsoils are not replaced. Special care will be required to restore existing soil density and slope conditions so as not to interfere with gravity flow irrigation.

Only on the Buford-Trenton project will presently irrigated land be crossed. The 4 miles crossed will affect about 48 acres of irrigated cropland. Severe disturbance will occur along the excavated trench and amount to about 5 acres. Additional cropland might be affected if construction prohibits needed irrigation water from flowing downslope from the right-of-way. Mitigation measures applied will depend upon applicant-farmer agreements.

Drainage Systems

Farm drainage systems will be crossed by the pipeline route throughout its length from North Dakota to Pennsylvania.

In the Dakotas the reduced wetland areas throughout the pothole country have resulted from intensive agricultural drainage. Most of the drainage in this area has been accomplished with open drains.

The most intensively drained region is the Midwest from Iowa to central Ohio. In these states combinations of underground tile systems and open drain collection systems have been constructed over a period of many years.

Water from the tile and open ditch collection systems is fed into open ditch mains and laterals which convey the water by gravity flow to a natural stream.

Table 3.1.3.4-2 shows the total drains in lineal feet in each county through which the pipeline passes. These data indicate that the cutting of tile drains will be a common occurrence along most of the pipeline route.

Most tile drain systems encountered will have tile line spacings of 80 to 100 feet across farm fields. The depth of tile throughout the Midwest is commonly 3 to 4.5 feet. The pipeline will have to be placed deeper than normal through tile fields if the gravity flow tile lines are to be reestablished. A depth of 10 feet will probably be required if present tile systems are to be restored. A 10-foot trench will require a greater top width and larger volumes of excavated material.

Tile lines in the Midwest commonly flow year-round except in very dry years when flow ceases in August and September. If the pipeline trench is deeper than the flowing drains, water entering the excavated trench will cause construction problems and large volumes of sediment laden water may cause adverse environmental impacts in the disposal process. Where subsoils are highly acid in the eastern portion of the pipeline, water disposal may create pollution problems in waterways and natural streams (see section 3.1.3.5).

Table 3.1.3.4-2

Existing Drainage Systems in Counties Crossed by Proposed Route*

Counties	Subsurface Tile Field Collection Systems (Lin. Ft.)	Surface Drains Field Collection Systems (Lin. Ft.)	Open Drains Mains and Laterals (Lin. Ft.)
North Dakota			
Williams	--	391,804	56,930
McKenzie	600	556,530	164,713
Dunn	--	1,825	--
Mercer	--	20,000	--
Oliver	--	7,560	45,000
Morton	--	75,238	14,000
Sioux	--	--	--
Emmons	--	43,672	--
McIntosh	--	55,900	--
South Dakota			
McPhersom	--	45,000	--
Edmunds	--	160,000	--
Brown	--	721,756	--
Spink	--	846,766	--
Day	--	2,900,000	--
Clark	--	105,000	26,000
Codington	--	594,805	--
Hamlin	10,000	608,400	--
Deuel	--	719,830	--
Brookings	277	3,363	515,850
Minnesota			
Lincoln	1,129,550	738,400	32,500
Lyon	4,741,952	869,433	1,589,100
Murray	2,847,081	18,001	28,747
Cottonwood	19,571,422	229,610	630,890
Jackson	8,103,593	289,350	124,390
Martin	17,000,000	16,000	225,000

*1974 data from On The Land Conservation Practices, USDA, Soil Conservation Service, Washington, D.C.

Existing Drainage Systems in Counties Crossed by Proposed Route (Continued)

Counties	Subsurface Tile Field Collection Systems (Lin. Ft.)	Surface Drains Field Collection Systems (Lin. Ft.)	Open Drains Mains and Laterals (Lin. Ft.)
Iowa			
Kossuth	77,795,771	222,803	63,268
Winnebago	13,368,924	308,951	473,647
Hancock	4,366,879	441,157	87,936
Cerro Gordo	23,661,307	43,915	128,655
Floyd	22,501,622	11,800	56,766
Franklin	47,312,777	192,416	272,952
Butler	17,392,337	265,037	150,213
Bremer	47,074,686	188,286	195,349
Black Hawk	52,245,593	336,135	224,310
Buchanan	68,723,469	14,000	126,258
Benton	38,586,159	57,085	44,140
Linn	10,367,986	26,431	11,054
Jones	7,410,725	73,182	94,905
Cedar	5,924,041	65,204	11,570
Clinton	7,734,695	128,889	108,379
Scott	4,472,487	104,950	51,967
Illinois			
Rock Island	1,061,823	13,658	356,189
Whiteside	3,842,212	75,502	72,937
Cureau	3,350,198	21,000	156,350
LaSalle	2,406,642	172,235	115,874
Grundy	690,000	123,485	265,475
Kankakee	10,685,000	70,550	1,282,940
Iroquois	9,169,294	1,067,615	392,880
Indiana			
Newton	800,000	93,000	220,000
Jasper	490,000	91,000	390,000
White	6,405,830	83,580	431,990
Cass	8,786,442	24,790	629,741
Miami	2,822,592	16,400	130,950
Wabash	5,532,341	27,075	135,415
Huntington	12,899,706	15,150	219,780
Wells	17,992,693	71,094	922,944
Adams	14,617,342	302,920	213,260

Existing Drainage Systems in Counties Crossed by Proposed Route (Continued)

Counties	Subsurface Tile Field Collection Systems (Lin. Ft.)	Surface Drains Field Collection Systems (Lin. Ft.)	Open Drains Mains and Laterals (Lin. Ft.)
Ohio			
Mercer	35,985,800	215,426	242,204
Auglaize	51,830,594	110,012	1,258,478
Hardin	15,740,250	208,800	474,300
Logan	14,712,359	95,051	393,798
Union	10,314,770	228,446	1,209,037
Marion	41,189,361	32,000	947,250
Delaware	44,736,490	75,184	516,632
Morrow	11,750,000	--	3,500,000
Knox	5,685,108	12,275	250,000
Licking	8,651,589	23,880	433,276
Coshocton	900,517	4,550	130,629
Tuscarawas	2,763,160	31,285	68,896
Guernsey	409,014	141,300	84,896
Harrison	25,187	1,100	2,956
Jefferson	60,125	8,453	59,782
West Virginia			
Brooke	39,360	1,000	--
Pennsylvania			
Washington	599,426	--	--
Allegheny	87,190	--	4,496
Westmoreland	1,760,348	9,748	3,627

As Table 3.1.3.4-2 indicates, the proposed route will also transect numerous open drains including small collection ditches and large mains and laterals.

Where the trench is cut through flowing open drains, significant amounts of sediment will be added to the drain flow until construction and rehabilitation are completed. This might impede water passage and pollute streams into which the drains flow.

In some cases the pipeline trench may act as a drain and accumulate water at low points. If the volume of accumulated water rises to the tile system level and exceeds the capacity of the system, wet spots may occur.

The movement of heavy equipment might crush shallow collection tiles. This would back water up in the tile lines and cause wet surface spots in farm fields.

Where water is allowed to accumulate at the surface there will be significant reductions in crop production and farming operations will be very difficult.

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3.1.3.5 Water Resources

Construction of the proposed pipeline can have impacts on the ground and surface water resources along and adjacent to its route. In most cases, these impacts are important because sufficient water of good quality is critical to human existence and necessary for population growth that is expected during future years. The impacts that will be caused by the project on water quality and quantity are generally small to negligible. For the most part, this low degree of impact is directly attributable to: (1) the short duration of some impacts and (2) the decrease in effect with the passage of time for some impacts of greater duration. Moreover, some of the impacts are essentially self-correcting in the natural course of events.

Although the impacts are readily identifiable, they are difficult to quantify at this time, because no final alignment has been determined. It is not yet definitely known, for example, just what drainage subbasins will be traversed, or just where streams and rivers will be crossed. However, general information regarding stream behavior, the character of shallow aquifers, patterns of ground-water flow, and existing quantities and qualities of various ground and surface water supplies are known. Thus, the relation of the ground and surface water to the proposed pipeline corridor can be approximated.

The impacts of pipeline construction and operation on the water resources are threefold: (1) effects on the quality and quantity, (2) effects on the use of the water, and (3) effects on the physical environment of which the water is a part.

These impacts largely will be the result of: (1) changes in the amount of sediment load due to increased erosion, (2) changes in the amount of sediment load due to construction activity, (3) changes in the amount of dissolved solids due to changes in the ground-water environment, (4) changes in the stream channel due to changes in the stream environment, and (5) changes in the amount of dissolved solids due to maintenance and operation procedures along the right-of-way. Other impacts will result from spills of fuels, and possibly from the application of chemicals, along and adjacent to the right-of-way.

In considering the effects of the proposed construction, it is important to understand the physical relation of surface water to ground water in shallow, commonly glacial aquifers. In a sense, the waters are the same for they normally are free to flow from the stream to the aquifer (bank recharge) or from the aquifer to the stream (bank discharge) in response to the local hydrologic environment of the season.

Effects on Surface Water

Increased Turbidity and Sediment Load

Causes of Increase

Erosion of soil and accelerated erosion of the underlying earth materials will be the chief causes of increased turbidity and sediment load in the streams, rivers, ponds and lakes that occupy drainage subbasins traversed by the proposed pipeline route. Additional but lesser causes include: (1) construction activities in water bodies to be crossed, (2) increased erosion of channel floors and banks, (3) discharge and perhaps withdrawal of water for hydrostatic testing, and (4) flood scour.

The erosion of soil as an impact along the right-of-way is discussed in Section 3.1.3.4. There the use of the Universal Soil Loss Equation suggests that with normal protective effort, a total of over one-third of a million tons of soil could be eroded from the entire length of the right-of-way. Part of this would be deposited as colluvium or alluvial fan deposits, but part would enter the streams and rivers. Reduction of the rate of erosion would be achieved by intensive conservation practices.

Accelerated erosion of the earth materials underlying the soil would follow soil loss, but at present, there is no means of estimating the potential loss quantitatively. Of the amount that is eroded, part of it also would be deposited as colluvium and alluvial fan deposits and part would enter the streams and rivers.

Thus, the increase in turbidity and sediment load carried by streams would be partly eroded soil and partly eroded underlying earth material. The relative quantities cannot be distinguished. However, the increase in stream load should be apparent in measurements at stream gaging stations. One estimate made (unpublished communication, U. S. Geological Survey) suggests that in Montana, the increase would be 10 to 20 times the normal load during construction, but would decrease to 2 to 4 times normal a year later.

Judging from the relative potential for soil erosion as represented in Table 3.1.3.4-1 (Section 3.1.3.4), the sediment load that would be measured in streams of the Midwest would probably be even greater, because of greater rainfall. This conclusion is supported by the data in the following paragraph. For the same reason, however, vegetation there could be reestablished more readily so that the decrease in sediment load over a year probably would be greater also.

The impact of erosion runoff on receiving streams and impoundments will be affected more by the capacity of these bodies of water to transport sediment than by the quantities of soil released. The following are the maximum values of suspended sediment and dissolved solids reported by the U.S. Geological Survey for the most recently available years within five regions along the route.

Location	Year	Maximum Suspended Sediment	Maximum Dissolved Solids
Missouri River Basin (Montana)	1973	107 mg/l	250 mg/l
James River Basin (South Dakota)	1973	150	1170
Minnesota River Basin (Minnesota)	1972	520	---
Cedar River Basin (Iowa)	1973	1580	570
Rock River Basin (Illinois)	1971	600	480

The high content of dissolved solids in the water of the James River probably reflects: (1) the slow rate of flow, allowing greater opportunity for solution, and (2) the lack of large tributaries, providing little mixing with less degraded water.

The maxima of suspended sediment and dissolved solids are always transitory phenomena, lasting only 1 or 2 days and all of them occurring during periods of high runoff in the months April through July. The norm for suspended solids was 50 to 100 mg/l, and about 100 mg/l for dissolved solids. The wide variations in maxima reflect the varying soil types along the route.

Gullies and small waterways that receive direct runoff will experience much higher sediment loads. Experience with highway construction indicates that sediment concentration will be as high as 20,000 mg/l (or about 2 percent solids) for periods of 1 to 2 hours.

In addition to the erosion that will occur along the right-of-way, erosion can occur in the area cleared and graded for access roads, in pits producing sand and gravel or other needed earth materials, and in the disposal piles for excess material from trench excavation. Neither the location of these facilities nor their design has been determined as yet.

Increased erosion of soil and other earth materials probably will occur along the entire pipeline right-of-way, along access roads, in borrow pits and from disposal piles. It will begin with clearing of the right-of-way, but once revegetation is started the rate of erosion generally will decrease and probably will reach normal preconstruction levels in from 3 to 5 years.

Another main cause of increased turbidity and sediment load will be construction activities at stream crossings of the pipeline. The instream activities necessary for trenching, pipe placement, and backfilling will contribute significant quantities of clay, silt, and sand, especially if blasting is required. The quantities of each size fraction produced for stream dispersion will differ from stream to stream, and depend on many factors including the thickness and mean particle size of the bottom sediments, current velocity, and construction equipment and practices.

Increased turbidity and sediment load caused by instream activity at crossings will occur during the construction stage and at such times during the pipeline operation as instream maintenance is needed. The rate of dispersion will depend chiefly on the quantities of materials produced and the current velocity. The slowest rate of dispersion probably will occur at the James River crossing. Here, the materials trenched will be almost wholly clay and silt-size glacial lake sediments. Moreover, the current velocity of the river drops to 0.5-foot per second during low flow and is reported to have reached 0.0 at times.

Other localities of low flow velocity and slow dispersion will be the two crossings of the Missouri River Valley in North Dakota; both crossings are at sites of reservoirs.

Disturbance of bottom materials will begin with initiation of instream construction activities and terminate with completion of the installation. Disturbance will be renewed if subsequent instream maintenance is required. Most streams probably will achieve dispersion with normal flow rates of from 2 to 4 feet per second. It is unlikely that any of the streams will reach a rate of 5 feet per second, except in flood stage.

A third, and perhaps less significant cause of increased sediment load would be backfilling of the trench in the stream channel and vicinity, especially any area subject to flooding, with sediment of significantly finer particle size distribution than that originally at the channel surface. This material would be more susceptible to erosion because of its finer particle size and could lead to local scour during normal flow and especially during flood stage.

Backfilling of the trench with too fine material will occur during the last part of the activity at each crossing and will be a result of insufficient care on the part of the applicant. Perhaps after a year of seasonal flows, the sediment load normally transported by a particular stream would again mantle the trench area and, thereafter, renewed erosion may occur only during flood stage.

A fourth possible cause of increased sediment load would be increased erosion of the channel floor caused by a break in slope. If the channel floor is left with a step in the profile at the trench line instead of a profile comparable to that of the original floor, the break in slope can initiate a cycle of erosion that will cut toward the headwater of the main-stream, and each tributary as well, until equilibrium is reestablished. It can affect not only the channel floors and walls, but eventually all the surface of each drainage subbasin affected. It could thus increase the erosion of soil on areas much greater in size than that of the pipeline right-of-way through the subbasin. Control of this erosion is difficult and costly.

This kind of erosion will take place from the time in-stream construction operations cease until the erosional cycle is complete and equilibrium is reestablished. It will be caused mainly by the applicant's failure to maintain the preconstruction gradient in the channel floor.

A probable fifth cause would be the increased erosion of channel floors and banks due to the greater exposure to current action that results from removal of protective vegetation.

The loss of vegetation along the channel banks at crossings will take place, and the resulting increased erosion will occur until vegetation is sufficiently reestablished, or other means of erosion control are used. This matter is discussed more fully in Section 3.1.3.6.

The fifth cause can lead to a sixth. Increased erosion of channel banks can result in increased lateral and longitudinal migration (shift) of stream channel meanders. This amounts to a shift of the location of potential scour, which exposes the trenched pipeline if it is not buried beneath scour depth in the flood plain area and channel floor.

Lateral and longitudinal migration (shift) of channels is an ongoing natural process that is accelerated by increased erosion of channel banks. Acceleration will begin with clearing of vegetation, and continue until vegetation is reestablished or other means of erosion control are used.

A seventh factor in channel erosion can be the discharge of hydrostatic test water. Even though the water is not discharged at a rate greater than the normal flow of the receiving stream, the greater turbulence of the flow in the vicinity of the point of discharge can cause more erosion than would the normal flow at the same location. A similar result, but smaller in scale, can occur from any pumpage required to drain the trench in areas of high water table or at some stream crossings.

Increased turbidity and sediment load caused by erosion due to the discharge of hydrostatic test water can occur at any time and place that the water is discharged, especially where the streamflow is below normal, and mainly at the locality of actual discharge.

Impacts of Increase

The turbidity and sediment load of a stream is not of itself serious, for the same condition is a natural result of a storm. It can, however, affect private and public water supplies: fish, wildlife, and vegetation associated with the streams; and commercial and recreational aspects of stream use.

A large sediment load can lead to increased sedimentation on the channel floor and banks. This can reduce the migration of water from the stream into the adjacent alluvium or other aquifers. This, in turn, reduces the quantity of water in the aquifer, and thus, the amount available to wells in that aquifer. The reduced recharge of the aquifer can also reduce the dilution of what may be less potable water in the aquifer.

Moreover, increased sedimentation on the channel floor and banks can lead to restricted channel dimensions and either an increased likelihood of flooding or a likelihood of higher flood levels.

The probability of increased sedimentation within a downstream distance of several miles is great, but the likelihood of it significantly restricting aquifer recharge, reducing dilution, or increasing the flood potential is small to negligible. Furthermore, the sediment so deposited can be eroded during the next flood flow of the stream.

Increased turbidity and sediment loads can cause fouling of private and public water supply filters, requiring backflushing operations to clear them sooner than required by normal maintenance schedules. The need for early backflushing probably will exist and may be identified as related to construction activities by the time relation. Clogging during and following the period of instream operations, but prior to the next natural high flow would probably result from the construction. Considering the planned length of time for each instream operation, the problem of additional back flushings appears to be small.

The impacts of an increase in turbidity and sediment load on fish (wildlife) and vegetation are discussed in Sections 3.1.3.7 and 3.1.3.6, respectively.

Effects on Local Watersheds

The proposed pipeline route will traverse principal watersheds or drainage basins. In crossing the drainage basin the pipeline will cross many subbasins--even "micro-basins." The impact of the pipeline on the surface drainage of a subbasin will be proportionately greater the smaller the subbasin. In addition, the effect of diversion can be greater if subbasins are crossed near their headwaters. Finally, most diversions of surface runoff will have little to negligible effect on small permanent streams, and negligible effect on the larger permanent streams.

One possible effect of the pipeline on a subbasin will be the diversion by the trench, acting as a French drain, of surface runoff from the headwater area of one subbasin to an adjacent subbasin across an intervening minor drainage divide. This will reduce the flow of the first stream, and increase that of the second. However, both may be tributary to the same principal stream; if so, its flow is essentially unaffected.

Because the final alignment of the pipeline has not been established, it is impossible to say just where this will happen. This kind of situation, however, is illustrated by that part of the proposed route from the vicinity of Watertown, South Dakota, to Fairmont, Minnesota. Here, the proposed route follows a principal drainage divide, and the transfer of surface runoff from one subbasin to another, and perhaps from one basin to the other can occur.

A particular situation that will probably occur is the effect of the diversion of surface runoff from a pothole located, for example, in that part of the route across southcentral North Dakota and eastern South Dakota. Here, the location of the trench across the side of a pothole can divert surface runoff from the pothole, perhaps to an adjacent pothole, or perhaps to an integrated drainage route. The diversion will have little effect on the pothole provided the floor of the trench is above the normal water table during the spring of the year. In that situation, a pothole that contains a year-around pond will experience negligible effect, for the pond level represents the water table, and the water table will be little affected by the diversion of runoff.

If the pothole is dry part of the year, and the pothole is situated above the average water table, the diversion of runoff from the pothole will cause the pothole to dry up sooner.

The effect of diversion of surface runoff on lakes and year-round streams that would have normally received that runoff will be negligible.

The impact of diversion of surface runoff can begin with the clearing of the route, and will begin with the opening of the trench. The impact will continue more or less indefinitely; the effectiveness of the diversion perhaps will decrease with time as the trench backfill consolidates naturally.

The impact will be negligible in its general terms. Should the diversion directly affect a private water supply, the impact would vary from case-to-case, but could be great. At this time, it is impossible to identify such situations.

Effects on Municipal Surface Water Supplies

Public supplies drawn from surface water sources and with intakes less than 50 miles from the proposed pipeline crossing are shown in Section 2.1.3.5.

Another possible impact on private and public surface water supplies could be caused by the too rapid withdrawal of hydrostatic test water from a stream or lake that constitutes a significant part of such a supply. This could result in an increase in the turbidity of the supply, or even a lowering of the water level relative to the supply intake. Although the situation could occur and be serious, it is considered unlikely. Locations for test water withdrawal have not been determined. Thus, it is as yet impossible to ascertain where this impact might occur.

Effects on Water Quality

Effects on water quality will be degradational, and will consist of: (a) an increase in turbidity and sediment load, and (b) an increase in dissolved solids. These impacts are believed to be negligible to minor in character. In addition, degradation from spillage or other loss of construction materials is expected and is discussed below.

An increase in the content of dissolved solids can result from construction of the pipeline. Sources of the increase will be chiefly (a) the fragmented backfill of the pipeline trench, and (b) the disturbed material that causes turbidity and increased sediment load.

Water that enters the permeable backfill of the trench can dissolve more solids because of the greater surface area of the fragmental backfill compared with the same unexcavated, less permeable material (see Section 2.1.3.5). Where that water is near or at the surface it can affect plant life. Where it enters a body of surface water, it becomes part of a potential human supply.

Along the 485 miles of the proposed route from the Canadian border to the second crossing of the Missouri River, water passing through backfill probably will dissolve sodium sulfate which is locally present in the bedrock, to a lesser degree in the overlying glacial deposits, and in considerable quantities locally on the ground surface. Where that water reaches the ground surface, perhaps at the foot of a slope, the sulfate content reduces or prevents vegetation growth. These areas are locally known as "slicks" and are from several feet to several yards across.

The probability is great that sodium sulfate will be dissolved, but the likelihood that sufficient quantities will be dissolved to significantly degrade a human water supply is small, and the likelihood of significant damage to a public water supply is negligible. The probability that additional slicks will be caused is also small. Loss of land use in the region because of slicks already exists.

Along that part of the route from about the crossing of Big Muddy Creek to the second crossing of the Missouri River, a distance of about 240 miles, lignite is widespread, and locally is exposed at the surface. Decomposition of iron sulfide materials in the coal yields sulfuric acid. The decomposition is increased by the presence of water, which carries dissolved oxygen. Thus, surface water passing over the coal can take up sulfuric acid, as does ground water passing through the coal, or through trench backfill containing coal. In either case, the water can enter a private or public water supply.

It is probable that surface water will receive some sulfuric acid in one way or another, but the likelihood that surface water will receive enough to significantly affect a water supply is negligible. Moreover, wells into bedrock are the customary source of water supplies in this region.

Degradation from Spills, Dumps and Chemical Applications

The large quantities of diesel fuel and gasoline required by the proposed actions will require concentrated storage and distribution points. At these points a certain amount of spillage is probably inevitable. Other spills may result from vehicle accidents, careless practice, or catastrophe.

These point sources of petroleum infusion into the environment will create minor impacts. Soil is an efficient absorbent for petroleum, and good management can prevent any escape of petroleum to bodies of water. Nevertheless, it is expected that some streams and ponds near the route will occasionally receive sufficient petroleum products to create detectable films for at least a short period. Such films may be very destructive to aquatic microbiota, but they present no hazard to larger, mobile species.

A catastrophic spill would be capable of affecting practically all aquatic life adversely.

No other construction-related materials present potential hazards to the environment. Pipeline coating materials will be used in vast quantities, but they and greases are viscous materials that possess very low mobility in the environment. No other liquid materials will be used in significant quantity, and there will be no solid materials to contribute debris that will threaten water quality along the route.

Most construction debris (apart from log dumps) will be associated with erection of compressor stations. Spills of paint, solvents and lubricants are to be expected, but their impact upon water quality will be negligible or nonexistent.

Chemical applications to the right-of-way will consist mainly of fertilizers. These will be applied when revegetation of the route is undertaken. Of the three universal fertilizer constituents (N, P and K), nitrogen and potassium are capable of migrating to and in bodies of water, but phosphorus is precipitated in the apatitic form within a few meters of application. Natural ion exchange processes will trap most of the potassium, but significant nitrogen (as nitrate, NO_3) may reach waterways and contribute to eutrophying conditions.

The major herbicides, roughly in order or volume used, include phenoxyl compounds (2,4-D, 2,4,5-T, etc.) triazines (Atrazine), dinitroaniline compounds, urea derivatives, and amides. The wide variety of herbicides available reflects the fact that specific compounds are capable of killing specific weeds. The phenoxyl compounds are a hazard because they are chlorinated chemicals, and they affect the biosphere in a fashion similar to chlorinated insecticides. The other classes are relatively benign and are degraded rapidly in the environment.

The farming regions along the route have all been shown to exhibit "background" levels of pesticides in the soil. Thus, the use of pesticides along the route will have only an incremental impact, unless there is a catastrophic spill. This incremental impact will be closely tied to erosion of soil from the acreage along the route.

No significant impact on ground or surface water is expected from the natural gas to be transported by the pipeline should a leak occur. Such impact as there may be will be only local in character since most constituents of natural gas are practically insoluble in water.

Effects on Ground Water

The relation of surface water to ground water in shallow (surficial) aquifers was described above. The relation of ground water in shallow aquifers to that in deeper (bedrock) aquifers is similar, but less direct. In some cases, there is water migration from shallow aquifers into deep aquifers, and locally there is leakage from deep aquifers to shallow. Probably much of the recharge received by deep aquifers has percolated downward through the soil and surficial materials, and underlying weathered and fractured bedrock, into aquifers, and has not reached the aquifer directly.

The potential migration of ground water from the pipeline trench into aquifers is reduced greatly by so much of the trench being located in till, which is of low permeability. Thus, localities of maximum concern are (1) those points where the trench passes through the boundary between till and a shallow aquifer, and (2) those localities where the trench is in bedrock that is permeable due to its fractured character or its porosity. There is no reported evidence that surface construction or excavation affects the quality of ground water unless impoundments are created or aquifers are intercepted.

There perhaps is less need for concern for those areas of shallow aquifers, for if backfilling is done with the excavated material, the potential for degradation of the ground water is less.

Increase of Turbidity and Sediment Load

Extremely fine (colloidal) particles eroded from the soil, the underlying earth materials, or the trench backfill can enter a groundwater supply despite the filtering effect of the enclosing sediment or rock. This is particularly true of the ground water moving through fractures in the rock. If this does occur it can increase the turbidity of water removed for use in either a private or public supply.

The source of such turbidity could be (a) disturbance of sediments in a channel floor by instream activity, (b) erosion of backfill, and (c) erosion of soil and underlying earth materials.

The probability that the turbidity of a shallow aquifer will be increased is negligible; for a deep aquifer it is believed to be nil.

Effect on Local Aquifers

Just as the trench can act as a French drain and so divert surface water runoff, the trench can also "behead" the upper part of the ground water present in a shallow aquifer, provided that the floor of the trench is lower than the water table surface. The ground water thus beheaded can be diverted from the source area if the trench provides a gradient; if it does not, the water will not migrate.

Beheading of the water table increases the depth of the water table adjacent to the trench, but the increase in depth becomes progressively less with increasing distance from the trench. The lateral distance in which the water table is lowered depends largely on the permeability of the material. For example, the position of the water table in till may not be affected more than 200 feet from the trench; in sand and gravel the effect may be felt perhaps 500 feet away. Similarly, the less permeable the material, the longer it takes for the surface of the water table to adjust to the change. Sand and gravel may adjust in a few hours or days; till in a few days or perhaps weeks.

One practical impact of this change in the position of the water table is on water supply wells into shallow aquifers. The water level in the well is lowered somewhat, but only dug wells depend on such shallow supplies, so that very few wells would be affected. The amount of lowering of the water surface in the well (the position of the water table) depends on the material of the aquifer and the distance of the well from the trench.

Another potential impact of the change of water table depth is the possible draining of a pond or wetland such as those present in the pothole country along the proposed route in North and South Dakota, Minnesota, and northern Iowa.

For example, a typical pothole pond contains about 5 feet of water, but the pipeline trench will be 7 to 8 feet deep. Thus, if the floor of the trench is below the floor of the pond, the pond can be drained if the gradient of the trench permits. If the position of the trench floor is not deep enough to drain a pond or wetland, it can be deep enough to lower the water level.

A third possible impact of beheading the ground-water table is the reduction of flow from a spring downslope of the trench, or conceivably its stoppage, because of reduced or lost supply. As the specific location of springs is not known presently, and the alignment location has not been determined, the springs that can be affected are not known.

In general, the trench will have only local, insignificant impact on the freedom and direction of flow of ground water because the trench floor will commonly be above the water table, and elsewhere will not intercept it deeply.

Effect on Municipal Ground-Water Supplies

Ground-water supplies for municipal use apparently are not drawn from shallow aquifers along or adjacent to the proposed route. Thus, there will be no impact from pipeline construction on such supplies.

Pipeline construction will have no measurable effect on the quantity of water that reaches (recharges) a deep aquifer used as a source of municipal supplies.

Water Quality

Effects on the quality of ground water can be degradational. The cause will consist mainly of (1) an increase in dissolved solids, but in small part may consist of (2) an increase in turbidity. These impacts probably will be minor to nil in character. In addition, negligible degradation from (3) spillage or other loss of construction materials is expected, and is discussed below.

An increase in the content of dissolved solids can result from the construction of the pipeline. The causes of increase, the principal likely solutes (materials dissolved), and the areas in which they are likely to be dissolved, were described in Section 2.1.3.5.

Water with an increased content of dissolved solids can flow from the trench or a disturbed stream into an adjacent aquifer, whether shallow or deep. Shallow aquifers are much more likely to be moderately to highly permeable than deep aquifers, and to be exposed for greater distances to bank recharge from the trench or by contact with stream channel deposits. Thus, the hazard of water quality degradation in an aquifer is greater for shallow aquifers, which are commonly of glacial origin. Moreover, shallow aquifers are commonly used for private water supplies and stock use, and are not known to be used for public supplies along the proposed route.

There probably will be an increase in the content of dissolved solids, particularly sodium sulfate and sulfuric acid in the areas indicated, by the movement of water through the trench backfill and from the disturbed bottom sediments at stream and river crossings. Although this increase can be measurable, its degradation of water quality probably will be minor to negligible in shallow aquifers and negligible to nil in deep aquifers.

The probability that such an increase can be measured in shallow aquifers is small, and the likelihood that the increase will be significant is negligible. For deep aquifers the probability that the increase can be measured is negligible to nil, and the likelihood of significance is nil.

Where these materials enter and affect water quality there exists a potential for transmission to shallow aquifers, and perhaps to deep aquifers in the same way and to the same degree as the transfer of sodium sulfate or sulfuric acid. Although the increase can be measurable, the impact in terms of use will be minor to negligible in shallow aquifers and negligible to nil in deep aquifers.

The proposed actions can have impact on the quality of ground water if impoundments are constructed for the purpose of receiving wastes. Such impoundments may include sewage or other materials. However, even in these cases, the possibility of ground-water contamination is dependent on the soil permeability and substructure.

3.1.3.6 Vegetation

Construction Impacts

Terrestrial Plant Communities

Upper Missouri River Basin

The proposed route will cross approximately 253 miles (3,036 acres) of native rangeland in Montana, North Dakota, and South Dakota. As described in section 2.1.3.6, Vegetation, the route through this region traverses the mixed grass prairie association and may cross as many as 22 identifiable terrestrial plant communities described as range sites.

An additional 6 miles of riparian woodlands and stream bottom plant communities will be traversed where waterways and flood plains are encountered.

Approximately 14,525 acres along 1,200 miles of the proposed right-of-way are presently devoted to intensive agriculture. While the crops grown are a form of vegetation, they differ greatly from the permanent perennial plant communities described in Section 2.1.3.6.

Most of the agricultural lands are planted each year with annual crops such as corn, soybeans, or small grains with periodic short-term rotations of alfalfa or other forage species.

The impacts to agricultural crops are covered in sections 3.1.3.4, Soils, and 3.1.3.11, Land Use.

An estimated 3,200 acres of native rangeland along the 100-foot wide right-of-way in the Upper Missouri Basin will be disturbed by clearing, grading, trenching, and the passage of heavy machinery. Additional areas will be disturbed by access roads, compressor stations, and other facilities.

The degree of distrubance within the pipeline right-of-way will vary with local conditions. On steep, sloping land the grading of a level right-of-way will require the removal of most of the topsoil and existing vegetation. On flat to gently rolling rangelands, clearing and minimal grading will allow most of the topsoil to remain. On these areas, only the brush species need to be removed except in the trenching area. However, where native sod is not removed the compaction from equipment movement will have a serious adverse effect on the existing vegetation.

The most seriously affected area along the right-of-way will be the trench where substrata material is used to cover the pipeline. This will make revegetation very difficult.

The range sites described in section 2.1.3.6 fall into three general categories which are easily correlated to topographic conditions: (1) range sites having shallow soils and steep slopes encountered in areas of rough topography, traversed for 158 miles (1,896 acres), (2) deep soil range sites where the topography is level to rolling, traversed for 199 miles (2,388 acres), and (3) wetland sites in relatively flat areas easily identified by the more lush vegetation interspersed in the deep soil range areas, and traversed for 228 miles (2,736 acres).

The rough topography range sites are the most fragile having thin topsoils and coarse sterile subsoil materials. Deep soil sites, i.e., silty and sandy sites are less fragile because the subsoils, although lacking fertility, provide a good medium for revegetation. Wetland sites recover rapidly if the water table is not altered.

Environmental impacts will be directly related to the relative fragility of the site. The steep shallow sites when disturbed will be the most difficult to revegetate. The steep slopes will be subject to erosion and the coarse substrata material will lack the characteristics needed to support the natural vegetation of the surrounding area.

Where total removal of the existing vegetation and topsoil occurs reseeding will be necessary. Natural plant succession through to climax condition will require many years. Where exposed soil material has been drastically changed, only aggressive introduced species such as crested wheatgrass might establish.

Trench lines through the steep shallow sites will be visible for many years because of the limited ability of the reconstituted site to support the kind and amount of vegetation in the surrounding area. Accelerated erosion in these areas will persist for many years.

Some areas where significant impacts on the vegetation will occur are listed below:

Montana--The proposed route will cross about 96 miles of native rangeland and disturb about 1,200 acres. Additional areas of rangeland will be disturbed by new access roads in the Frenchman and Rock Creek areas.

Most of the rangeland crossed in Montana is in Phillips and Valley Counties and is dominated by the deep soil, moderate topography range sites described in section 2.1.3.6. Shallow sites will be encountered in the eroded tributaries of Frenchman, Rock, and Willow Creeks for about 38 miles.

East of Porcupine Creek the rangeland traversed is primarily the silty site on level to rolling topography with approximately 60 acres of clay soil sites having high alkaline accumulations.

The most fragile areas encountered will be the shallow steep sites and where significant eroded streambeds are crossed.

Impacts to vegetation will be relatively high in Montana because of the low precipitation which slows natural plant succession and makes revegetation difficult.

Approximately 600 animal unit months of grazing will be lost during the construction year and the first year of new vegetation establishment. Plant communities along the route will change in composition making the pipeline strip visible for at least 10 years. Scattered stands of hardwood trees are found on the flood plains of Frenchman Creek and the Poplar River, where scattered trees occur along the banks and small stands of cottonwood occur in some of the oxbows. This type of vegetation is also found along some of the lesser streams and clumps of small trees and shrubs occur in some of the swales and coulees. This woody growth is composed of scattered junipers, green ash, big sage, silver sage, rabbit brush and some other shrubs, and it is genrally more abundant on the north-facing slopes. The total extent of woodland within the Study Area accounts for less than 1 percent of the total area and, where it occurs, woody growth is extremely dispersed due to the intermittent nature of the streams and associated moisture conditions.

Impacts to woodland will not be severe in these areas but even the loss of small patches of trees and shrubs will reduce important wildlife habitats.

North Dakota--The proposed route crosses about 120 miles of rangeland in North Dakota affecting approximately 1,500 acres.

Shallow range sites (badlands or rolling rangeland with numerous bluffs, buttes, and coulees) are prominent primarily in the western part of the Study Area for 78 miles along the Missouri River, the Little Missouri River, and the Heart River. Most rangeland is not rugged, but merely undulating or rolling. This is particularly true in the glaciated part of the region east of the Oahe Reservoir, where the rangelands are less broken by erosion.

Badlands are found on both sides of the Little Missouri River for a distance of approximately 20 miles. It is a steeply eroded area marked by deep ravines, and numerous benches, buttes, and pinnacles. The gorges can be as deep as 500 feet, and barren or partially vegetated slopes are common. The most eroded parts are, as a rule, the southfacing slopes where moisture conditions are extremely unfavorable for vegetative growth. These are the most fragile range sites along the route in North Dakota. Where the vegetation is destroyed and bedrock material left on the surface, plant communities will not establish for many years.

Approximately 700 animal unit months of grazing will be lost during the first 2 years of the project.

Except in the badland areas, revegetation is not difficult and full productivity can be achieved in 2 or 3 years.

Changes in plant communities, however, will be evident for many years marking the pipeline route.

Forest growth is extremely restricted in North Dakota. The total extent of woody growth accounts for less than 1 percent of the Study Area and, except for those woodlands around the Killdeer Mountains, it is extremely dispersed due to the intermittent nature of the streams and associated moisture conditions. Impacts will be relatively slight but will cause some loss of wildlife habitat.

Bottomland hardwood forests have a more widespread distribution along the major rivers. Within the Study Area, good stands of hardwood forest are found on the Little Missouri River, Cannonball River, and Big Beaver Creek. The fringes of the lesser streams, and the swales and coulees leading to these tributaries, are frequently vegetated with clumps or scattered elements of flood plain forest, like green ash, elm, willows, currents, hawthorn, and wild raspberry.

The removal of this vegetation will reduce wildlife habitat and decrease esthetic values until new vegetation is established. It will require many years for mature trees to reestablish.

South Dakota--About 22 miles of rangeland interspersed with tame pastures will be crossed by the proposed route in South Dakota.

The more extensive areas of rangeland in the Study Area occur along the sloping margins of the Coteau du Missouri and Coteau du Prairie and in association with the pothole terrain that marks the surfaces of these two glacial landforms. Elsewhere in South Dakota the rangeland is restricted to scattered sections and to the margins of streambeds.

Because of higher precipitation, revegetation is not as difficult as in the drier areas of Montana and North Dakota. The range sites encountered will be of the wetland or deep soil type with relatively flat topography. These sites are described in section 2.1.3.6. If properly reseeded these sites will produce plant communities comparable to those disturbed in 2 to 3 years.

Practically no woodland habitats will be encountered.

Upper Mississippi River Basin

The impact of pipeline construction in the Tall Grass Prairie and Oak-Hickory Forest Region is imposed mainly on croplands. Clearing will destroy all standing crops along the route. This action affects crop production rather than vegetation patterns.

In the Tall Grass Prairie and Oak-Hickory Forest Region, native prairie is a scarce resource which, when identified, tends to be protected in the form of nature preserves. However, unmanaged pastures such as are found along drainage ditches, streams and potholes, resemble the original prairie and these areas have been identified as grasslands. They exist for 26 miles along the route.

The impact of pipeline construction needs to be no greater on these grasslands or permanent pastures than on hayfields and croplands in the same area. Yet the impact may be of a higher level if these lands are not given considerable attention during the rehabilitation phase. The reason for this is that permanent pastures are often relegated to the poorest sites on the farm, and manure and fertilizers are diverted largely or entirely to croplands. As a result, it is probable that the right-of-way will remain visible for a longer period of time than on croplands or on rotational pastures receiving a more intense management.

Another aspect to consider is that permanent grasslands are found adjacent to water or trees and constitute a preferred cover not only for many birds and waterfowl, but also for farm game and animals of the open fields that frequent croplands in the same area.

Woodlands occupy only a fraction of the Tall Grass Prairie and Oak-Hickory Forest Region. Very few woodlands are found along the route through Minnesota and Iowa, and most of the available woodland is overgrazed and open. Fairly dense and extensive bottomland hardwood forests are restricted to major rivers in eastern Iowa and Illinois, and shelterbelts and woodlots are abundant in Illinois. Six miles (72 acres) of woodlands will be traversed.

Bottomland hardwoods are encountered along almost every stream and while stream crossings will frequently be made via pastures or grazed open woodlands, it will not be possible to avoid all bottomland stands. Bottomland sites are prone to flooding and streambed erosion, and emphasis should be placed on streambank restoration.

Some specific vegetation impacts that will be caused by the project follow:

Minnesota--Grasslands in Minnesota consist mostly of tame, permanent pastures, but the possibility that these pastures include native tall grass communities cannot be excluded. Permanent pastures are found along approximately 10 percent of the proposed route, a distance of slightly more than 10 miles (140 acres).

About half of these 140 acres of grassland are associated with slopes and margins of a dozen streams and drainage ditches, and the remaining pastures are generally found as small patches near farms or as wet meadows around wetlands. Few grasslands are large enough to be listed individually, and all but two grassland areas are less than one-half mile wide at the point of intersection. Perpendicular stream crossings minimize the impact on the adjacent grassland habitat, since most grasslands parallel streams and ditches.

Pastures are dominated by perennial plants which require at least two growing seasons to regain their original density and vigor.

Woodlands are a scarce resource in the part of Minnesota which will be crossed by the proposed route. Trees are found as shelterbelts on farms and as thin stands along the Redwood River and Cottonwood River in Lyon County and along creeks in the Hall Lake and East Chain Lake areas of Martin County. The woodlands are almost always open, overgrazed stands lacking an understory of saplings and shrubs, and frequently they consist of little more than a single row of scattered trees.

The proposed route will cross less than one-half mile (6 acres) of woodland. About 200 feet of woodland are involved on the east side of the Redwood River in Wilbert County. Here it involves one of the more significant wooded areas in the region. The stand has a relatively closed canopy and covers a steep slope, mostly on the east bank of the creek. Its location on a slope along a highway renders the stream and associated forest of considerable value for esthetics and soil conservation. Construction will remove less than a dozen trees. The forest is open and no slopes are implicated on Elm Creek in Martin County where the proposed route will remove another one-half dozen trees. An even smaller number of trees may be destroyed along the creek connecting Hall and Wilmert Lakes, and no trees will be lost from scattered stands in the East Chain Lake area of Martin County.

Shelterbelts have been routinely avoided in the selection of the proposed route. The only shelterbelt to be crossed has the aspect of an open-grazed woodland, south of Willow Creek in Murray County where construction will lead to the removal of less than one-half dozen shrubs or small trees.

Iowa--Grasslands in Iowa consist mostly of tame, permanent pastures, which are found along approximately 5 percent of the proposed route for a total distance of 13 miles (160 acres). The probability is low that a few pastures may represent original tall grass prairie communities.

About three-fourths of the grassland acreage are associated with the slopes and margins of about 50 streams and drainage ditches, and the balance is generally in the form of small fields near farmsteads and around wet meadows. Few grassland areas are large enough to be listed individually and most are less than a couple of thousand feet wide at the point of intersection. Most grasslands parallel streams so that perpendicular stream crossings will minimize the impact on the adjacent pastures.

The proposed route will cross a region in which woodland vegetation constitutes a scarce resource; therefore, woodlands and major shelterbelts were avoided wherever possible in the design of the route. The total distance through woodlands amounts to about 2.5 miles, which includes about 2 miles of bottomland hardwood forests and 2,000 feet through four shelterbelts and one grazed woodlot. The proposed route will cross bottomland hardwood forests along the Shellrock and Cedar Rivers in Black Hawk County, along the Wapsipinicon River in Clinton County and on the Mississippi River in Scott County.

The route will cross bottomland hardwoods for about one-half mile along the Shellrock River, but closed canopy forest is restricted to 100 feet on the west and 500 feet on the east side of the stream. The other 2,000 feet have been grazed and reduced to a partially wooded, open stand. About 1,500 feet of closed canopy forest will be crossed on the Cedar River.

The Wapsipinicon River will be crossed twice. The western crossing traverses an 800-foot stand of bottomland hardwoods on the west bank and the margin of woodland and open fields on the east side of the river. In three places east from the river, the proposed route will then cross bottomland forest for a total distance of another 800 feet. The eastern crossing of the Wapsipinicon River traverses almost 5,000 feet of woodland, but the stand has been grazed on both sides and closed canopy stands are restricted to the bank areas.

The route will pass through about 2,500 feet of bottomland forests in the Upper Mississippi River National Wildlife Refuge along the Mississippi River. However, the route will adjoin an existing right-of-way for part of the way, and only a minimal amount of woodland will be affected.

The impact on woodlands is intimately associated with major river crossings. The total area of woodland involved amounts to about 40 acres, which includes the requirement for additional work space on both sides of the crossings of the Wapsipinicon River and on the western approach to the Mississippi River. The total woodland area includes less than 20 acres of closed canopy forest, and the proposed route will follow open situations wherever possible.

Esthetic values will be reduced on the Shellrock River, Cedar River, and west bank of the western crossing point across the Wapsipinicon River. These values are derived from the water and forest "edge," and the significance of the impact bears no relation to the limited acreage involved.

It may require 50 years to restore the bottomland woodlands to near their present condition.

Illinois--Grasslands in Illinois consist of tame, permanent pastures, which are found along less than 2 percent of the proposed route for a total distance of about 2.5 miles (30 acres). The probability is very low that one or more pastures may represent original tall grass prairie.

Almost all of the grassland acreage is associated with the slopes and margins of about 20 streams and drainage ditches. None are large enough to be cited individually, and few, if any, are 1,000 feet wide at the point of intersection. Most grasslands parallel streams so that perpendicular stream crossings curtail the length of the route through this type of habitat.

No particular difficulties are anticipated in right-of-way rehabilitation, but grazing may have to be deferred for about 1 year to permit the establishment of a good grass cover.

Woodlands are found as bottomland hardwood forest along rivers and in the form of scattered woodlots and shelterbelts on farms. Woodlands and shelterbelts were avoided wherever possible during the design phase of the project. The total extent of woodland on the proposed route amounts to less than 3 miles (40 acres) and this consists of two-thirds bottomland hardwood forest and about one-third woodlots and shelterbelts.

The most valuable wooded area to be crossed, about 1 mile, is found on the Illinois River in LaSalle County. The Illinois River will be crossed at just about Pecumsaugan Creek. On this course, the route will first traverse about one-half mile of forest on the Pecumsaugan Creek and then about 500 feet of open forest along both sides of the Illinois and Michigan Canal on the slope of the Illinois River flood plain. On the flood plain, scattered remnant stands will be affected for less than 600 feet on the west side of the Illinois River, and the proposed route will then cross about 2,000 feet of high quality bottomland and upland hardwoods on the east side of the river.

All of these stands are continuous along the river system and the area is of considerable esthetic and recreational value. Urban development and quarrying mar the wooded environment in several places, but two State parks and one proposed park are found in the vicinity of the route. Construction will contribute to the fragmentation of forest cover in this area and the proposed route will lower esthetic values associated with about 4,000 feet of closed canopy woodland.

All other woodlands to be crossed by the proposed route are of lesser value. Virtually all have been severely grazed and/or have been displaced and fragmented by agricultural land use. The location and extent of these woodlands will be described below in order from west to east.

About 700 feet of bottomland forest are crossed on the Mississippi River in Rock Island County. Three stands, of which two are situated on bars in the river, represent good habitat, but the value is marginal because woodland is displaced just north of the route by the Quad Cities Nuclear Power Plant.

The proposed route will traverse about 2,000 feet of open-grazed woodland on the west bank of the Rock River in Rock Island County. About one-half mile east of this river, a closed canopy woodland will be crossed for about 2,500 feet. Farther east, another 600 feet of open-grazed woodlands will be affected, but again, only a few trees will need to be removed. similarly, a very small number of trees will be in the way of construction on the Illinois and Michigan Canal Feeder and on Green River in Bureau County.

About 800 feet of a closed canopy forest will be crossed on Big Bureau Creek, and in this same area the route will lead to the removal of perhaps one-half dozen trees along 200 feet of open woodlands. A closed canopy forest is involved for 350 feet on the Little Vermillion River in LaSalle County. The crossing of Tomahawk Creek will affect one-half dozen trees or less. The proposed route will cross about 600 feet of forest on the west bank of the Mazon River (Grundy County) and 400 feet of forest lining the banks of the Iroquois River (Iroquois County).

The impact of construction upon these woodlands is not particularly significant in the case of open woodlands, but the route through more than one-half mile of closed canopy forest will contribute to the further reduction of the woodland resource. This impact is virtually unavoidable due to the north-south flow of the streams.

The esthetic and recreational significance associated with these forest and stream situations is less than along the Illinois River; however, the clearing of a corridor involves a significant impact. These forests grow on sites prone to flooding and soil erosion; special emphasis should be placed on streambank stabilization, and restoration should be accomplished as early as possible.

Shelterbelts are numerous particularly along the western part of the route in the area between the Mississippi and Rock Rivers. Construction will affect about 35 shelterbelts and this will mean the removal of some 1,200 feet of woody vegetation. Hedgerows and drainage ditch borders will be crossed at a rate of two or three per mile in the eastern part of the State. The total distance through these woody habitats is quite small but they frequently represent the only available permanent wildlife cover.

Ohio River Basin

Original tall grass prairie communities are extremely rare in the western half of the Eastern Broadleaf Forest Region. Grasslands take the form of tame pastures which, on the till plains, are confined mostly to the margins of streams and drainage ditches. Grasslands are comparatively abundant on the unglaciated plateau, where much of the land not used for row crops or woodland is in hay and pastures. On the unglaciated plateau, especially on slopes, erosion should be prevented, and liming and fertilization will be necessary to establish a vigorous cover. Grazing on the reestablished cover should be deferred for 1 year.

Woodlands are found in the form of bottomland hardwood forest along the streams, upland forests and farm woodlots. Upland forests are prevalent on the unglaciated plateau.

Less than 10 percent of the till plains is now wooded. Scattered woodlots are common and many of the woodlots and bottomland stands are used to pasture livestock. The impact of construction upon grazed woodlands is essentially the same as for pastures, with the exception that it involves the removal of scattered trees.

Productive woodlots and bottomland hardwood stands are a valuable and limited resource which has been avoided wherever feasible in the design of the route. Bottomland hardwoods are particularly sensitive because clearing of the stands may lead to streambank erosion and openings, which will be visible to people utilizing the waterways for recreation.

Stream crossings are generally made perpendicular to the streams in spots where woodland is relatively restricted in extent. As a result, the approach to stream crossings is frequently via permanent pastures or heavily grazed woodlands. Construction may involve a long-term impact upon wildlife, esthetics, and the timber-production potential of wooded sites.

On the unglaciated plateau upland, forests occur in tracts of variable size, which are determined by agricultural patterns and are affected to various degrees by mining, roads, and right-of-way development. The impact of construction will vary almost from stand to stand depending on its current aspects, which are determined by such factors as location, extent, age, volume, and management. In general, the route will contribute to further fragmentation of the forests.

Listed below are some specific impacts to vegetation along the proposed route in the Ohio River Basin.

Indiana--Grasslands crossed by the proposed route in Indiana occur as wet meadows on sites adjacent to drainages, or as permanent pastures where poor drainage and steep slopes and shallow soils limit farming. In either case, these sites consist mostly of tame pastures which are subjected to heavy grazing, and the probability of encountering original tall grass prairie communities is extremely small.

The proposed route will cross permanent pastures for about 7 miles (95 acres). In most instances, this amounts to crossing meadows along drainages for distances of a few hundred feet. The only areas in which the proposed route will cross a significant extent of grassland, are found on slopes adjacent to the Eel and Wabash Rivers in Carr, Miami, and Wabash Counties, where the distance through pastures amounts to a total of 3.5 miles. The erosion potential is higher on these slopes than elsewhere along the proposed route through Indiana.

The proposed route traverses woodlands for a distance of approximately 8 miles (95 acres). The required acreage involves only about 30 acres of solid stands distributed over a dozen woodlots and bottomland hardwood forest along a number of streams; the balance consists of grazed woodlots and woodlands with an open canopy forest.

The grazed woodlands occupy sites identical to those occupied by permanent grasslands, and have an understory of grasses and sedges as opposed to woody plants. The impact upon grazed woodlands is essentially the same as for pasturelands, with the exception that construction will cause the removal of scattered trees.

Productive woodlots and bottomland hardwood stands are a valuable and limited resource which has been avoided wherever feasible in the design of the route. Construction will require the removal and disposal of timber and understory vegetation on about 30 acres of woodland, and this will involve a long-term impact upon wildlife, esthetics and on the timber-production potential.

Bottomland hardwoods constitute a particularly sensitive resource because clearing of the stands may lead to streambank erosion and openings which will be visible to people utilizing the waterways for recreation. These aspects merit consideration on all of the following stream crossings; Curtis Creek (Newton County), the Iroquois River and Carpenter Creek (Jasper County), the Tippecanoe River (White County), the Eel River (Carr County), the Wabash River (Wabash and Adams Counties), Treaty Creek (Wabash County), and the Salamonie River (Huntington County).

Stream crossings are generally made perpendicular in spots where woodland is relatively restricted in extent and deficient in sloughs which are of prime wildlife value. As a result, the approach to stream crossings is frequently via permanent pastures or grazed woodlands. In the case of the Tippecanoe, Eel and Wabash Rivers, and Treaty Creek, the bottomland forest occupies strips of less than 100 feet on either side of the stream. Wider strips of bottomland forest occur on Curtis Creek and along the Iroquois and Salamonie Rivers. Since these riparian sites are prone to flooding, special emphasis will be needed on streambank stabilization and restoration as early as possible.

Fencerows, drainage ditch borders, and the margins of small streams constitute "idle" land which occurs adjacent to croplands as strips of woody vegetation. These belts are usually less than 20 feet wide and will be crossed by the proposed route at the rate of about two or three per mile. Shrub borders frequently represent the only available permanent wildlife cover.

Ohio--The proposed route will cross about 30 miles (400 acres) of grasslands used for grazing livestock. Grasslands along the route exist mostly in the form of tame permanent pastures consisting of perennial pasture plants, but a proportion consists of brush pastures or old fields and open woodland pastures. The latter have been regarded as woodlands unless few or no trees were left to identify these pastures as wooded habitat. Approximately three-fourths of the grassland acreage will be traversed on the unglaciated plateau. The probability of encountering original tall grass communities in the former prairie areas of Mercer, Marion, and Morrow Counties is extremely small.

Grassland habitat tends to occupy sloping sites with shallow and infertile soils that are more sensitive to erosion than adjacent croplands.

Pipeline construction through pastures of the till plains will involve crossing meadows along drainages for distances of a few hundred feet.

A long-term impact on esthetics is not usually associated with construction on pastures. In the case of certain old fields, however, construction will retard succession towards a woodland condition for the duration of the project and this may have a delayed effect on esthetics in certain situations.

The proposed route will traverse woodlands for about 40 miles (480 acres). About 4 miles of woodlands are involved in the glaciated region, where construction will affect about 20 acres of grazed, open woodland, 20 acres of relatively closed canopy woodlots and 10 acres of bottomland hardwood forest. In the unglaciated region, the proposed route will cross about 40 acres of grazed, open woodland, just over 50 acres of closed canopy woodlots, less than 3 acres of bottomland hardwoods, and 340 acres of upland forest.

In addition to woodlands, the proposed route will cross numerous borders of shrubs and small trees along fences, drainage ditches, and streams. The ecology of these borders is intimately associated with adjacent croplands and pastures. These belts are normally less than 20 feet wide, and they will be crossed at a rate of two or three per mile on the till plains and more frequently on the unglaciated plateau. While the total distance is small, shrub borders frequently constitute the only available permanent wildlife habitat.

Open woodlands occupy sites along streams and on slopes that cannot be tilled efficiently. Grazing has eliminated the shrub stratum and the understory consists of grasses and sedges. The effect of construction is comparable to that on pastures with the exception that it may cause the removal of scattered trees.

Productive woodlots are a valuable and limited resource in the glaciated region.

The proposed route will traverse 18 woodlots for 1.6 miles, and this will have a long-term effect on esthetics, wildlife, and the site's timber-production potential. The route will cross about 50 woodlots for less than 5 miles on the unglaciated plateau.

Bottomland hardwood forest represents a valuable and limited resource throughout the entire region. Clearing of bottomland hardwoods is accompanied by the risk of streambank erosion, and the forest openings tend to depreciate existing esthetic values where waterways are utilized for recreational purposes. These aspects merit consideration on all of the following stream crossings: St. Mary's River, Six-Mile Creek, and the Auglaize River (Auglaize County); Great Miami River (Hardin County); Rush Creek (Union County); the Scioto River, Olentangy River, and Whetstone Creek (Marion and Morrow Counties); Plum Creek (Morrow County); Sugar Creek (Delaware County); Ford Creek (Knox County); Licking River (Licking County); Muskingum River and Center Creek (Coshocton County); the South Fork (Harrison County) and Long Run (Jefferson County).

The extent of bottomland forest along streams was considered at the time of route selection, and stream crossings are generally made perpendicular in those spots where woodland is restricted in extent. As a result, stream crossings are frequently made via permanent pastures or grazed open woodlands. Except for three of the above mentioned streams, bottomland hardwood forest is confined to strips of about 100 feet or less on either side of the stream.

Major stream crossings are found on the Muskingum where open fields can be used as staging areas, so that the requirement for additional work space will not impact on the narrow banks of bottomland hardwoods.

Upland forests constitute a relatively extensive resource on the unglaciated plateau. These forests occur in tracts of variable size which are determined by agricultural patterns and affected to various degrees by mining, roads, and right-of-way development. The impact of the proposed route on the 340 acres of upland forest will vary almost from stand to stand depending on its current aspects. In general, the route will contribute to the further fragmentation of the forests.

A long-term impact on esthetics is unavoidable where side slopes and steep terrain necessitate direct descents or ascents, which will be visible for considerable distances. Examples are the west side of the Muskingum River Valley (Coshocton County), Laurel Creek (Tuscarawas County), Still Water Creek (Harrison County), and the east side of Long Run (Jefferson County).

These timbered slopes also play a most significant role in soil and watershed conservation, and long-term erosion could result from disturbance. Other parts of the proposed route will be across relatively flat parts of the plateau where soil erosion will be less of a problem.

Construction through upland forests as well as through farm woodlots will take wood-producing land out of production for the duration of the project. This is negligible in terms of the regional forest economy, but it may merit consideration locally in cases where individual owners have been improving the stands or are managing them on a sustained yield basis. From the point of view of utilization, the loss can be significant when timber is cut prior to reaching economic maturity, at which time it represents a considerable investment involving for example, 50 to 60 years of growth on which the full potential stumpage and product value cannot be realized. This is pertinent since much of the timber along the proposed route consists of immature, pole-sized trees which can now be sold only as pulpwood or firewood.

It should be added that in some locations on the Allegheny Plateau, in Coshocton, Harrison and Jefferson Counties, partially reclaimed strip mines dominate the landscape.

The proposed route will cross mined land for just over 4 miles (50 acres). Of the total, 35 acres have been revegetated with grasses or are covered by woody plants and about 15 acres are presently barren.

West Virginia--The proposed route in West Virginia extends for about 8 miles from the Ohio border to the Pennsylvania border through Brooke County. About 2 miles of the route will cross croplands.

The proposed route will traverse woodlands for nearly 55 percent of its total length for a distance of about 4.5 miles (57 acres) through the State. This total includes just over 1 acre of open grazed woodlands, less than 1 acre of a small farm woodlot, less than one-half acre of bottomland hardwood forest, and the balance (54 acres) consists of upland forests.

In addition to woodlands, the proposed route will cross numerous borders of shrubs and small trees along fences, property lines and small drainages. These belts are normally less than 20 feet wide and, though the distance is small, these shrub borders are important as wildlife cover.

The 1.2 acres of open woodlands occur on an upland site where grazing has eliminated the shrub stratum and the understory consists of grasses and sedges. The effect of construction is comparable to that on pastures, with the exception that it may cause the removal of a few scattered trees.

Clearing of bottomland hardwoods is accompanied by the risk of stream-bank erosion, and the forest openings tend to depreciate existing esthetic values where waterways are utilized for recreational purposes. These aspects merit consideration particularly at the Buffalo Creek crossing. The proposed route adjoins an existing utility right-of-way at the point where it crosses Buffalo Creek, but does not follow this corridor for an appreciable distance. In total then, less than 100 feet of bottomland hardwoods will be involved on each side of this creek. An additional right-of-way may further depress esthetic values, which are high in this area. The only significant stream crossing in West Virginia is at the Ohio River. This crossing will be on a vacant industrial site where no natural values of any importance exist.

Upland forests and farm woodlots constitute a relatively extensive resource in northern West Virginia. These woodlands occur in tracts of variable size determined mainly by mining, roads, and right-of-way development. The impact of the proposed route on about 50 acres of upland forest will vary from stand to stand depending on its current aspects.

The general impact of the proposed route is that it will contribute to the further fragmentation of these forests; however, routing through forests was generally unavoidable, since at least 60 percent of the region is wooded. Additionally, the proposed route will follow an existing right-of-way through wooded areas for only a few hundred feet.

A long-term impact on esthetics is unavoidable where side slopes and steep terrain necessitate direct descents or ascents, which will be visible for considerable distances. This will occur on the east side of the Ohio River, the west side of Buffalo Creek, the slope of the junction of Buffalo Creek and Mingo Run, the west side of Cascade Run, a shallow between Cascade Run and Camp Run. This impact is least significant on the east side of the Ohio River where the proposed route follows an existing right-of-way. The esthetic impact upon the hollow between Cascade Run and Camp Run can still be avoided by a deviation north across agricultural land beyond the head of the hollow.

These timbered slopes also play a most significant role in soil and watershed conservation.

Emphasis should be placed on slope stabilization to prevent soil losses upon the removal of the wooded cover and soil disturbance. Other parts of the proposed route will cross relatively flat parts of the plateau where soil erosion is less of a problem.

Construction through upland forests will remove wood production for the duration of the project. This is negligible in terms of the regional forest economy, but it may merit consideration locally in cases where individual owners manage on a sustained yield basis. From the standpoint of utilization, the loss can be significant when timber is cut prior to reaching economic maturity, at which time it represents a considerable investment including, for example, 50 to 60 years of growth on which the full potential stumpage and product value cannot be realized. This is pertinent since most of the timber along the proposed route consists of pole-sized and immature sawtimber stands, which contain only a minimum of sawlog volume.

The area along the proposed route in northern West Virginia has not been subjected to the degree of strip mining that is common in adjacent parts of eastern Ohio and southwestern Pennsylvania. No strip-mined land will be crossed by the proposed route, and this places additional emphasis on the preservation of existing values because the area is well wooded with good quality timber in comparison to other sections along the proposed route.

Pennsylvania--The proposed route will cross about 17 miles (220 acres) of grasslands which is used for livestock grazing. Grasslands in and along the route occur mostly in the form of tame, permanent pastures occupied by perennial pasture plants, but a portion consists of brush pastures or old fields and open woodland pastures. The latter have been regarded as woodlands except where only very few trees remain.

Pastures generally occupy slopes with shallow infertile soils that are more sensitive to erosion than adjacent croplands, and revegetation procedures should begin immediately after construction. Liming and fertilization will be necessary to counter soil acidity and infertility, and slopes have to be protected against soil erosion until revegetated. In the case of a few old fields, construction may retard succession towards a woodland condition for the duration of the project, and this may have an effect on esthetics in certain situations.

The proposed route will traverse woodlands for about 21 miles (270 acres), which amount to about 32 percent of the total route through Pennsylvania. Of the total, less than 1 mile (10 acres) will be through open grazed woodlands; about 2 miles (25 acres) will be through about 30 small woodlots scattered throughout farmland areas; about 18 miles (230 acres) in upland forests, and only a fraction of the route, affecting about 3 acres, will be through bottomland hardwood forests.

In addition to woodlands, the proposed route will cross numerous borders of shrubs and small trees along fences, property lines and small drainages. These belts are normally less than 20 feet wide and, though the total distance is quite negligible, these shrub borders are important as wildlife cover in farmland areas.

Open woodlands occur in association with upland pastures. Grazing has eliminated the shrub stratum and the understory consists of grasses and sedges. The effect of construction is comparable to that on pastures, with the exception that it may cause the removal of scattered trees.

Clearing of bottomland hardwoods is accompanied by the risk of streambank erosion, and the forest openings tend to depreciate existing esthetic values where waterways are utilized for recreational purposes. These aspects merit some consideration on all of the following stream crossings: Chartiers, Little Chartiers, Mingo and Pigeon Creeks (Washington County); the Monongahela and Youghiogheny Rivers (Washington, Allegheny, and Westmoreland Counties), and Possum Hollow Run (Westmoreland County).

Stream crossings are generally made where woodland is restricted in extent. However, residential or commercial strip development along highways and drainages like Chartiers Creek and the Monongahela and Youghiogheny Rivers, where steep terrain and the presence of highways and railroads left a narrow choice of alternatives, has tended to dictate the position of stream crossings. A significant impact upon bottomland hardwoods on the east side of the Monongahela River and on both sides of the Youghiogheny River is associated with the requirements for clearing relatively large "staging areas."

A long period is required to recover the aspects of the present stands. Along these major river crossings, bottomland hardwoods are restricted to strips of about 200 feet or less in width.

Upland forests and farm woodlots constitute a relatively extensive resource. These forests occur in tracts of variable size determined by agricultural patterns and are affected to various degrees by mining, roads, residential or commercial development, rights-of-way and other forms of land use. The impact of the proposed route on the 260 acres of upland forest and woodlots will vary almost from stand to stand depending on its current aspects, which are determined by such factors as location, extent, age, standing volume and the management objectives of the individual owners. In general, the proposed route will contribute to a further fragmentation of these forests.

The proposed route will adjoin about 4 miles of an existing right-of-way through wooded cover.

A long-term impact on esthetics is unavoidable where side slopes and steep terrain necessitate direct descents or ascents, which will be visible for considerable distances. This will be the case on Brashears and Indian Camp Run (Washington County), on a tributary to Hanen Run (Washington County), on the east side of the Monongahela River (Allegheny County), and on the east side of the Youghiogheny River and Possum Hollow (Westmoreland County). On these slopes, the impact on esthetics cannot be mitigated completely by screening and "feathering" the right-of-way which will be visible on account of the steep terrain and vantage points typical of the area.

These timbered slopes also play a most significant role in soil and watershed conservation, and long-term erosion should be prevented.

Emphasis should be placed on slope stabilization to prevent soil losses upon removal of wooded cover and disturbance of the soil. Other parts of the proposed route will be across relatively flat parts of the plateau where soil erosion is less of a problem.

Construction through upland forests as well as through farm woodlots will take wood-producing land out of production for the duration of the project. This is negligible in terms of the regional forest economy, but it may merit consideration locally in cases where individual owners have been improving the stands or are managing them on a sustained yield basis. From the point of view of utilization, the loss can be significant when timber is cut prior to reaching economic maturity, at which time it represents a considerable investment involving, for example, 50 to 60 years of growth on which the full potential stumpage and product value cannot be realized. This is pertinent since much of the timber along the proposed route consists of pole-size or immature sawtimber stands, which have only a minimum amount of sawlog volume.

The proposed route will cross strip-mined land for more than 1 mile (14 acres). These areas seem to have been regraded rather recently and have probably been planted with tree seedlings or grasses. Revegetation is difficult on toxic and infertile soil.

Aquatic Vegetation

The proposed route will cross a variety of sites with distinctive plant communities resulting from high water tables or standing surface water. These aquatic and semiaquatic sites will be referred to as wetlands. They are described in Section 2.1.3.6 as wetland, wet meadow or subirrigated range sites or potholes.

Missouri River Basin

Wetlands are particularly abundant in the glaciated part of the Mixed Grass Prairie Region known also as the prairie pothole region. This area is described in Section 2.1.3.6.

A long-term impact of pipeline construction on wetlands will result if the water levels of the marsh or pothole are affected by trenching, spoil disposal or seepage along the pipe and trench. The magnitude of this impact depends on the present characteristics of the wetland and the degree to which these are likely to be changed. A wide range of possibilities exist and the impact will have to be determined on an individual basis. For example, the wetland may not be more than a grass or sedge meadow that dries early during the summer, when it may be pastured. In this case, associated waterfowl values will be low, but drainage could lead to a further reduction of existing values. On the other hand, the wetland can be a highly productive marsh or swamp that retains water throughout the summer. The value of a wetland is also determined by its size, and construction in wetlands can affect the habitat beyond the limits of the right-of-way. In view of this, wetlands should be reestablished to their preconstruction water levels and flow characteristics and be avoided wherever possible in the design of the route.

The revegetation of wetlands is generally not feasible by conventional methods because of the impassable conditions of the wet soils for equipment and the difficulties in properly covering seeds. However, wetland areas that are disturbed generally reestablish quickly from the strongly rhizomatous aquatic plants bordering the disturbed area.

The project proposal includes plans to avoid wetland areas wherever possible in the final location survey of the right-of-way. It is also planned to reestablish preconstruction water levels and flow characteristics. To accomplish this, special care will be necessary in compacting fill in the pipeline trench so that it does not act as a subsurface drain.

The adverse impacts from crossing wetland areas will include temporary loss of wildlife habitat, particularly for waterfowl,and possible loss of pasture for livestock on the seasonally wet areas. Since wetlands recover rapidly, losses will be limited to 1 or 2 years.

The impacts to wetlands cannot be precisely quantified until the final route is located.

Montana--The proposed route will traverse 35 potholes totaling 17.5 acres (Type III and IV wetlands) in the Frenchman Creek drainage. In the Rock Creek-Willow Creek Area, nine potholes totaling 12 acres will be crossed. Several small oxbows along tributaries of Porcupine Creek, which will be crossed also, contain wetland sites. About 15 acres of wetland (Type III) will be crossed in the Cottonwood Creek drainage. In the Boxelder Creek drainage approximately 10 acres of wetland (Types II and III) will be crossed. In the Big Muddy Creek flood plain, about 36 acres of marsh sites will be traversed. In the Shotgun-Little Muddy Creek drainage, four potholes totaling 15 acres including one permanent water body will be crossed.

If the proposed route is followed the total loss of waterfowl habitat during the construction period will be approximately 147 acres. This includes 48 potholes and associated oxbows and stream bottom wetlands. Forage losses to livestock would be limited to Type I or II wetlands which are usually grazable and total about 25 tons.

North Dakota--In North Dakota the proposed route traverses portions of the prairie pothole region in Emmons and McIntosh Counties. A total of 20 separate wetland areas are crossed affecting approximately 33 acres. These are primarily Type III wetlands. Since Type III wetlands are usually too wet for grazing, the impact would be the loss of 33 acres of wildlife habitat for the construction period.

South Dakota--The proposed route through South Dakota will cross the most extensive area of wetlands along the entire route. For approximately 170 miles the route traverses the heart of the prairie pothole region. Although the route has been planned to avoid major potholes, it will transect about 16 miles of wetlands including 307 potholes. These potholes total 1,928 acres, 198 of which will be in the pipeline right-of-way.

Four miles of the proposed route traverses the 7,600 acre Ordway Memorial Prairie in McPherson County. This relict area of native mid-grass prairie and potholes was established in 1975 as a nature preserve and biological research station. It is considered to be one of the finest examples of relict prairie in the Midwest. Construction of 4 miles of pipeline would have a significant adverse impact on this preserve by destroying approximately 50 acres of relict prairie and pothole country which cannot be replaced.

The major adverse impact to the wetland vegetation will be on the 198 acres crossed by the right-of-way; however, construction activities will probably preclude wildlife use of the 1,928 acres in the total wetlands through which the route passes. After construction is completed and man ar machinery leave, wildlife will probably return. Approximately 100 acres of the right-of-way appears to be Type I or II wetlands which are grazable by livestock. Forage losses will amount to about 250 tons the year of construction but production should be back to normal in 1 or 2 years.

Upper Mississippi Basin

While the original tall grass prairie region was rich in wetland areas, drainage for agricultural purposes has practically eliminated wetlands across most of the Corn Belt. Remaining wetlands are generally those areas not adapted to agricultural use or special areas set aside for waterfowl habitat. Specific wetland impacts caused by the proposed project are described below:

Minnesota--Lakes abound along the proposed route through Minnesota, since the area belongs to the prairie pothole region. However, almost all of the land is under cultivation, and agriculture has left comparatively few marshes and wet meadows.

The proposed route will cross 26 wetlands or temporary wetlands for about 2 miles (25 acres). At least 19 of these are wet meadows or low prairies of temporary and marginal wetland quality. The other seven wetlands include one small permanent marsh and six shallow temporary marshes. Another three marshes and four wet meadows are found in Lincoln County near the South Dakota line, in Lyon County, in the area of Murray County, and south of the Watonwan River in Cottonwood County. The largest of the wetlands is about 700 feet wide at the point of intersection, and many are no wider than 200 feet.

Impacts from the proposed project are estimated to be wildlife habitat loss of about 25 acres during construction and forage losses to livestock of about 60 tons. It may require several years for the vegetation to reach normal production levels.

Iowa--The proposed route will cross a region in which most original wetlands have been drained for agricultural purposes.

Less than 2 miles (25 acres) of the proposed route will affect wetland habitat, which occurs at 20 wet meadows and temporary wetlands. These are small in size and sparsely distributed throughout the region. The largest wetland area is about 1,500 feet wide; however, the other wetlands do not approach this size and vary from 100 to 800 feet in width at the point of intersection.

The impact on a wetland is, in part, a function of the wildlife value of wetlands but, as stated above, those involved are temporary and of marginal quality. Many are used for agricultural purposes. High quality sloughs are found on bottomlands along a number of major rivers, but no sloughs will be crossed by the proposed route.

Construction activities during late spring are likely to curtail the productivity of a portion of the temporary wetlands to be crossed by the proposed route. This would be a short-term local effect which would last during the year of construction. The proposed route in Iowa passes through a climate zone favoring revegetation, and it is anticipated that the temporary wetlands along the proposed route will be completely restored to their original condition within a couple of growing seasons.

Illinois--Less than 2.5 miles (30 acres) of the proposed route in Illinois will affect wetland habitat which is found in the form of about 20 wet meadows and one former marsh.

The wet meadows range in size from about 100 to 1,500 feet across, and occur scattered throughout the region. This marsh may have been productive in the past, but its water supply has been affected by river channelization, road construction and urban development, and it does not now appear to be a valuable wetland.

The impact of construction on wetlands will primarily affect its wildlife value. The wet meadows to be crossed by the proposed route are of temporary and marginal waterfowl value, and many are subjected to agricultural utilization during the summer. However, these wet meadows provide excellent habitat for common birds and mammals associated with open fields.

A long-term impact on the wet meadows is likely because construction may improve drainage, leading to early drought conditions and to changes in the vegetation. This could be avoided by reconstruction of the original slopes, by revegetation and by compaction of the soil to prevent vertical and lateral drainage along the pipeline. In Illinois, the proposed route passes through a climatic zone favoring revegetation, and it is anticipated that the temporary wetlands along the proposed route will be completely restored to near original condition within a couple of growing seasons.

Ohio River Basin

Throughout the Ohio River Basin region, wetlands are rather insignificant. In the till plains of Indiana and Ohio, most wetlands have been drained for agricultural purposes. In the deciduous forest areas, high water tables are common but natural drainage into water courses occurs rather rapidly due to the steep topography. Where the land is level enough for pastures, it has been drained.

In Indiana the proposed route will cross only one small, isolated wet meadow in White County for about 100 feet. This meadow appears to be grazed and contains only a small area of shallow marsh. Forage losses and wildlife habitat losses will be minimal.

In Ohio the proposed route may involve the edge of one small, isolated, shallow marsh in Knox County for about 200 feet and this one appears to be grazed. The vegetation of the area can be reestablished within 1 or 2 growing seasons, and long-term impacts are insignificant.

In West Virginia and Pennsylvania no wetland areas will be crossed.

River Crossings

No significant impacts to vegetation on river bottoms at crossing sites is anticipated. Although some underwater plants provide habitat to fish and waterfowl food organisms in backwater areas, floodwater scouring allows very little vegetation to establish in the channels. Where underwater plant species are destroyed, they should reestablish in 1 or 2 years from adjoining areas.

Approximately 1,200 miles (14,525 acres) of intensively farmed cropland will be traversed by the proposed route including the spring wheat area of the Great Plains and the cornbelt of the Midwest. Project impacts relating to loss of crops are discussed in Sections 3.1.3.4 (Soils) and 3.1.3.11 (Land Use).

About 256 miles (3,000 acres) of native rangeland will be crossed; 96 miles (1,200 acres) in Montana; 120 miles (1,500 acres) in North Dakota; 22 miles (275 acres) in South Dakota, and 3 miles (25 acres) in Minnesota.

An estimated 116 miles (1,438 acres) in Montana and North Dakota will traverse shallow range sites where revegetation will be difficult and erosion hazard high.

The remaining 140 miles of rangeland crossed is on deep soil range sites where revegetation can be successfully accomplished in 2 years and erosion hazards will be slight to moderate.

An estimated 1,374 animal unit months of grazing will be lost because of construction on rangelands: 600 in Montana, 700 in North Dakota, 68 in South Dakota, and 6 in Minnesota. Approximately 73 miles of woodland (905 acres) will be crossed by the project; 2 miles in Illinois, 7 in Indiana, 40 in Ohio, 4 in West Virginia and 20 in Pennsylvania.

Impacts will include loss of potential timber, wildlife habitat degradation, creation of erosion hazards, and esthetic degradation. Approximately 365 acres that will be maintained for permanent right-of-way will create a scar for 73 miles on the landscape for at least 50 years beyond the life of the project.

Approximately 270 miles of prairie pothole country will be crossed in North Dakota, South Dakota, and Minnesota and numerous small wet areas will be crossed in other states. Although many wet areas will be avoided in the final route survey, it is estimated that 330 acres of wetlands will be crossed. Special adverse impacts to wildlife will result from disturbance to wetlands (see Sections 3.1.3.11, Land Use, and 3.1.3.7, Wildlife). In addition to wildlife impact there will be losses of forage for livestock and esthetic degradation.

Threatened or Endangered Plant Species

The occurrence of threatened or endangered plant species along the proposed route is not generally known. A reconnaissance tour by USDI personnel in November 1974 indicated that the proposed route would not encounter relict areas in the tall grass prairie or beech-maple associations where unique plants might exist. It is possible, though unlikely, that plants considered locally threatened or endangered might exist along the pipeline right-of-way in the western rangelands, the pothole wetlands, the eastern deciduous forest, and at stream crossings.

A survey to determine the occurrence of these plants would probably require many years of effort by highly trained botanists. Many rare plants are difficult to identify and are in a green or bloom stage for very short periods.

Where unique plant communities are encountered they should be avoided in the final routing of the pipeline. In Illinois local communities of Arbor vitae (Thuja occidentalis) and Plains muhly (Muhlenbergia cuspidata) have been reported along the Pecumsaugan Creek in the vicinity of the pipeline crossing. It is likely that some of these plants, considered rare in Illinois, will be destroyed by construction activities.

Operation and Maintenance Impacts

The major impacts on vegetation will result from pipeline construction activities. Once the pipeline is buried it is intended that most of the land through which the pipeline passes will revert to its previous use and condition. The intensity of mitigation will determine how fast this occurs. Where adequate mitigation measures are not applied during construction, impacts will persist through the life of the project or the operation and maintenance period.

Changes in soil temperature in the root zone of crops and other vegetation brought about by gas temperatures in the buried pipeline may have some effects on plant growth.

Data gathered by soil scientists of the U. S. Soil Conservation Service indicate that for land below 8,000 feet elevation, soil temperatures at 20 inches depth average 17° F warmer in the summer than average annual air temperatures, and 13° F colder in the winter than average annual air temperatures. These data were gathered where frost penetration was above 20 inches. Since maximum frost penetration may reach 70 inches in Montana and the Dakotas and 30 to 40 inches along the remainder of the route, soil temperatures of 32° F or below may be common. Frost depth is dependent upon a number of variables including soil moisture content, snow cover conditions, and seasonal temperatures.

Table 3.1.3.6-1 shows comparisons of anticipated soil temperatures in the absence of frost and designed gas temperatures in the pipeline at various locations along the route. These data indicate that soils will be warmed during the summer over most of the pipeline. In the Pennsylvania segment the soils will be cooled. Winter temperatures of the gas do not vary significantly from soil temperatures if frost is not present. Where frost conditions exist, gas temperatures will be above freezing, and may thaw the soil to the surface (see Section 3.1.3.1.).

Impacts that may occur from temperature differentials are not precisely known. However, it appears that some impacts to vegetation are likely. The warmer soil temperatures over the pipeline may benefit crop or native vegetation growth during the growing season. The plants could, however, be induced to early growth and damaged by low early spring air temperatures. Early greening of range vegetation might lure livestock and wildlife onto the pipeline resulting in overgrazing and damage to plants.

Where gas temperatures cause early or continued thawing of the frost, the pipeline strip may create soft wet surfaces subject to trampling damage from animals and a hazard to farm equipment.

The primary element of disturbance will be soils. As previously indicated the quality of subsoil material is highly variable along the route.

Topsoil replacement will not be practiced except where required by the landowner or federal stipulation. Where subsoils are of good quality and practices such as liming and fertilization and application of manure are utilized, new vegetation can be reestablished to an acceptable level during the first 2 to 5 years of the operation period. Where very poor materials such as heavy clay, shale, sandstone, gravel, cobbles, and highly alkaline or acidic subsoils are left on the surface, restoration of vegetation or crops to previous levels will not be achieved during the complete operation period. The severity of impacts to native vegetation along the pipeline that persists after construction fall into three categories. The trench itself, 353 miles (4,380 acres), where soils have been excavated and

Table 3.1.3.6-1

FLOWING GAS TEMPERATURES AND SOIL TEMPERATURES*
ALONG PROPOSED ROUTE

LOCATION	GAS TEMP.**		SOIL TEMP.	
State	Summer	Winter	Summer	Winter
Montana	61°	52°	62°	33°
North Dakota	65°	52°	59°	33°
South Dakota	66°	59°	64°	34°
Minnesota (W)	76°	68°	61°	33°
Minnesota (E)	77°	73°	61°	33°
Iowa	75°	74°	67°	37°
Illinois	66°	60°	68°	38°
Ohio	58°	55°	69°	39°
Pennsylvania	49°	36°	67°	37°

* Temperatures at 20" depth without frost.

** From Section 1.1.3.3 Facilities.

reconstituted on native vegetation sites to a depth of 7 to 10 feet will present the most severe and lasting impact to vegetation. The maintenance right-of-way, approximately 40 feet wide (141 acres) which must remain relatively free of all but low-growing vegetation, will have visual impacts throughout the operation period. The approximately 30-foot wide strip along each side of the right-of-way that will be allowed to reestablish without further disturbance after construction (212 acres) will have the least impact on vegetation. In the forested areas, impacts on 73 miles (365 acres) will persist during the entire operations period because of the long time frame required for trees to reach previous growth stages. In the western range region and through the wetland sites (330 acres) these right-of-way borders should reestablish in only a few years.

Those areas required for compressor stations, microwave towers, measuring stations and other facilities necessary to operate the system will create impacts to vegetation over the life of the project. Most of these facilities will be located on agricultural lands including present range and pasturelands. New access roads that are left after construction will also add to the acreage of long-term impacts on present vegetation. Estimates of land affected by operation and maintenance facilities follow:

	Acres
Compressor Stations	500
Communication Towers	248
Mainline Block Valves	6
Delivery-Measuring Stations	26
Permanent Access Roads	152
Total	932

Impacts to Vegetation from Pipeline Failure

The probability of pipeline failure is discussed in Part I, Overview. Should leakage or ruptures occur as discussed in that section, it would result in adverse effects to vegetation.

It is unlikely that significant damage would occur to vegetation from escaping gas unless it is ignited.

A pipeline failure involving fire could cause serious adverse impacts. In the western range area the natural vegetation cures early and is subject to range fires. The high fire hazard period is July through December or until snow cover occurs. The area that might burn would depend upon climatic factors, especially wind velocity, at the time the fire occurred and upon the efficiency of fire control efforts. While range fires generally do not have long-term effects on the vegetation, they frequently cause property and livestock losses. Loss of life is also a possibility.

On spring wheat fields common in Montana and the Dakotas, fire hazards exist when the wheat is ready to harvest in late summer and when stubble is standing after harvest. A fire before harvest would cause crop losses and if allowed to spread could cause property damages.

In the Midwest, corn and soybean fields would carry a fire if it occurred during the fall months when standing crops are cured and dry. Crop losses, property damage, and loss of life are possibilities.

In the eastern deciduous forests, understory fires and full-scale forest fires are a hazard in the fall months when dry leaves are still on trees and shrubs. Losses could include timber resources, property damage, esthetic values, and possible loss of life.

3.1.3.7 Wildlife

In analyzing construction and operation impacts on terrestrial and aquatic habitats and related species, evaluations have been based primarily on the impacts within a 100-foot right-of-way along the proposed route. Current construction procedures, however, use several hundred feet on steeper slopes and at river crossings but no estimates are available as to the actual width of clearing in these areas for this project. Consequently, the levels of impact given here must be regarded as below the anticipated levels. Little or no information is currently available on the length and locations of access roads; the extent and location of borrow areas for roadfill and pipe bedding materials; on the location and extent of disposal areas for excess soil and other materials on the area; of pipe storage areas, construction camps, etc; nor on the size, location or water requirements of gas treatment facilities. These impact areas not covered in the following evaluations could involve the filling of wetlands, the disruption of drainage patterns, the clearing of brush and woodland, the fording of streams and the use of large quantities of water. Such activities in some segments of the pipeline route could have adverse impacts on wildlife habitat and the size and diversity of wildlife populations far in excess of the impacts on the right-of-way itself.

<u>Nature and Extent of Direct and Indirect Construction Impacts</u>

Terrestrial Habitats and Species

The primary impact of construction on terrestrial wildlife habitats and species relates to the fact that very little comparatively natural habitat is left along the route. The brushy gullies and thin stands of brush and trees along the creeks in western range country, the remaining wetlands in the pothole country of the Dakotas and the scattered woodlots, shelterbelts and bottomland hardwood fringes as the route proceeds eastward through the cropland areas are all critical to maintaining the diversity of wildlife populations. The clearing of the construction right-of-way with its destruction of all brush and trees over a 100-foot swath and over a wider swath along stream and river banks will add to previous losses of natural habitat from overgrazing, clearing, drainage, clean farming, highway construction, and urban expansion. For those species such as squirrels, owls, predatory birds, and woodducks which depend on mature trees for nesting, denning, or food, the losses involved will last far beyond the life of the project. The noise, the smells and the activities associated with construction, which will take place primarily during the period when most birds and mammals are producing their young, will inhibit, for at least one season, the reproduction of many species along a band across the country wider than the right-of-way.

In the event of a persistent gas leak or a major pipeline rupture, low temperature natural gas could cling to the ground long enough to cause local wildlife mortalities. Such losses would be of a temporary nature.

Montana

In Montana, the construction phase will destroy 300 to 400 acres of high quality mule deer habitat in the Frenchman Creek, Rock Creek, Willow Creek, and Lime Creek areas of Montana as ground clearing, leveling, ditching, pipelaying, and ditch filling advance across rangeland broken by brushy coulees and ravines. Considering the disruption of the soil profile, the meager rainfall and the steep slopes in some areas, it may be 25 years before these local habitat areas can recover naturally to furnish some semblance of current food and cover values. It is difficult to assess the impact on the size of the mule deer population since the existence of areas of cover and winter foods can be the key to maximum use of surrounding open rangelands. However, it is possible that there could be a significant drop in local mule deer populations. Some of this habitat is shared with white-tailed deer so that any actual habitat losses may also place a stress on this population.

Critical white-tailed deer habitat here is generally associated with brushy gullies and watercourses. Some 200 to 250 acres of such habitat in Frenchman Creek, Rock Creek, Willow Creek, Cottonwood Creek, Big Muddy Creek, and Shotgun-Little Muddy Creek drainages will be disrupted by construction activities. Even considering the slightly moister ground conditions in locations preferred by this species, recovery of these areas may take up to 15 years. Here, again, the cover and winter food in these critical habitat areas can be the limiting factor for populations ranging over much wider areas on a daily and seasonal basis. There will be a significant drop in local white-tailed deer population sizes until reestablishment of disrupted habitat has been effected. It is significant to note that 60 to 100 acres of white-tailed deer habitat, which will be lost for an extended period, is on the Fort Peck Indian Reservation and is in one of the few areas where big game species are available on the Reservation.

In the Rock Creek-Willow Creek drainage, construction will disrupt approximately 100 acres of flood plain rangeland and rangeland broken by coulees and ravines well vegetated with sagebrush and sagewort which are utilized by pronghorn antelope as key winter range forage. In the 25 years it may take for this critical habitat to recover naturally, antelope populations could be reduced on the local level.

Sage grouse which share the above type of habitat with antelope and concentrate in somewhat similar habitat in the Lime Creek drainage will lose 80 to 120 acres of key habitat during construction.

Across Montana construction will disrupt considerable areas of more open rangelands utilized by a variety of terrestrial wildlife. Over 500 acres of this disrupted area are used by sharp-tailed grouse and Hungarian partridge. It may take up to 15 years for this habitat to recover to a condition where it will be capable of producing at present levels.

Waterfowl production and production of many species of shorebirds in Montana depend on the scattered potholes or small basins left as glaciers retreated. The ability to retain water through the breeding season is based in many of these potholes on basin seals formed by the natural compaction of the soils as fine material is carried into the basin and by the drying of organic materials. Cutting a ditch through this basin seal could drastically increase the permeability of the pothole floor and result in dry potholes long before the breeding needs of waterfowl and shorebirds are met. The pipeline route traverses 48 potholes and 16 oxbows and streambottom wetland areas in Montana as well as other bottomlands susceptible to drainage, totaling about 147 acres. There could be an annual loss of production of 260 waterfowl and undetermined numbers of shorebirds until basin seals are restored and vegetation is reestablished. This loss could be for 1 or 2 years if restoration is undertaken immediately and is successful, or for the life of the project if adequate restoration measures are not taken or if they are found to be ineffective.

Canada goose nesting will be disturbed on 10 acres of isolated oxbows and flood plain upstream from Frenchman Reservoir. There could be a loss of production of up to 15 geese for one season. Canada geese nesting close to the route on Manning Lake marshes may be disturbed by construction activities with a 1-year production loss.

Bottomland and flood plain habitat is used by a number of wildlife species; beaver, mink, marsh hawks, short-eared owls, wintering snowy owls, diving ducks, songbirds, small rodents, amphibians, etc. An index of the impact of construction on these species is the 36 acres of flood plain in Big Muddy Creek. Marsh vegetation will be disrupted with losses to populations of most of these species of a short-term nature if vegetation is restored. The removal of trees and large brush during construction will limit opportunities for nesting, perching, denning, and feeding for many species, particularly hawks, owls and songbirds, and will limit locally the size and diversity of animal populations for the life of the project. These same bird species will also be deprived of nesting and roosting cover in the same watershed as construction pushes through brushland in the sandhill area.

Some 165 acres of critical cover for pheasants will be removed along the route which may cause a drop in pheasant populations until this cover is reestablished.

The construction of microwave towers along the route will have an adverse impact on migrating birds of all species, particularly those towers on high points. Height, size, and placement of guy wires are all factors which will determine the level of such impact, but data on these construction parameters are not available. The endangered whooping crane has a major flyway across Montana between mile 75 and 180 of the proposed route where six or seven of these towers are strung across their path. The collision of even one of these birds with a tower would be a serious loss.

The construction of the two compressor stations and the eight microwave towers not on the right-of-way in Montana will require access road construction and will severely limit use by wildlife, during the season of construction, of the acreage in the sites themselves. This will primarily affect upland terrestrial species.

Short- and long-term losses of wildlife habitat have been discussed previously. These habitat areas will eventually recover. There will be additional critical areas destroyed which will not recover within the life of the project. Permanent structures, access roads, and permanently cleared right-of-way account for these losses.

The above paragraphs indicate that there will be a permanent reduction in the local populations of many of the prominent wildlife species since the habitat listed as lost is of a limiting nature for these species. These same areas are also indispensable elements of the life history of many songbirds and small mammals so that there will be an overall local reduction in populations of a whole spectrum of animal life and also reductions in the diversity of animal life as certain animals can no longer find the right combination of food, cover, denning, nesting, or hibernating areas or other vital factors.

North Dakota

In North Dakota the brushy coulees and breaks to be cleared during the construction phase furnish critical mule deer cover and food. Mule deer fawning areas with usually dense stands of chokecherry, aspen, willow, juniper, or sagebrush are a vital element of mule deer habitat needs. Possible habitat losses are 0.4 mile on Jim Creek, 12 miles in the Knife River drainage, 3.3 miles at the Heart River crossing, and additional amounts on either side of 250 other stream and tributary crossings. Acreage figures do not indicate the value of the habitat lost, since the breaks and brushy areas which offer protection from winter stress are not available anywhere else. The steep slopes, erodible conditions and limited rainfall in these critical habitat areas do not presage any early recovery. Many of the important wildlife forage shrubs have a rooting zone of less than 4 feet in soil with a low water storage capacity. A 25-year recovery period may be estimated for those areas of the right-of-way where tree and brush control will not be practiced. Some of these areas may not recover for the life of the project. In the areas of permanent right-of-way where large brush and trees will be eliminated for the life of the project, there will be diminishing chances of eventual restoration and the loss may be a permanent one. Local mule deer populations along the route may diminish for the life of the project at least, recovering somewhat as vegetation recovery takes place in some parts of the temporary right-of-way over an extended period.

These same effects of construction on the vegetation of brushy coulees and breaks will have long-term adverse impacts on a variety of other species which depend on this type of habitat for food, cover, nesting and clearing. Coyotes, jack and cottontail rabbits, sharp-tailed grouse and a variety of songbirds and small rodents all range out from these thickets to utilize the food resources of the surrounding open areas. The number and variety of these species on a local basis will be depressed until this habitat is restored.

All of the more rugged badland area from the ponderosa pine area of the Little Missouri National Grassland unit north through Slope, Billings, and McKenzie Counties is potential bighorn sheep habitat and may eventually be occupied from the successful stocking program began in 1956. The removal of food plants in the breaks and reduction of the important ingredient of isolation will degrade the value of the habitat for bighorn sheep and may limit northward herd expansion.

Flood plain areas along the Missouri, Little Missouri, Cannonball River and Big Beaver Creek and at many other stream crossings are critical elements of white-tailed deer habitat. Tree and large brush elimination along the permanent right-of-way may result in a reduction in herd size for the life of the project. White-tailed deer also share some of the break areas with mule deer so that this may also result in reduced numbers of white-tailed deer.

As the critical winter habitat of both mule and white-tailed deer is reduced along the route, there may be additional pressure on adjacent habitat areas until the herd size has dropped to a new lower level consistent with remaining habitat. This is assuming that all deer habitat is supporting deer at or beyond its present carrying capacity. In this adjustment period, other cover and browse areas may be damaged through overuse with increased deer mortalities in areas not directly affected by construction activities.

The same flood plain habitat used by white-tailed deer offers food, cover, nesting, roosting and denning opportunities to a variety of wildlife species not adapted to rolling plains and drier areas. Beaver, muskrat, mink, raccoon, skunk, small rodents, songbirds, hawks and owls all utilize and depend on this habitat. Where the route cuts through this habitat and tree and brush revegetation is controlled, the potential size of populations of these species may be reduced for the life of the project. Additional short-term reductions may also take place until the temporary right-of-way has been revegetated.

The proposed route will cross 10.8 miles of U. S. Fish and Wildlife Waterfowl Production Area easements in North Dakota. Approximately 13 wetland acres in 10 basins will be affected by construction clearing and ditching. In addition, 10 other wetland areas, not under current easement, will add another 20 acres to the waterfowl breeding habitat affected. These affected wetlands are primarily seasonal basins (Type III) and are valuable during the breeding season. Several temporary wetland areas which furnish transitory resting and feeding areas lie within the right-of-way. Principal waterfowl species found in the proximity of the proposed route, either as migrants or breeding birds include blue-winged teal, mallards, shovellers, pintails, gadwalls, coots and Canada geese.

The destruction of wetland vegetation, erosion from adjacent areas, disposal of spoil and the possibility of permanent drainage, if the permeability of the pothole floor is increased in the ditch area are all factors which could adversely affect waterfowl production. It is anticipated that there will be a positive effort made to restore those potholes under U. S. Fish and Wildlife Service easement to their previous condition. There is no assurance, however, that those wetlands on private land will not be significantly reduced in value since it is the intention of the applicant to abide by the wishes of the landowners in such cases. Leveling and deposition of excavated materials could reduce the depth and permanence or totally eliminate wetlands on private lands. Considering these factors and the wide area of disturbance during construction, the loss for the construction year might be in the neighborhood of 100 waterfowl, while the loss of production on private lands could amount to 30 or 40 birds annually over the life of the project. This is assuming that the seal on pothole floors can be restored. The wetlands also are heavily used habitat for 22 species of migrant shorebirds and breeding sites for 10 other kinds of shorebirds. Breeding species include the American avocet, piping plover, killdeer, long-billed curlew, marbled godwit, upland plover, spotted sandpiper, willet, Wilson's phalarope and the common snipe. The breeding of many of these species will be disrupted during the construction period with some loss of recruitment for 1 year. Any permanent reduction of wetlands means a reduction in population size for many species since wetlands breeding habitat is a limiting factor in a region where so much drainage has taken place.

Much of the proposed route south and east of the badlands crosses gently sloping uplands. At least 1,600 acres which will be graded for the construction right-of-way is unbroken sod which still retains many of the characteristics of the native prairie. This habitat cannot be restored by reseeding the often salty subsoil turned up and spread in the ditching process. It can be revegetated, but the character of the habitat may be considerably altered.

The best antelope habitat along the proposed right-of-way is that portion of the rolling prairie which is free of agriculture or disturbed areas and with big sagebrush quite common. Densities in this habitat average 2 but can reach 5 antelope per square mile, whereas in other habitat there are only 0.2 per square mile. The stripping of sod and topsoil over the right-of-way in the rolling prairie area and the spreading of subsoil on the surface may reduce the quality of this habitat for an extended period, possibly beyond the life of the project and reduce the antelope population on a long-term basis. White-tailed deer, pheasants, cottontail and jackrabbits, sharp-tailed grouse, some Hungarian partridges, coyotes and variety of songbirds and small rodents also share this prairie habitat and may all suffer local losses in population size on a long-term basis, but the local diversity of species will probably not be affected.

The blackfooted ferret is officially classified as an endangered species. Only nine ferret sightings have been reported in southwestern North Dakota since 1910. Most recent sightings in the vicinity of the proposed route were in Morton County in 1968, about 10 or 12 miles from the proposed route, and also in Morton County in 1971, about 1 mile or more from the route. The ferret's potential range coincides with that of the prairie dog and its chances for survival have been made much slimmer by the 86-percent decline in the number of prairie dog towns in this area since 1942. Helicopter and fixed -wing plane flights over the route in November 1974, did not locate any prairie dog towns within or close to the right-of-way, but an on-the-ground survey will be required to make a positive finding on this. The destruction of a prairie dog town could have a long-term adverse effect on blackfooted ferret recovery chances if this turned out to be one of the towns where the blackfooted ferret still exists. Only a ground survey of the final construction alignment could provide a positive impact evaluation. As noted previously information on specific access roads, borrow areas, spoil areas, and other off-route impact areas is not available. These could adversely affect prairie dog towns with ferrets in residence.

South Dakota

In South Dakota along the construction right-of-way 10 acres of woodland, 843 acres of grassland, 1,190 acres of cropland, 18 acres of intermittent streambed (94 crossings), and 2 acres of permanent streambed (5 crossings) will be disrupted by the project. Scattered throughout the grassland and cropland segments are 307 potholes totaling about 2,000 acres which are crossed by approximately 86,000 feet of the proposed 100-foot-wide right-of-way. There are U.S. Fish and Wildlife Service Waterfowl Production Area easements on 57 of these potholes while 3 of these areas are on game production lands of the South Dakota Department of Game, Fish and Parks.

White-tailed deer are as the dominant big game animal in eastern South Dakota. The counties along the proposed route have a substantial white-tailed deer harvest, with only occasional mule deer and a few antelope taken. The destruction of woodland, shelterbelt and brushy streambank areas of critical cover and watering habitat will have a depressing effect on white-tailed deer populations along the route. For the temporary construction right-of-way this will be a relatively long-term impact until trees and brush are reestablished. For the permanent right-of-way the impact will last well beyond the life of the project since no brush and trees will be allowed to begin to grow back until the pipeline is abandoned. Potential harvests of white-tailed deer and of mule deer which also depend on this type of habitat may be lowered for local areas along the proposed route for a period extending beyond the life of the project. While it is difficult to quantify this adverse impact, it is significant that the areas of these habitats affected are only remnants of once much more extensive cover and as such assume an importance far beyond the limited acreage involved.

These same woodland, shelterbelt, and brushy streambank habitats are also the key to the local population sizes of many small mammal and bird species. The variety of such species in a local area is also related to the availability of these limited habitats and to special needs they meet for food, cover, nesting, roosting, and denning. Among these species are red fox, raccoon, cottontail rabbits, pheasants, red-tailed hawks, marsh hawks, Swainson's hawk, great horned owl, and a considerable number of songbirds and small rodents. The ferruginous hawk, a rare bird, which nests in this area, is very intolerant of disturbance while nesting so that nests in the larger trees would stand a better chance of hatching success. The loss of woodlands could adversely affect the local occurrence of this species. Construction activities may disturb nests and probably cause abandonment, a rather serious impact.

Grasslands are utilized by antelope, mule and white-tailed deer, cottontail rabbits, pheasants and by a variety of songbirds and small mammals. The quality of grassland habitat will adversely be affected by construction activities until revegetation has taken place. If the topsoil is buried and seeding, fertilizing, and protection are not provided, there will be a long-term adverse impact on the productivity of the grassland areas and a corresponding long-term reduction in the wildlife carrying capacity of the area for herbivorous and insectivorous species of mammals and birds, and for the related predatory mammals and birds.

The proposed route traverses the Ordway Memorial Prairie dedicated in 1975. This relict prairie preserve is critical habitat for one of the only antelope herds known east of the Missouri River. Any impact on the preserves vegetation would also have an impact on the antelope herd.

In crossing the pothole country of South Dakota, 307 potholes will be traversed by the proposed 100-foot-wide right-of-way. Many of these potholes are the best waterfowl breeding habitat in the country and are also important as feeding and migration habitat. All together, they constitute the principal production areas for waterfowl in the Dakota "duck factory" as well as for many species of shore birds. Pheasants, raccoons, white-tailed deer and a variety of other species use the wetlands vegetation as food or cover.

Construction activities scheduled to take place during the waterfowl breeding season could cause many problems. Wetland vegetation would be destroyed during site preparation. The floor of the basin, with its layer of fine particulate matter washed in from the basin, bound together with organic detritus could be breached by the ditch. Subsoils, whose clay contents reduce permeability of the basin, may also be breached and expose permeable underlying material. If the ditch fill is well compacted so that drainage along the pipe does not take place; if the very productive topsoil from the basin floor is saved for replacement at the surface; if excess soil is disposed of where it will not erode into the basin; if erosion is controlled where the route crosses the rest of the pothole watershed; if the original contours and drainage patterns are restored; if the pothole floor is restored to its previous level of permeability and if reseeding, fertilization and protection take place immediately, then, by the second year after construction, the potholes should again have regained their previous wildlife potential. There would still probably be a major loss of waterfowl production for 2 years. This may involve a loss of waterfowl production of up to 3,000 birds in the construction year and possibly up to 1,000 birds in the next year. The applicant has signified his intention to fully restore the potholes traversed by the route so that the short-term waterfowl production losses cited above would be those anticipated. There could, however, be long-term losses if the integrity of the basin seal in certain potholes cannot be restored so that permanent drainage can take place. Here, the waterfowl production of those potholes would be lost permanently. With full pothole restoration, there could also be a short-term reduction in the local populations of shorebirds, game birds, songbirds, small mammals and big game animals which use these areas.

Minnesota

In Minnesota the route crosses the eastern edge of the prairie pothole country. These wetlands are fringed in many instances by woody growth and permanent pasture providing a diversity of wildlife habitat. Not only are these wetlands valuable for their role in water fowl production, but they also support populations of pheasants, Hungarian partridge, cottontail rabbits, white-tailed deer, muskrats, and a variety of songbirds and small mammals. The route will cross at least 26 wetland areas with the consequent destruction of woody growth as it crosses the wetland fringes and with the disruption of the floors of the basins with permanent drainage a possibility. Some of the larger wetland areas traversed by the route are: (1) a privately-owned 20-acre marsh in Royal Township, Lincoln County, (2) the Ivanhoe Wildlife Management Area, (3) a 30-acre private marsh in Hendricks Township, Lincoln County, (4) Thostenson Wildlife Management Unit, (5) the State's Coon Creek Wildlife Management Unit, (6) the Lyons Wildlife Management Unit, (7) a 10-acre private marsh in Custer Township, Lyon County, (Aquisition of this marsh has been proposed by the State.) (8) a private marsh near the Shetek Wildlife Management Unit in Shetek Township, Murray County, (9) Clear Lake in Cottonwood County, and (10) Mud Lake in Martin County.

A considerable number of very valuable Waterfowl Production Areas, upland and big game habitat areas, and a considerable number of wetlands, brushy fringes and adjacent upland complexes, valuable to a great variety of small birds and mammals, will be traversed by the route in Minnesota, with a consequent loss of all vegetation in the path of the construction right-of-way, the digging of a ditch through this cleared area, including the basin floor, and the disruption of soil profiles. If care is taken to replace the topsoil at the surface in these critical habitat areas, and immediate and intensive efforts are made to restore drainage patterns to prevent erosion and to revegetate the right-of-way, it is anticipated that there will be a loss of waterfowl production in the area in the construction year, less of a loss in the following year, but that pre-project waterfowl production potential might be restored by the third year. Where, however, wetland basin seals are breached by the ditch and an increase in permeability cannot be prevented there could be a permanent loss of these wetlands and their wildlife values. Local populations of water birds, pheasants, Hungarian partridges, white-tailed deer, cottontail rabbits, songbirds and small mammals will be depressed for several years until food and cover conditions around the wetland fringes are restored, but the long-term population size potential and variety of species present should be unaffected, assuming again, that the water holding capability of wetland areas can be maintained. Where tree plantings will be destroyed, there will be a more serious loss of wildlife population potentials and of the time and money which went into establishing these food and cover areas. This will be a relatively long-term impact. Where these tree plantings may not be reestablished on the permanent right-of-way, the loss of wildlife potentials may continue well beyond the life of the project.

Those affected shelterbelt type plantings on the Thostenson and Lyons Wildlife Management Units and scattered trees along the edges of Coon and other small creeks will be removed from the construction right-of-way. In this area of very limited woodlands tree nesting, roosting, and denning habitat is very limited and this could have a minor, but long-term depressing effect on the local occurrence of such groups as hawks and owls. There may also be a limited but long-term depressing effect on populations of species using wooded areas such as white-tailed deer, fur bearers, and songbirds.

In Minnesota, as in other agricultural areas, native plant communities have been systematically eliminated and along with the loss of these plant communities has gone a loss in the size and variety of wildlife populations. The remnants of natural wildlife habitats in the form of wetlands and wooded creek bottom are vitally important to the continued existence of remaining resident wildlife species and to birds migrating through the area. A considerable number of these remnants will be seriously disrupted along the proposed route in Minnesota and while the impact should be limited and short-term if restoration takes place immediately, there is still the distinct possibility that restoration procedures will not be fully successful and that irreparable losses in the variety of habitat and in the variety of species will occur. The possible irreversible drainage of some of the valuable wetlands traversed is one of these areas of concern.

No critical habitat for endangered terrestrial species was identified along the route in Minnesota.

Iowa

Today, less than 1 percent of the original waterfowl production wetlands remains. Consequently, any further loss would be significant. Twenty-five acres of wetland habitat lie within the construction right-of-way and will be directly impacted by clearing, ditching, etc., while additional adjacent wetlands in the same drainage could be affected by construction noise and erosion. Again, with restoration of the topsoil, proper fill compaction, prevention of erosion, restoration of drainage patterns, restoration of water-holding capacity of the basin floor and immediate revegetation, there would be a short-term limited loss of production of waterfowl, shorebirds and other wetland related wildlife. There is, however, no guarantee that the full potential of these wetland areas can be restored, even with immediate and intensive restoration attempts, and some drainage may take place. This would be of long-term significance in a State where wetland destruction has already eliminated over 90 percent of the habitat.

Productive woodlands throughout the area are a sensitive resource because of their limited extent and high esthetic and wildlife value in an area which is primarily cropland. The route will cross fringes of bottomland hardwoods along the Shellrock and Cedar Rivers in Black Hawk County, at two crossings of the Wapsipinicon River in Clinton County and at the Mississippi River where the route traverses some 2,500 feet of bottomland forest in the Upper Mississippi National Wildlife Refuge. Twenty acres of closed canopy hardwoods and some 20 acres of open woodland would be lost due to construction. This loss of closed canopy hardwoods would result in a long-term and locally serious loss of browse, mast and other wildlife foods, nesting and denning sites and protective cover used by such species as woodpeckers, woodcock, wood duck, raccoon, fox squirrel, white-tailed deer and a variety of songbirds and small mammals. The size of local wildlife populations, and the variety of wildlife species in local areas will be reduced for the life of the project. The losses of open woodlands will result in long-term losses in local wildlife population sizes and species diversity, but these losses will be at a limited level since heavy grazing has already eliminated valuable understory species. The loss of both closed canopy and open woodlots reduces the carrying capacity of the adjacent cropland area since most feeding in open fields takes place in the vicinity of escape cover along the woodland edge.

Construction on agricultural land will lead to small changes in the distribution of cover and may eliminate winter cover vital to local populations of ring-necked pheasants and other upland game species with short-term losses in these species and for locally nesting songbirds and resident small mammals.

There will be habitat losses and construction disturbance at compressor stations with some limited loss of wildlife population potentials at the compressor site.

No critical habitat for endangered terrestrial species was located along the route. The special concerns here are the impacts resulting from the crossing of the Mississippi River. The Corps of Engineers Princeton Wildlife Area and the Upper Mississippi River National Wildlife Refuge will be crossed.

The effects of pipeline construction on both of these areas will be immediate and detrimental. Loss of upland vegetation, especially woody vegetation, will have long-term effects on breeding birds, due to loss of mature habitat. For example, cavity trees, utilized by nesting wood ducks, will take many years to replace, if replaced at all. Construction activities on the marsh will result in destruction of waterfowl breeding and brood habitat and also destroy fur bearer habitat. Siltation from construction activities will destroy benthic organisms that are vital to both waterfowl and fish feeding in the area. Clearing of lowland hardwoods from refuge islands may be a long-term, if not permanent, destruction of wildlife habitat. This action may result in the loss of upland wildlife.

Probably the most serious effects will be the destruction of substrata in the sloughs. Excavation of the pipeline channels will result in a significant amount of siltation. This may not only destroy wildlife values at the construction site, but also downstream in the various sloughs, as silt is deposited in them. The proposed crossing will be located at the head of Steamboat or Cordova Slough. This fact is of special concern in that this slough supplies a large backwater area downstream from the construction site. Siltation will result in shallower water areas, and destruction of the benthic communities that are vital in the food chains of the slough. It is anticipated that the sport and commercial fisheries in the area will suffer significant losses.

At this time, it is not known exactly where the spoils from dredging activities will be placed. However, the only apparent sites available are on lands dedicated to wildlife management. Spoiling on these lands will result in direct habitat loss. Also, spoil removal activities will result in destruction of vegetation. The most serious effects will be silt deposition in the Princeton Wildlife Area and sloughs in the bottomland. The effect of siltation has been mentioned previously. Crossing at this point on the Mississippi River may cause long-term damage to both wildlife and fishing reserves.

Illinois

In Illinois, as in many of the other States along the proposed route, agricultural development has led to drainage of most of the original wetland areas. Some 2.5 miles of the route crosses 20 wet meadow areas scattered along the route and one marsh along the Illinois and Michigan Canal directly impacting some 30 acres. Again, with a positive program as promised by the applicant to restore these areas to their former condition, there would be a short-term loss in terms of waterfowl and wetlands wildlife production. These remnant wetlands have an importance far beyond what the acreage involved might indicate since they provide a variety of habitats and a variety of wildlife species not found in an uninterrupted cropland cultured ecosystem.

Woodlands along the route in Illinois also appear only as scattered remnants of bottomland hardwoods along the rivers and in limited woodlots and shelterbelts on farms. One of the most significant impacts on woodlands will be on the approach to the Illinois River crossing. First, some 3,750 feet of upland hardwoods along Pecumsaugan Creek will be traversed and then, some 3,000 feet of bottomland hardwood and sloughs and 1,000 feet of open woodland will be bisected before the route reaches the Illinois River shore. On the eastern shore another 750 feet of bottomland hardwood and sloughs, and some 1,875 feet of upland hardwoods will be cut through before open agricultural lands are reached. These woodlands traversed east of the river are owned by the Illinois Department of Conservation and proposed as an addition to the State Starved Rock Nature Preserve.

The segment of the route from the upland hardwoods along Pecumsaugan Creek through the wet woods and marshes to the west bank of the Illinois River has a diversity of habitats which include unusual plant assemblages, a relative lack of disturbance and a scenic quality which matches the nature preserve on the east bank of the river. In addition, the route passes 2,000 feet from the Blackball Mine, an abandoned quarry along Pecumsaugan Creek which has the largest colony of hibernating bats in Illinois. Five species of bats including the endangered Indiana bat use the mine. Blasting in bedrock could damage the mine or disturb hibernating bats. Construction through the Pecumsaugan Creek drainage and across the Illinois River at this point, may cause long-term damage to valuable waterfowl and wildlife habitat as trees and taller brush are eliminated from the right-of-way. Construction activities and improved access might lead to disturbance of the bat hibernating area at Blackball Mine with possible damage to populations of the endangered Indiana bat. There may be some temporary reduction in numbers in some of the other wildlife populations of the area.

Another woodland area affected is the Big Bend State natural area along the Rock River. The route traverses both flood plain and upland woods with populations of white-tailed deer, pheasant, rabbit, quail, Hungarian partridge, fox, raccoon, muskrat, mink and many other small mammal and songbird species. Some 24 acres of this area will be disrupted by pipeline construction with less than half of this area lost as woodland for the life of the project. There may be some temporary losses in the size of local wildlife populations and a long-term loss in local species diversity if critical mature denning and nesting trees are in the construction path. The major impact, however, will be the limitation placed on the management options available to the State by this cleared area and the loss of maximum productivity for wildlife and its use by man. The crossing site on Big Bureau Creek is bordered by a dense closed-canopy bottomland forest of mature cottonwoods, oaks and ash. In this intensively farmed part of the state, a relatively small tract of timber such as this provides the breeding, feeding or escape habitat essential for the maintenance of local fauna, both game and nongame. There may be a long-term loss in both the quantity and diversity of local wildlife populations associated with the destruction of woodland along Big Bureau Creek. While only the major areas of woodlands impacted by construction have been identified, the losses in other small woodlots and stream fringes of trees and bushes where clearing will be done for the pipeline will reduce these already scarce habitats and have a long-term adverse effect on the size and diversity of local wildlife populations.

Indiana

In Indiana the proposed route again covers an area of intensive farming where the remaining remnant woodlots, bottomland and wetlands are critical factors in maintaining a diversity of wildlife populations.

Only one wet meadow lies in the path of the route and only limited and short-term loss of local production is anticipated for water related small mammals and birds.

Bottomland hardwood strips along Curtis Creek, Iroquois River, Carpenter Creek, Tippecanoe River, Eel River, Wabash River, Treaty Creek, Salamonie River and along other water courses will be breached by construction and a permanent cleared corridor maintained. While the acreage involved is small it is one more loss of a rapidly diminishing type of critical habitat. This is also true of the dozen productive woodlots in the path of the pipeline. In both these woodland areas there will be long-term loss of habitat associated with the permanent right-of-way. A series of more open grazed woodlands will also be traversed with additional losses of nesting and denning trees.

The route crosses the Salamonie River Reservoir Recreation Area and 600 feet of the bottomland hardwoods discussed above are in this area. The section of the recreation area involved is open for hunting but is not under intensive management for wildlife production. Again, only a limited variety of habitat left will be reduced still more, and management options will be limited by the imposition of a cleared strip on the recreation area.

Ohio

In Ohio the proposed route crosses from west to east 120 miles of till plains where intensive agriculture predominates and little natural wildlife cover remains, 15 miles of the glaciated Allegheny Plateau with scattered woodlands, and 95 miles of the unglaciated Allegheny Plateau which is a much more wooded area.

In the till plains segment, construction will involve clearing a 100-foot or wider path through the narrow strips of brush and trees bordering streams, ditches and fencerows. This will occur two or three times per mile. A 40-foot swath will be held devoid of trees or large brush for the life of the project. In this intensively farmed area these special cover, food, nesting and denning habitats are a limiting factor in the size and diversity of farm game, songbird, furbearer, avian predator, and other animal populations. They are the key to the full utilization of cropland and meadow areas by wildlife. There will be a long-term adverse impact on the size and diversity of these animal populations on the local level resulting from the continuing effects of construction clearing and a short-term adverse impact on local wildlife reproduction levels during actual construction.

In the glaciated segment about 20 acres of open woodlots, 20 acres of closed canopy woodlots, and 10 acres of bottomland hardwoods will be cleared during construction as well as tree and brush fringes along ditches, hedgerows, etc. While these cover types are becoming more prevalent as the route moves eastward they are still a major limiting factor in the size and diversity of wildlife populations. White-tailed deer, racoon, fox squirrel, flying squirrels, woodpeckers, wood ducks and a variety of songbirds and predatory birds have special habitat needs related to trees. The loss of trees along the route may have long-term adverse effects on the size and diversity of animal populations.

In the unglaciated region of eastern Ohio the route crosses an area where woodland habitat is much more available. In this segment construction clearing will involve about 40 acres of open woodlands, over 50 acres of closed canopy woodlands, some 3 acres of bottomland hardwoods, 340 acres of upland forest and cuts through scattered tree and brush ranges along streams, ditches, etc. Where clearing is done through more extensive areas of woodlands there will be some short-term disruption of animal populations, but on a long-term basis the opening up of the area and the increase in edge will increase the size and diversity of local wildlife populations. Deer, rabbit and quail populations could all benefit. Where, however, permanent clearing is done through the limited areas of bottomland hardwoods and fringes along streams and through scattered woodlots, this will destroy scarce and critical habitat, for example, wood duck nesting trees, and will result in long-term and local reductions in wildlife population sizes and in numbers of species. Any procedure which tends to further reduce remaining natural habitats within the farm's cultured ecosystem is damaging to the environmental quality of the area.

Only a portion of one wetland area, a shallow marsh in Knox County, lies within the right-of-way and only a minor, short-term loss of wildlife use will occur in this area.

The proposed route crosses the northern portion of the State's Delaware Reservoir Wildlife Area. Construction of the pipeline and revegetation of the right-of-way will cause only temporary interruption of use of the public hunting and fishing areas. Effects could be more long lasting if the route crossed ponds in the area but the actual route location is not clearly defined in this area. The Division of Wildlife has established permanent research plots to monitor vegetative succession and the effects of burning to control this succession. Any route across the Division of Wildlife area would have to pass through one or more of these scattered research areas and this would result in the loss of many years of research and information. This loss of the investment of scientific manpower and money involves the use of Federal Aid funds. Even with monetary compensation there would be a serious and long-term setback in the development of scientific procedures for vegetative management of the area.

West Virginia

In West Virginia the proposed route covers the West Virginia panhandle for some 8 miles. This will involve clearing some 2 miles of croplands, 4.5 miles (57 acres) of woodlands and a mile or so of shrubs, small trees and other rough areas along fences, property lines and small drainages. Most of the woodland clearing (50 acres) will take place in scattered stands of upland forest. Here, for the main part, the loss of wooded habitat will be balanced by the additional edge produced and by the early regrowth of brushy food and cover along the temporary right-of-way so that only minor, short-term losses of wildlife production result. Construction clearing will cut the bottomland hardwoods on either side of Buffalo Creek and leave a permanent opening at least 100 feet on either side of the creek. This type of habitat is extremely limited in West Virginia and there will be a long-term loss of such habitat and a diminution in the local variety of plant and animal species. The environmental value of the area is pointed up by the proposal for a county park along Buffalo Creek to the north of the route for the purpose of preserving some of this limited bottomland hardwood habitat. There will be short-term losses in wildlife production involved in cutting through shrubs and small trees along fences, etc., but regrowth of shrubs will take place quickly.

Pennsylvania

In Pennsylvania the major impacts on wildlife species will be those resulting from the clearing of woodland habitat. Of the 270 acres directly impacted by clearing, 230 acres are in sizable tracts of upland forest.

Here, while there will be some short-term disturbances of wildlife, the additional edge created and the early regeneration of shrubs along the temporary right-of-way may benefit local populations of deer, rabbits and other forest edge species. Some 25 acres will be in 30 small woodlots scattered throughout farmland areas. Here there will be a long-term adverse impact on the size and diversity of local wildlife populations since these scattered cover nesting and denning areas are the key to the full wildlife utilization of agricultural areas. There will be a recovery of some of the values as the temporary portion of the right-of-way reverts to shrubs. Three acres of bottomland hardwoods habitat at the Monongahela River and Youghiogheny River crossings will be destroyed with resulting long-term limitations on the size and diversity of local wildlife populations, using this very limited habitat type. In addition to the woodlands, the proposed route will cross numerous borders of shrubs and small trees along fences, property lines and small drainages. These borders are important as wildlife cover in farm areas and there will be losses in wildlife production until shrubs and other cover have regenerated.

Aquatic Wildlife Habitat and Species

The principal impacts of pipeline construction on the uses of a stream result from: (1) the clearing of streambanks, with loss of stream side vegetation, to provide access to the crossing site; (2) stream bottom disruption from instream activities, including its use as a transportation corridor and blasting where necessary; (3) possible erosion of the cleared right-of-way, including streambanks, with a subsequent increase in stream silt loads; (4) the withdrawal and discharge of hydrostatic test water; and (5) oil, chemical, or other pollution.

The major impact of construction activity on the aquatic environment will result from the increased silt loads. The general effects of the proposed construction are discussed in this section. Discussions of specific impact follow for stream crossings in the 10 states traversed by the proposed route.

Impacts of pipeline construction on the aquatic environment will generally be short term in nature, with the exception of the long-term esthetic impact which may result from the clearing of flood plain forests on certain streambanks. In most cases where deliberate attempts have been made through use of fish toxicants to alter the fish species composition of warm water streams or where chemical spills have decimated fish and aquatic invertebrate populations, repopulation has quickly taken place from adjacent stream segments and tributaries, and the original species composition has been reestablished in 2 or 3 years. This, of course, applies only where there is no permanent change in water quality or substrata conditions. This same principle applies to pipeline construction impacts except where rare or endangered species of very limited distribution are involved.

The nonmotile, benthic community, including rooted aquatic vegetation, periphyton and benthic invertebrates, will be disrupted in the section of the stream bottom affected by construction activities. This impact will extend downstream for some distance as a result of increased sedimentation from instream excavation. Sediment from overland runoff will affect the receiving stream at both the point of discharge and for a distance downstream in a similar manner. These disruptions, however, will be short-term, and the affected areas will be repopulated by recruitment from adjacent stream reaches soon after construction is completed. The increased sediment loads will also result in a temporary reduction in primary productivity for some distance downstream of the crossing site. The return to preconstruction conditions will not occur until the adjacent right-of-way has been stabilized, thus, ending increased surface runoff and resultant increased silt loads. Once instream activities have begun, most motile organisms will vacate the vicinity of the crossing and, therefore, will not be directly harmed. Any motile organisms remaining may be impaired or destroyed by the construction activities. Motile organisms may also succumb to lack of carrying capacity, territoriality, and so forth after being displaced.

The impact of a pipeline stream crossing on the maintenance and propagation of fish, aquatic invertebrate, and aquatic plant populations, including endangered species, will be a reduction in the reproductive success of fish and invertebrates and in plant growth due to increased silt loads. Pipeline construction during spawning periods will eliminate any fish nests located in the section of the stream to be trenched, and for some distance downstream the eggs will be surrounded by silt which can render them inviable by restricting the free flow of oxygen around them. Construction during other times of the year may result in silt-covered spawning beds for some distance downstream of the crossing site.

The fish population of the entire stream system will be negligibly affected, because of the early reoccupation of the crossing site, the short time interval involved in most stream crossings and the limited extent of the reach of stream affected by significant increased silt loads. After several periods of high stream flows, the bottom silt loads will be back to normal. Preconstruction conditions of the altered stream bottoms will be restored, and they can once again function as spawning sites. According to the proposed construction schedule, approximately 75 percent of the stream crossings associated with the project will be made at times other than the spring when most warm water species spawn. In most warm water stream sport fisheries, the harvest level is below the maximum sustainable harvest level so that a short-term reduction in the number of harvestable size fish in a limited stream segment will not result in major adverse effects on sport fishing opportunity.

There are several differences in the impact on aquatic biota associated with pipeline crossings of lowland and upland streams. These are primarily associated with the nature of the biota and the volume of material put into suspension.

Construction in lowland streams will generate considerable increases in silt loads. The resuspended bottom material will have a high concentration of organic material, which may reduce the dissolved oxygen concentrations of the overlying waters. However, organisms inhabiting highly turbid, sluggish lowland streams are adapted to withstand high turbidities and periods of low dissolved oxygen concentrations and, thus, will be better able to tolerate stresses placed upon them by pipeline stream crossings. Due to the consolidated nature of upland stream bottoms, significantly less silt will be put into suspension by instream construction when compared to stream crossings of lowland streams. However, organisms inhabiting upland streams are adapted to live in clear water and increased silt loads could disrupt these communities.

To facilitate the analysis of the potential environmental impacts generated by the construction of pipeline stream crossings, the streams along the proposed route have been divided into five groups. The potential impacts associated with each of these groups are discussed below.

Varied construction methods will be used for the numerous stream classes. Intermittent streams and drainage ditches will be constructed with the main spreads. As a result, the time of construction will be similar to the main spread average of 1 to 2 months between initial clearing and cleanup operations. Creek and river crossings will be constructed using special stream crossing and tie-in crews independent of the main spread. These crossings are estimated to take from a few days for a creek up to 4 weeks for a river. The major rivers will be crossed using special spreads, and time estimates for these streams range from 40 to 140 days for completion of construction.

The flow in intermittent streams is generally limited to the period from late winter through early summer, as well as after periods of heavy rainfall. Construction of the pipeline through a stream of this type during flow periods could result in a localized reduction in the reproductive success of fish and amphibians spawning in the stream and will interfere with the limited use of this type of waterway for fishing. Since fish, amphibians, and aquatic invertebrate species use this uncertain and temporary aquatic habitat only on an intermittent basis, the disruption resulting from pipeline construction will have only a minor impact on these adaptable species. Pipeline construction and channel restoration during periods of no flow will not significantly impair any stream uses. A long-term esthetic impact will result only when an intermittent stream is crossed in a forested area. However, if adequate care is not taken to stabilize streambanks to minimize sedimentation and to restore substrate conditions, the stream environment could be degraded for many years with adverse effects on populations of aquatic species using these areas. Any delay in revegetating streambanks could result in undesirable stream warming through lack of shade with a loss of part of the growing period.

The impact on drainage ditches is the potential impairment of any limited, low quality fishery that may be present and of the fish and aquatic invertebrate food supply of local birds and mammals. Flow will be maintained during construction through this type of waterway. Some siltation would take place but since drainage ditches generally have a substrate of windborne and waterborne silt from surrounding agricultural areas, bottom conditions will probably not change significantly. There will be short-term losses in any fish populations in the ditches and in aquatic invertebrate populations, but since most drainage ditches must be cleaned periodically, there would be no long-term, project-related adverse impact. After each ditch clearing, a new cycle of plant and animal repopulation will occur in the ditch erasing any interim project impact. Local bird and mammal populations which feed on aquatic animals and plants in the affected ditches will find some loss of feeding opportunity for a short period, but this is not likely to have a significant effect on the size or diversity of local bird and mammal populations.

In considering the general impact of construction of crossings over creeks and permanent streams, siltation again appears as the major adverse factor with losses of fish reproduction, smothering of populations of bottom invertebrates and a general reduction in basic productivity involving algae and higher aquatic plants. During trenching on streambanks and across the stream bottom and until the streambanks have been stabilized, turbidity and siltation will seriously inhibit all aquatic life for a limited stretch of stream below the crossing. Wading birds, raccoon and other species which find their food in these streams will experience a local shortage of desirable food items over one or two growing seasons. Impacts on the local size and diversity of aquatic animals and plants will persist over one or two growing seasons with some local limitation on opportunities for fishing, hunting, nature study, etc. If streambank revegetation is delayed and the stream substrate is not restored, these adverse conditions could persist for many years.

At crossings of minor and major rivers, the adverse impact again will be primarily from siltation from riverbank and riverbed trenching and associated construction activities. Again fish, aquatic invertebrates and aquatic plants will suffer from the turbidity and the blanketing of eggs, fry, gills, plant surfaces and all living surfaces with silt. While in most instances local aquatic populations will recover over one or two growing seasons, the crossings of major rivers which may take up to 140 days to complete could result in several years of greatly reduced populations of aquatic animals and plants for a limited stretch of river below the crossing. In those instances, discussed later in this section, where rare or endangered mussels occur in the rivers to be crossed, critical broodstock could be eliminated.

Montana

In Montana all the streams crossed are lowland streams where construction activities will cause limited losses of production and fish reproduction confined mainly to one growing season. There is only one river crossing involved, on Poplar River. Here the most sought after game species, walleye, sauger and northern pike are found upstream from the crossing while populations of chubs, carp, suckers, minnows, white crappie and yellow perch are more common at the crossing site itself and would suffer a one season depression of reproduction levels. No endangered fish species or commercial fishery resources will be involved.

North Dakota

In North Dakota most streams already have high sediment concentrations due to both natural causes and man's activities. Runoff from the erodible badlands into the Little Missouri and Missouri Rivers from intensively used agricultural areas is already carrying a maximum silt load in many instances. While materials from pipeline construction activities will accelerate sedimentation in Sakakawea and Oahe Reservoirs, this contribution will be relatively minor. Only limited reductions in basic production and fish reproduction will occur in North Dakota waters impacted by construction activities with minor short-term adverse effects on sport and commerical fishing opportunities. No endangered aquatic species on the federal list occur along the route in North Dakota but several species, the pallid sturgeon, the flathead catfish and the blue sucker are considered uncommon in the State. Habitat for these species in Sakakawea and Oahe Reservoirs and in the Missouri River will be affected by siltation arising from construction activities, but as has been noted, the extra silt load will be relatively minor when many of the tributary waters are already carrying a maximum silt burden. No specific areas of critical habitat for these species have been identified within the area of project impact.

South Dakota

In South Dakota only limited adverse impacts of short duration on stream productivity and fish reproduction are anticipated as a result of siltation from construction activities. Sport and commercial fishing opportunity will not suffer any major limitation. No endangered fish or fish considered rare in South Dakota will be affected by construction activities. The leopard frog is the most abundant amphibian in the State and in wet years assumes some economic importance when several hundred thousand pounds may be exported from the State. It is also an important food source for mink, raccoon, heron, northern pike and walleye. The disruption of 307 wetland areas during construction will adversely affect the breeding of this species and result in a short-term diminution in population, a minor loss in marketing opportunity and in wildlife food.

Minnesota

In Minnesota all streams crossed are lowland streams where primary effects of construction activities will be the disruption of fish spawning for one season in a limited downstream stretch of those creeks and rivers crossed, and a reduction of primary productivity during one growing season. The sport fishing potential harvest will suffer a minor short-term reduction. No commercial fishing resources are involved. No endangered species occur in the waters impacted and no critical habitat of locally rare aquatic species has been identified along the route.

Iowa

In Iowa except for the Mississippi River crossing, effects of construction on aquatic resources will be similar, with minor short-term impacts on sport fishing harvest potentials, no significant commercial fishery impacts and no endangered or unusual species are involved. At the Wapsipinicon River crossings, the quality of the fishing experience on this federally designated recreational river will be degraded until streambank vegetation and tree screens are reestablished. At the Mssissippi River crossing, there are slough areas which are extremely productive of aquatic plants and benthic animals which are a valuable food source for waterfowl and sport and commercial fish species. The disruption and siltation of these areas from the extended construction activities may have a limiting effect on waterfowl and fish populations over an extended period and certain slough areas may be eliminated as productive habitat for many years. Waterfowl production and sport and commercial fishing harvest potentials will be adversely affected over a considerable period of years.

A species of mussel, the Higgens Eye Pearly Mussel, has been proposed for inclusion in the Federal endangered species list. This mussel occurs in the Mississippi River in the general vicinity of the crossing, but definitive studies have not been made as to the actual occurrence at the crossing or in river areas which would be affected by sediment from project operations. The extended period of bottom disturbance and increased sedimentation during construction could have a serious adverse effect on any local populations of this mussel, if it is still present.

Some species considered rare in Iowa, such as the lake sturgeon, pallid sturgeon, blacknose shiner, longnose dace and western sand darter could occur in the vicinity of crossing sites but no critical habitat for these species has been identified as being directly impacted.

Illinois

In Illinois there will be some short-term reduction in basic productivity in the streams crossed and some reduction in the reproductive success of warm water fish species at and below crossing sites. There will be a limited and short-term reduction in the potential harvest of sport and commercial fisheries. At the Illinois River crossing, blasting may be necessary and will reduce the standing crop of fish in the immediate vicinity and will kill many sessile and benthic organisms including mussels. No endangered aquatic species are critically involved in construction areas. Lake sturgeon, western sand darter, blacknose shiner, bigeye shiner and pallid shiner are considered rare in the State and may occur in the vicinity of crossing sites but no critical habitat for these species has been identified as being directly impacted.

Indiana

In Indiana the streams are low gradient, warm water streams, many with water quality problems from municipal and industrial effluents. Again, the impact of creek and river crossings will be a temporary loss of primary production and a disruption of fish reproduction during the construction period. There will be some limited reduction of available harvests for sport and commercial fisheries for one or two seasons. Mussel stocks in the Wabash could be adversely affected by siltation and local harvests could be depressed for one or two seasons. No endangered species are encountered in Indiana. The blue sucker is considered rare in Indiana and may occur in the Tippecanoe River in the vicinity of the crossing, but no critical habitat for this species has been identified in this area.

Ohio

In Ohio the general impact on aquatic wildlife will be the disruption of fish reproduction by disturbance and siltation and the reduction of primary productivity through turbidity and siltation. This will be a short-term limited impact affecting the size of potential harvests of sport and commercial fisheries for one or two seasons. Mussel populations will also be adversely affected in the crossing vicinities, but no extensive harvests by fisheries take place in these areas. Where blasting is found to be necessary, some loss of fin fish will take place in the immediate vicinity and there will be losses of sessile invertebrates including mussels. This will have a limited impact on sport and commercial harvests. Two species of mussel, the tuberculed-blossom pearly mussel of the Ohio River and the pink mucket pearly mussel of the Muskingum River, have been proposed for addition to the Federal endangered species list. There is no specific information available as to the occurrence of these species at the crossing sites, but local populations of these unusual mussels may exist and would be adversely affected by dredging and blasting activities. Some peripheral species in Ohio such as the western tongue-tied minnow, the eastern sand darter and the sauger may occur in the vicinity of some of the crossings but no critical habitat of these species has been identified as being directly impacted.

West Virginia

Since the Ohio River was covered for Ohio, only one river and four creek crossings need to be covered in West Virginia. The disruption of fish spawning and some loss of basic productivity due to turbidity will result in some minor losses of harvest potentials for sport fishermen. Where blasting takes place, there will be an immediate loss of fish which cannot be screened out of the area and of benthic invertebrate populations. This will also cause some temporary reduction in harvestable populations. The channel darter, tongue-tied minnow, river shiner and blue sucker are considered rare species in West Virginia and could occur in stream segments affected by construction but no specific critical habitat of these species has been identified in stream segments involved in the project.

Pennsylvania

In Pennsylvania sedimentation from construction activities will impair spawning habitat during the season of construction and cause some temporary loss of sport fishing opportunity. Blasting will cause fish and invertebrate mortalities and will further limit fish harvests for 1 or 2 years in affected streams. There are a number of fish species considered rare in Pennsylvania which occur in streams crossed by the route.

Populations of these species will be adversely affected where sedimentation and blasting occur. No critical limiting habitat has been identified for these species in the impacted stream segments but further stress on these peripheral populations could eliminate them from some areas. This is particularly true for the darters which prefer clear water conditions. Species which could be adversely affected are the Allegheny brook lamprey, bridled shiner, blackchin shiner, blacknose shiner, southern redbelly dace, longnose sucker, mountain madtom, pirate perch, least darter, Tippecanoe darter, longhead darter and slenderhead darter.

Nature and Extent of Operation and Maintenance Impacts

The impact of operation and maintenance on terrestrial wildlife species will primarily relate to the continuing suppression of trees and large brush where the permanently cleared right-of-way of 40 feet cuts through brushy gullies, streams and ditch bank fringes, bottomland hardwood woodlots and various scattered patches of relatively natural habitat. These limited and critical habitat areas will be adversely affected for the life of the project and beyond, until regrowth of trees and large brush can take place. If control is by means of brush cutting machinery, there could be considerable losses of those ground nesting birds and small mammals which would utilize these cleared areas if brush cutting occurred in spring or early summer. Brush and tree control by herbicide sprays could be deleterious not only to animals in the right-of-way, but also to animals in adjacent drift areas and to aquatic species where the pesticides wash into or drift into surface waters. The level of damage will be related to the herbicide material used, and the method of application. There will be a zone of elevated noise levels at each compressor station, but this will have limited effects on wildlife populations and many species will adjust to these noise levels. The use and maintenance of access roads to the pipeline permanent right-of-way and to the compressor stations will cause a limited, but continuing level of disturbance to some wildlife species. Microwave towers will cause a continuing hazard to migrating birds, particularly where they are in the migration path of the endangered whooping crane.

The impact of operation and maintenance on aquatic wildlife species will primarily relate to the continuing suppression of trees and large brush in the permanent right-of-way along the streambanks. Brush cutting machinery could cause a sufficient level of surface disturbance to cause limited erosion of streambanks with adverse effects on primary production and fish reproduction in the stream for a considerable period after each brush cutting effort. This could be almost an annual situation in more humid eastern segments of the route. The use of herbicides could cause acute poisoning of fish and macro-invertebrates or more insidious long-term sub-acute adverse effects on micro-organisms critical in the stream's food chain. The specific herbicides used and the methods of application are the keys to how serious the hazard would be.

3.1.3.8 Ecological Considerations

As described in Sections 2.1.3.6, 7, and 8, natural vegetation, wildlife, and ecosystem relationships have already been drastically altered by man's activities along the pipeline route.

The construction and maintenance of the proposed pipeline project will add to the disruption of natural ecosystems where they exist and to varying degrees affect ecosystems already adapted to man's influences.

When topsoils are excavated for rights-of-way and the pipeline trench, soil micro-organisms and the producer green plants will be destroyed. With the elimination of the basic food chain elements, the present ecosystems will cease to function along the disturbed right-of-way. Even where soils are replaced and revegetation is successful, the reconstituted site will differ from that existing before disturbance.

Because the pipeline involves only a narrow strip of disturbance through the major ecosystems, the adverse effects to total major ecosystems will be relatively insignificant.

In the cultured ecosystems where man harvests the crops and makes supplementary energy inputs it will be man, the ultimate consumer, who will be affected by the decreased productivity of his grazing and croplands. These ecosystem productivity losses have been described in previous sections.

Disturbances to the limited natural existing ecosystems along the pipeline will create the most serious impacts, especially to the wildlife consumer members of the ecosystems. Adverse impacts will occur primarily during the construction phase of the project. Biotic communities will be adversely affected not only by the loss of habitat but also by the disturbance created by man's presence with his equipment. In some areas adverse impacts will be long lasting. There are some specific situations where adverse effects to the wildlife segments of the ecosystems will be most significant.

The pothole area is a very special ecosystem which is critical in the life history of many waterfowl and shorebird species. Loss of any of this breeding and migration habitat, which has already been decimated by agricultural drainage, will not only cause environmental changes in the pothole area itself but also in breeding areas in Canada, whose use is related to availability of migration habitat in the pothole area, and in wintering areas far to the south. Most of the species involved are covered under international treaty with Canada and Mexico providing for the management and conservation of these migratory species. Without very intensive efforts to fully restore any potholes impacted at the earliest possible date, there could be a loss of productivity which would affect ecosystems in several nations. The endangered whooping crane migrates down through this same general area and this aerial pathway is a vital link between their far northern breeding areas and their southern wintering areas. Microwave towers distributed across this flyway are a distinct hazard to a population with only some 50 individuals. A loss of one or two birds would be a very serious affair.

The basic productivity of aquatic ecosystems would be lowered for a short period during and after construction in a segment of those creeks and rivers crossed by the route. The reproduction of game, commercial and forage fin fish, and the reproduction and growing conditions for commercial and rare mussels and other macro-invertebrates would be adversely affected for probably one breeding and growing season. If intensive measures to limit erosion and siltation from streambanks are employed, the aquatic ecosystems impacted should have essentially recovered within 2 years.

A major impact on the environment is not on any one extensive ecosystem in a particular segment of the route but on the small scattered remnants of natural habitat areas along the route which will be disrupted by construction clearing. The brushy gullies, the fringes of brush and trees along intermittent streams and drainage ditches, the strips of bottomland hardwoods along the creeks and rivers, the scattered woodlots and windbreaks, and the uncultivated areas along fencerows and property lines are critical aspects of primarily cultured cropland ecosystems. These limited natural areas are basic to any remaining diversity of vegetation, wildlife habitat, and wildlife species within the cropland ecosystem. They form oases from which big game, furbearers, game birds, songbirds, hawks and owls can venture out into the cultivated areas. The rodents and insects consumed in these excursions can be an important factor in cropland productivity. The destruction of segments of these limited habitats along the construction route will have significant adverse effects on the size and diversity of wildlife populations along the route, on the diversity of plant species, and on human opportunities to use and enjoy these diverse populations. The trend has been toward pure cultured cropland ecosystems over extensive areas of the country and this additional loss will accelerate this trend.

3.1.3.9 Economic Factors

Principal Economic Activities

The cost of construction of the Northern Border Pipeline is estimated by the applicant to be $1.347 billion, including costs of construction, materials and land acquistion. Construction of the pipeline and support facilities is scheduled to begin in May 1978 with initial gas deliveries to begin in July 1980. Construction of all pipeline and support facilities will take place during this period.

The proposed construction includes the installation of the pipeline, compressor stations and microwave towers for the communications system. The proposed route has been divided into 15 segments, several of which will be constructed concurrently.

In addition to the mainline spreads, special spreads will be required for each of the 12 major river crossings and separate crews will be employed for the construction of compressor stations and microwave towers.

In addition to the economic and social impacts of the construction and operation of the pipeline itself is the larger, longer term impact of the supply of 560 billion cubic feet of gas annually on the markets to be supplied via the pipeline and the potential stimulative effects of the presence of a natural gas transportation system upon other possible future developments such as coal gasification in North Dakota. This discussion emphasizes the immediate economic and social impacts of the construction, operation and maintenance of the pipeline itself. It further concentrates on the more local impacts rather than the total national impacts. The importance of the broader secondary impacts is recognized and discussed though in less detail.

The applicant anticipates that about 60 to 65 percent of the workers employed in construction of the pipeline will be hired from outside the local pipeline area and a major portion of monies paid to these workers will flow back to their home areas, wherever these may be. Since the contractors who will actually build each spread of the pipeline have not yet been selected, it is impossible to know just where this portion of the construction expenditures will flow and its ultimate economic impact. Bidders on construction of the pipeline will likely be firms with some degree of experience in pipeline construction. There is no reason to expect that these will be mainly local companies. Also unknown at this time is the geographic pattern over which construction supplies and materials will be purchased. It is likely that supplies and materials will be purchased from a diverse area. The largest single expenditure will be for the 1,619 miles of large diameter, heavy wall pipe. The source of the pipe required is unknown, except that the applicant states it will be purchased in the United States. Hence, the locality of the socioeconmic impact of a considerable amount of the expenditures for this pipeline cannot be specifically identified at this time and will likely not be known until actual construction decisions begin to be made.

Additional materials which will be consumed during the construction of the project are estimated by the applicant to include approximately 12.5 million gallons of diesel fuel, 6.3 million gallons of gasoline, 208,000 gallons of lubrication oil, 142,000 pounds of grease for equipment operation, and 4.5 million pounds of welding rods. These items along with a wide variety of handtools, etc., but with the exception of welding rods, would be more likely to be purchased locally although again, this will depend upon the contacts and purchasing habits of the individual spread contractors and the capabilities of local suppliers. The applicant states that from past experience, 75 percent of these materials may be purchased from local suppliers.

The impacts, both beneficial and adverse, of construction of the pipeline on local economic activities will be mostly short term. It is unlikely that the increase in demands for goods and services resulting from this construction will induce increased capital investment by the local suppliers of these goods and services since it will be apparent that the demand will last only a few months--until the construction crew moving at 4,000 feet per day builds out of that supplier's service area. Some temporary increase in personnel, inventory stocks and the finance required to carry them will be the most likely response of local suppliers to construction of pipelene through their areas.

Disturbance of agricultural production will be one of the important economic impacts along the construction route. Of approximately 19,626 acres disturbed by the construction right-of-way, about 14,500 acres are estimated to be cultivated cropland. The table on page 556 shows crop values lost because of pipeline construction and gives a crude estimate of value of agricultural production lost. It is based on the cropland in the 100-foot wide, 1619-mile long right-of-way. Thus, the crop loss would be approximately $3 million for one season of lost production.

Because of the disturbance of the soil profile and the resultant changes in the distribution of available plant nutrients, soil moisture, temperatures and porosity relationships, some portion of the disturbed cropland will likely require a period of years to return to full production. Portions of the 1,500 acres dug up in the trenching operations may not return to full production for many years. If we assume this could be the equivalent of another full season of production, the crop loss induced by the pipeline construction could be of the magnitude of $6 million. This, of course, is just a rough approximation and does not include possible loss from grazing land or woodland disturbance. Nor does it include possible loss from the disturbance of an additional 2,500 acres at river crossings, stockpile locations, temporary access roads or the more permanent location of compressor stations, microwave tower sites and delivery-measuring stations. Compensation for all of these losses is included in the estimated $24 million that will be spent for land requirements--$21 million for right-of-way acquisition and $3 million for acquisition of sites for compressor stations, microwave towers and other related facilities. Another possible cost to the agricultural industry along the pipeline route is the disruption of field drainage systems by the trenching operation. The cost involved will depend upon how successful individual spread contractors are in restoring these systems after the pipeline passes through.

Crop Production on Northern Border
Pipeline Right-of-Way

	Corn	Soybeans	Small Grains	Hay
Montana	--	--	$ 48,500	$ 12,875
North Dakota	--	--	97,000	51,500
South Dakota	$ 51,750	--	80,000	51,500
WG & W Area	51,750	--	225,500	115,875
Minnesota	241,500	$ 81,700	16,000	25,750
Iowa	517,500	155,230	44,800	51,500
Illinois	310,500	163,400	--	15,450
CB Area	1,069,500	400,330	60,800	92,700
Indiana	244,950	130,720	22,000	15,450
Ohio	421,500	122,550	32,000	30,900
West Virginia	3,450	--	--	1,030
Pennsylvania	17,250	572	6,400	18,025
GLIB Area	687,150	253,842	60,400	65,405
NBP Total	$1,808,400	$654,172	$346,700	$273,980

Source: Statistical Reporting Service, Agricultural Prices, October 1974. NBP Environmental Assessment.

Employment and Income

The economic impacts of construction of the proposed pipeline on the local communities through which it passes will be generally stimulative though short term and minor. These impacts will result from the infusion of new money into the local economies, increased demand for services, as discussed above, the creation of local jobs and the importation of labor into the area. The importance of these impacts will be directly related to population size and hence, will vary considerably at different points along the line. The economic and social impacts can be expected to be most noticeable in the relatively sparsely populated western grazing and wheat area of the line, i.e., in Montana, North Dakota and South Dakota. They will be absorbed more easily in the more populated and industrialized eastern half of the proposed pipeline. Some individual communities will be more affected than others depending upon nearness to the project and the availability of services and commercial establishments in the community. Most of the communities affected will be within 50 miles of the pipeline, which is about the limit that workers can be expected to commute to work. The socioeconomic impact will vary from year to year between 1978 and 1980 depending on the construction schedule, with the heaviest impact occurring in the first and second years..

The following tables give the parameters of the impact of construction on employment and income along the stretch of pipeline in each State. Table 3.1.3.9-1 illustrates the average level of employment that the applicant anticipates each year in each State segment of the line. The applicant estimates that about 40 percent of construction workers will be hired from the local labor force. Locally filled jobs will tend to be the less skilled jobs. Positions which will be filled from local work forces will likely include: truck driver, watchman, power saw operator, laborer, dozer operator, mechanic, bus driver, helper and tractor operator. The

Table 3.1.3.9-1 Average Annual Manpower Required for Pipeline Construction by State

	1978	1979	1980
Montana			
Local	127	33	1
Nonlocal	190	49	2
Total	317	82	3
North Dakota			
Local	184	63	8
Nonlocal	276	95	11
Total	460	158	19
South Dakota			
Local	--	154	24
Nonlocal	--	230	36
Total	--	384	60
Minnesota			
Local	--	108	17
Nonlocal	--	161	25
Total	--	269	42
Iowa			
Local	--	200	34
Nonlocal	--	299	52
Total	--	499	86
Illinois			
Local	19	129	20
Nonlocal	29	193	31
Total	48	322	51
Indiana			
Local	52	56	6
Nonlocal	78	84	9
Total	130	140	15
Ohio			
Local	50	118	14
Nonlocal	74	178	21
Total	124	296	35
West Virginia			
Local	--	10	2
Nonlocal	--	15	4
Total	--	25	6
Pennsylvania			
Local	--	64	15
Nonlocal	--	97	23
Total	--	161	38

applicant's estimate of peak manpower requirements is reproduced in Table 3.1.3.9-2. The payrolls that correspond to these levels of employment are shown in Table 3.1.3.9-3.

Pipeline construction could put a serious strain on the availability of labor in several areas. In Montana, for example, the peak construction manpower requirement of 560 workers in 1977 is nearly equal to the number employed in contract construction in the pipeline counties of that state in 1970. For contrast and to illustrate comparative impacts, Table 3.1.3.9-4 lists the number of workers in the labor force of each state, group of pipeline counties within each state for 1970, and the income of these areas for 1972. In agricultural areas such as this where there is a chronic seasonal shortage of labor, pipeline construction would aggravate the manpower problem of other activities in the area. This possibility diminishes along the more populated segments of the pipeline route. Local labor will be drawn from a wider area than the immediately adjacent counties. The amount of dislocation that develops will depend upon other construction projects that might coincide with pipeline construction.

Other parameters of construction and their potential impact are shown in Table 3.1.3.9-5. In addition to the monies expended for land requirements shown in this table, the applicant estimates 40 percent of payrolls will be spent within the state in which construction takes place. Also in addition to the employment shown for pipeline construction, the construction of each compressor station will require an average work force of 44, about 50 percent of whom will be hired locally during a 6-month construction period. Each microwave tower will require 6 weeks, and a total of from 15 to 20 workers will be employed--about 25 percent of them hired locally. Construction of these facilities will be spread out through the 3-year construction period. Compressor station and microwave tower construction work will require craftsmen skilled in the building and mechanical trades. Among the positions to be filled from the local work forces are: carpenter, electrician, plumber, mason, ironworker, roofer, glazer, millwright, painter, electronic and instrumentation technicians, equipment operators, laborer, and sheetmetal worker.

All of the above construction impacts are expected to be short term. Longer term employment and income impacts will result from the operation and maintenance of the pipeline system. The system is expected to be fully automated requiring the employment of only 200 personnel, with an annual payroll of $3 million, when in full operation. Operation and maintenance of the system will be through two division and seven district offices. Types of positions which will probably be hired locally include: clerk, typist, stenographer, file clerk, engineer, grounds and equipment maintenance personnel, draftsman and technician.

The socioeconomic impact resulting from the construction of the pipeline through the Fort Peck Indian Reservation may present a special case and should be reviewed with the Tribal Executive Board to determine how these impacts will be perceived by the people there. Unemployment, generally higher in Montana than elsewhere along the proposed construction route, is particularly acute on the Reservation. The Tribal Executive Board may desire special efforts to employ Indians or other benefits from the pipeline location on the Reservation.

Local Tax Structure and Tax Base

It is not expected that installation of the proposed pipeline will affect the local tax structures. It will, however, affect local tax bases. The applicant's engineering estimate of cost of the pipeline in each county

Table 3.1.3.9-2

Peak Manpower Required by State, 1978 - 1980

	1978	1979	1980
Montana	1,018	395	12
North Dakota	1,560	1,232	198
South Dakota	-	1,185	340
Minnesota	-	1,125	332
Iowa	-	1,867	517
Illinois	488	1,340	352
Indiana	455	769	176
Ohio	482	1,179	341
West Virginia	-	507	164
Pennsylvania	-	671	175

Table 3.1.3.9-3

Estimated Total Annual Payroll by State

1978 - 1980

($1,000)

	1978	1979	1980	Total
Montana	10,430	2,670	75	13,175
North Dakota	15,100	5,230	378	20,708
South Dakota	--	12,460	1,976	14,436
Minnesota	--	8,852	1,379	10,231
Iowa	--	15,853	2,644	18,497
Illinois	1,521	10,181	1,515	13,217
Indiana	4,237	4,579	428	9,244
Ohio	4,020	9,400	1,040	14,460
West Virginia	--	683	136	819
Pennsylvania	--	5,220	1,086	6,306
Total	35,308	75,128	10,657	121,093

Table 3.1.3.9-4

Civilian Labor Force, Contract Construction Employment 1970, Total Income 1972 by Pipeline Counties in States

	Civilian Labor Force 1970 (000)		Contract Construction Employment 1970 (000)		Personal Income 1972 (000)
	Pipeline Counties	Total State	Pipeline Counties	Total State	Pipeline Counties
Montana	9.8	260.6	.59	16.7	$ 109,387
North Dakota	24.6	214.3	1.47	11.8	239,703
South Dakota	37.3	249.4	2.15	13.5	447,809
Minnesota	36.5	1,528.4	1.96	87.1	337,885
Iowa	280.2	1,127.4	14.39	59.8	3,274,537
Illinois	215.6	4,591.6	12.17	234.4	2,618,892
Indiana	102.3	2,103.4	5.05	111.5	1,020,685
Ohio	259.3	4,234.5	14.71	211.7	2,571,578
West Virginia	11.0	--	.51	--	108,148
Pennsylvania	843.2	4,712.3	44.90	254.5	10,418,495

Table 3.1.3.9-5

Construction Parameters by State

	Miles of Pipeline	Number of Compressor Stations	Number of Microwave Towers	Major River Crossings	Stockpile Locations	Expenditures for Land Requirements (millions)	Gas Delivery Points
Montana	180	1	9	0	4	$1.2	0
North Dakota	266	2	14	3	5	1.7	1
South Dakota	176	2	10	0	2	1.3	1
Minnesota	126	1	7	0	3	1.3	0
Iowa	241	2	15	3	5	3.5	2
Illinois	160	2	9	1	3	4.0	3
Indiana	148	1	10	1	2	3.6	3
Ohio	231	1	9	2	4	5.3	1
West Virginia	8	0	1	0	1	.1	0
Pennsylvania	62	0	3	2	1	1.7	3

and estimates of ad valorem taxes that may be derived are given in Table 3.1.3.9-6. If this estimate is close to the mark, the amount of tax generated would be significant--$39.6 million annually. This averages one-half million dollars per county. Because of the disparity in assessment method and applications between counties, a definitive estimate is really not possible except through each county assessor.

Estimating income tax to states as a result of pipeline construction payrolls is equally beset with uncertainties. If we assume 40 percent of payrolls will be subject to local state income taxes and that this tax will average 5 percent in all states except Indiana and Illinois where it averages 2 percent, and South Dakota which has no state income tax, the amount would be $2 million one time only. Annual tax on the $3 million payroll for operation and maintenance personnel would be on the order of $150,000. State revenue from sales taxes related to construction crew expenditures can also be very roughly estimated to be $2 million based on the assumptions that 40 percent of total construction payrolls will be spent locally and that average sales tax collected will be 4 percent.

Much of the data on wage structures of the construction crews and expenditure patterns of contractors and crews needed for better estimates of sales taxes and income taxes that will accrue to state and local governments will not be available until construction plans develop further.

Economic Trends and Development

The construction and operation of the proposed Northern Border Pipeline itself are not expected to have a noticeable impact upon the trend or development of economic activities in the areas through which the pipeline passes. A possible influence on zoning and land use is mentioned in section 3.1.3.10. Secondary impacts will be much more significant and include the impact of 560 billion cubic feet of natural gas annually on the energy supply of the entire area served by the Northern Border companies and possible development of new industry based to some degree upon existence of the pipeline--such as a coal gasification industry in the Northern Great Plains area.

The size of the economic impact that the supply of natural gas the Northern Border Pipeline would make available is illustrated by the applicant's estimate that $12 to $15.5 billion of the GNP (gross national product) and 519,000 to 670,000 jobs are dependent upon this supply of gas replacing present supplies that are being depleted faster that they are being replaced.

Although not designed to transport gas from potential coal gasification plants, the construction of the proposed pipeline could have an influence on the development of coal gasification industry in North Dakota, and the Great Plains area of Montana and Wyoming as well, by providing an access to markets that does not now exist.

3.1.3.10 Sociological Factors

Population

Existing Population and Distribution

The impact of pipeline construction on the existing population and its distribution is expected to be negligible. There will be a temporary increase as the construction crews pass through each area, but these crews

Table 3.1.3.9-6

Pipeline Value and Estimated Ad Valorem Tax by Counties

State-County	Estimated Total Cost ($1,000)	Estimated Ad Valorem Tax ($1,000)
Montana		
Phillips	$ 25,787	
Valley	83,788	
Roosevelt	112,637	
Total	222,212	$4,500
North Dakota		
Williams	12,626	
McKenzie	54,594	
Dunn	71,169	
Mercer	21,600	
Oliver	11,405	
Morton	78,398	
Sioux	13	
Emmons	52,024	
McIntosh	28,412	
Total	330,241	8,500
South Dakota		
McPherson	49,185	
Edmunds	10,488	
Brown	41,888	
Spink	10,387	
Day	3,169	
Clark	33,797	
Codington	21,701	
Hamlin	22,291	
Deuel	24,757	
Brookings	204	
Total	217,867	6,000

Pipeline Value and Estimated Ad Valorem Tax by Counties
(Continued)

State-County	Estimated Total Cost ($1,000)	Estimated Ad Valorem Tax ($1,000)
Minnesota		
Lincoln	$ 31,048	
Lyon	22,720	
Murray	23,105	
Cottonwood	39,614	
Jackson	5,803	
Martin	43,751	
Total	166,041	$9,000
Iowa		
Kossuth	21,294	
Winnebago	10,692	
Hancock	28,427	
Cerro Gordo	26,284	
Franklin	3,156	
Butler	37,206	
Bremer	2,851	
Black Hawk	28,166	
Buchanan	15,774	
Benton	713	
Linn	37,602	
Jones	16,406	
Cedar	19,579	
Clinton	20,581	
Scott	13,949	
Total	282,680	6,000

Pipeline Value and Estimated Ad Valorem Tax by Counties
(Continued)

State-County	Estimated Total Cost ($1,000)	Estimated Ad Valorem Tax ($1,000)
Illinois		
Rock Island	$ 4,285	
Whiteside	28,510	
Bureau	45,526	
Putnam	13	
La Salle	47,733	
Grundy	20,594	
Kankakee	22,010	
Iroquois	16,888	
Total	185,559	$2,000
Indiana		
Newton	9,105	
Jasper	10,385	
White	14,403	
Cass	14,992	
Miami	8,046	
Wabash	11,382	
Huntington	17,151	
Wells	10,424	
Adams	11,591	
Total	107,479	1,500

Pipeline Value and Estimated Ad Valorem Tax by Counties
(Continued)

State-County	Estimated Total Cost ($1,000)	Estimated Ad Valorem Tax ($1,000)
Ohio		
Mercer	$ 12,115	
Auglaize	20,812	
Hardin	16,824	
Logan	--	
Union	10,858	
Marion	7,785	
Morrow	3,741	
Delaware	7,850	
Knox	18,291	
Licking	3,028	
Coshocton	20,812	
Tuscarawas	8,190	
Guernsey	2,290	
Harrison	21,352	
Jefferson	8,909	
Total	162,857	$ 3,000
West Virginia		
Brooke	5,233	
Total	5,233	100
Pennsylvania		
Washington	25,010	
Allegheny	6,212	
Westmoreland	13,448	
Total	44,670	500
Ten-State Total	$1,724,839	$39,600

are not expected to spend more than 6 weeks in one area. The 200 or more permanent operations and maintenance personnel represent a population change of perhaps 1,000 people distributed in an as yet unknown order along the pipeline route, although in communities in which the seven district and two division offices will be located. This number would not have much impact, even in the more sparsely populated areas, but will be beneficial in offering an additional amount of employment.

Future Trends

It is not believed that the construction and operation of the pipeline itself will affect future population trends anywhere along the route. The effect of the energy supply which will be made available because of the existence of the pipeline is quite a different matter.

A much larger population impact results from the supply of gas the pipeline makes available. The applicant estimates more than one-half million existing jobs are dependent upon this gas supply in the Northern Border Companies market area. If true, this represents a population of about 1.2 million people.

The impact of construction of the proposed pipeline on development of a coal gasification industry in North Dakota and elsewhere in the Northern Great Plains area remains problematic, although the pipeline is designed for transporting Alaskan gas only. Assuming, however, that such development takes place, and crediting the proposed pipeline for making this development possible, the increase in population that would result is 66,000 (33,000 in North Dakota) in the year 2000 under the "most probable" development projection discussed in the Northern Great Plains Resources Report and 195,000 people (81,000 in North Dakota) under the "extensive development" projection. The caveats on taking these projections with a grain of salt enumerated in earlier sections should again be kept in mind. These population estimates are based upon 750 workers per 250 MMcf/d (million cubic feet per day) plant, 200 workers per 10.5 million ton per year lignite mine, 1 service job for each basic industry job and an average family size of 2.5.

The impacts of this kind of development would reverberate throughout the economic and social structure of the areas where development takes place.

Community Structure

Housing

The impact of the proposed pipeline construction on the housing market of communities along the route will be very uneven. In those areas within commuting distance of cities of some size, most of the construction crew can be absorbed without seriously disrupting the local housing market. At the other end of the scale, in the most rural areas, the only suitable alternative will be construction camps; the applicant proposes requiring contractors to provide such camps in Montana, North Dakota, and Northern South Dakota. In this case, the contractor will make arrangements to obtain water and electrical facilities and supply sanitary facilities. Based on past experience, a large portion of the nonlocal construction workers typically will own a mobile home of some sort.

Rental unit vacancy rates were higher than the national average in the Montana, North Dakota and South Dakota pipeline counties in the 1970 Census of Housing. If the same rates pertain in 1978 to 1980 when the pipeline construction takes place, this could lessen the impact of the influx of construction workers on housing in these areas. (Construction camps should eliminate such impacts entirely.) It is probable that pipeline construction workers will be highly paid relative to other workers in the more agricultural areas of the pipeline route (western grazing and wheat area, and northwestern part of the cornbelt area). Hence, they will be able to outbid most other seekers of housing in these areas during the construction period. The construction period, however, will be so short as to have little permanent effect on rental housing prices, or upon the total number of housing units available in each locality.

Services

The impacts of the brief, but intense inflow of pipeline construction workers on community services will be much the same as that upon other economic parameters. They will bear much more heavily upon small communities close to the route. They will be more in evidence along the northwestern, sparsely populated segments of the line. They will cause very few ripples in larger cities along the more intensively populated, eastern spreads of the pipeline.

Impact upon local school districts is expected to be light. If construction takes place during the summer months, as is planned, public schools will not be in session. In cases where construction might be in the winter months when school is in session, it is unlikely that a large number of construction workers would bring their families to the construction sites in view of the relative rapidity at which construction is expected to move along the route.

Impacts upon recreation, cultural and related services will be greater. Construction workers will likely be working long days and long weeks, but there will be those looking for a good time. Local bars, movie theaters, pool halls, etc., will be well attended by pipeline construction workers. In the less populated areas where these impacts will be greater, pipeline workers will also be relatively affluent when they hit town and hence have a comparatively high effective demand for recreation services. Following close upon this demand for local recreation services will be an increased demand for law enforcement services; pipeline construction workers will be no different from any other group away from home in a strange town, bored and looking for action. There will also be an increased demand placed upon many communities for medical and dental services as well as all public utilities, including water, power and sewage disposal. The demand for local welfare services can be expected to increase as some job hopefuls find themselves disappointed in their job expectations and without funds to move on, and as an occasional family is abandoned along the route by construction workers. On the other hand, the increased job opportunities, however temporary, could relieve some welfare burdens.

The impact of construction vehicles on county roads could be particularly heavy as most such roads will not have been built to heavy vehicle standards. Construction related traffic will likely have an adverse impact in increasing congestion and decreasing safety on affected roads. Counties may well find themselves with increased road repair and replacement costs after pipeline construction use, and this could constitute an adverse impact. The applicant states his intention to repair any roads damaged by his equipment.

Local government, particularly in rural and semirural areas, is generally poorly equipped to deal with the increased demands for urban services that could occur when 500 to 1,000 people move through an area as part of a construction team and its support. The increased demands for urban services such as could occur in this project will be of such limited duration that they will not warrant, in most cases, those services being delivered by the local community. Rather, the contractor, particularly in the sparsely populated, rural sections of the route, should expect to develop appropriate, temporary service delivery mechanisms for his own people, such as through the proposed construction camps in Montana and North and South Dakota.

So little is known about which specific communities will be impacted by the proposed pipeline construction, let alone the existing urban service characteristics of those communities, that little more than generalized speculation can be offered about the likely impact in type or magnitude, or to what degree these impacts will be focused on a particular community or dispersed over many communities. Because of the short duration of construction impacts, it is expected that no new capital investments will be required of communities along the proposed pipeline route.

Once the construction phase of the project is completed, the urban service demands of the maintenance and operational aspects of the project will be much more manageable.

The presence of construction crews in many small communities will undoubtedly create some degree of friction and community controversy no matter how brief their stay. This will be an adverse effect but is believed not to be large for most communities.

Waste Generation

There are many types of waste generated during the construction of a natural gas pipeline. The environmental impact of these wastes will depend strongly on how they are handled. All states along the route have regulations which prohibit unregulated dumping so if those regulations are followed, the primary impact will be on the refuse disposal facilities that exist near the route. The amount of waste developed during a large construction project has a great impact on small facilities that exist in rural areas. Typically, the contractor is required by the applicant to clean up wastes during and after construction. The contractor will make arrangements locally to accept these wastes at disposal facilities. The probable amount of waste generated by construction is given below by type.

Construction Generated Wastes

Trees and brush, cut primarily in the Ohio, West Virginia, and Pennsylvania parts of the route, must be disposed of. These states restrict open burning so it may be necessary to dispose of approximately 177,000 cubic yards of timber in authorized waste disposal facilities or by sale. A large number of truckloads will be required, but because the facilities in that part of the country are well developed, it is likely that the impact will be small.

Grading operations will produce excess materials, primarily due to cuts in the rough terrain areas of the Dakotas and in Ohio, West Virginia, and Pennsylvania. Much of the material will not be suitable for use in building access roads and must be disposed of along with the excess material displaced by the pipe. Estimates of the amount of excess are difficult to make, varying from about 2,500 cubic yards per mile up to 25,000 cubic yards per mile. The method proposed by the applicant is spreading that material along the right-of-way. Since some of this material will be rocky and might otherwise be disposed of on valuable farmland, it will be necessary to haul it to disposal sites. Onsite disposal of suitable excess earth materials could be accomplished, in some cases, by recontouring of the ground surface. Any offsite disposal will require haul trucks.

Waste construction materials will need to be carried from the pipeline route. These wastes can be scrap pipe, concrete, steel, or lumber. Contaminants may be found in the soil at river crossings. If so, the material cannot be replaced but must be put on approved land sites. Since there are a number of stream and river crossings, there is high probability that a significant amount of river bottom must be truck hauled to a waste disposal site.

It is estimated that the primary impact of construction wastes will be through the truck traffic generated. That traffic will cause a temporary and small noise and air quality impact.

Human Generated Wastes

The amount of these wastes is directly related to the number of people involved in the construction. Since there are both employees (which can be estimated) and nonemployees such as dependents, support personnel and temporary commercial establishment employees (which are more difficult to estimate), the amount of various human wastes generated cannot be estimated in detail.

It is estimated that the worst case situation would be when a pipeline construction crew, a river construction crew, a compressor station crew, and a microwave tower crew might be working simultaneously in a geographically constrained area. It is estimated that 1,000 people may be directly involved and another 1,000 people indirectly involved.

Considering that about 5 pounds of garbage (solid waste) is generated per day per person, it is estimated that about 10,000 pounds per day would be generated. Using standard commercial trash trucks with compaction units, this amount would result in about 20 cubic yards per day of compacted waste which must be hauled to the local waste disposal facility. In the easternmost parts of the route, this amount could probably be handled easily, but in the western states, this quantity of waste may cause impact on community facilities. The applicant plans to obtain other approved sites if such is the case.

Estimates of liquid waste generated vary between 25 and 75 gallons per person per day. In a typical situation, between 50,000 and 100,000 gallons of additional sewage will be generated each day. The contractor will have the task of providing the necessary water supply and disposal facilities for construction camps, and communities will provide facilities where they are adjacent to construction. Regulations on this type of waste disposal appear adequate to insure that minimal impact will occur. There is no indication that previous pipeline construction has caused a significant impact.

Deterioration Caused Wastes

During the construction phase, there will be substantial heavy truck traffic. This traffic will carry pipes from stockpiles to the site, construction equipment to and from the site and around river crossings, and miscellaneous materials to, and wastes from, the site. Many of these trucks are anticipated to be quite heavy and will overload the light duty county roads on which they will travel. The applicant plans to obtain overload permits and will accept responsibility for any damage. On small bridges, modifications will be made to insure integrity. The damages are likely to be washboarding of dirt roads and destruction of lightly asphalted roads. For light duty county roads with a 4- to 6-inch gravel base and a 1- to 2-inch asphaltic surface, destruction would generate up to 780 cubic yards per mile for a 24-foot wide road. Since little information is available on the condition of roads adjacent to the right-of-way, it is difficult to estimate total amounts. However, if even one-half of the county roads in the project area with low to medium class asphalt surfacings are subject to intensive, heavy construction type loadings, the volume of destroyed road materials could reach 262,000 cubic yards (336 miles x 780 cu yd/mi). The applicant does not anticipate that any roads will be severely damaged, but is prepared to repair those that are, so no economic burden is placed on any community.

3.1.3.11 Land Use

Current Land Use

Agriculture and Forestry

Because of the nature of the pipeline project, permanent or long-term changes in agricultural land use will not be great. While land use impacts will be locally significant during the construction period, most of the agricultural land crossed will revert to its original use after the pipeline is installed.

As previously discussed in Sections 3.1.3.4, Soils, and 3.1.3.6, Vegetation, there may be some long-term adverse effects to crops and native vegetation where subsoils are left on the surface. These effects, however, will relate to production and not to changes in land use. An exception will be where the pipeline crosses forested land. In these areas, trees about 50 years old will be removed from the construction right-of-way and will not be allowed to reestablish on the maintenance right-of-way during the life of the project. This will result in a primary land use change from recreation or forest products to livestock grazing and open corridor along approximately 73 miles of the route. Where livestock are not allowed to graze the cleared woodlands, the new primary use may be wildlife habitat of the more common farm type rather than the woodland type. Total area of woodlands affected will be approximately 1,000 acres of construction right-of-way and approximately 450 acres of maintenance right-of-way.

Other areas of significant agricultural land use change will involve pipeline facilities constructed on agricultural lands. These include the compressor stations, communication towers, mainline block valves, delivery-measuring stations and access roads. These facilities will change approximately 575 acres of agricultural land to pipeline industrial uses during the life of the project.

The table on page 574 illustrates the effects of construction on crop production during the construction year on lands disturbed along the 100-foot wide right-of-way. The additional 575 acres required for pipeline facilities will add to these temporary land use change effects. The effect has not been quantified in terms of crop losses since the exact locations of facilities have not been determined. The land use change at facility sites, however, will carry over for the life of the project.

Pipe stockpile locations will also add to the effects of temporary land use changes since they will probably be located on present agricultural land.

Land Removed from Cultivation During Pipeline Construction and Estimated Crop Losses*

State	Acres Affected	Corn bu.	Soybeans bu.	Small Grains bu.	Hay (tons)
Montana	1,100			10,000	250
North Dakota	1,800			20,000	1,000
South Dakota	1,800	15,000		20,000	1,000
Minnesota	1,400	70,000	10,000	5,000	500
Iowa	2,700	151,000	19,000	14,000	1,000
Illinois	1,800	90,000	20,000		300
Indiana	1,600	71,000	16,000	7,000	300
Ohio	2,000	70,000	15,000	10,000	600
West Virginia	25	1,000			20
Pennsylvania	300	5,000	70	2,000	350
Total	14,525	472,000	80,070	88,000	5,320

*Estimates prepared by applicant.

Industrial

The proposed pipeline is expected to have little primary impact upon industrial land use. It would pass through a proposed industrial park area in Rock Island County, Illinois. This will require the developer of this property to locate prospective industrial buildings in a manner that would not encroach upon the pipeline right-of-way, but should not otherwise limit development of the property. The same would be true of other property that might come under consideration as industrial property in the future. If, however, coal gasification development in North Dakota is based on use of the proposed pipeline for marketing purposes, industrial land use in Dunn and Mercer counties may expand considerably as coal gasification plants are constructed.

Commercial Fisheries

Since the pipe will be buried below the scour depth at river and reservoir crossings, no long-term adverse effect on commercial fishing use of these waters is anticipated.

Residential

The proposed pipeline route would traverse a number of areas that might logically be expected to develop as residential areas, such as the Waterloo, Iowa, and Jeanette, Pennsylvania, areas. The existence of a buried, high pressure pipeline probably will affect values of property and platting of houses, and will proscribe building on the pipeline right-of-way itself.

The pipeline right-of-way with its cleared area might have varied effects if residential development expanded and included the right-of-way. This could constitute a greenbelt which would add to the quality of life of an urban setting. It could even increase the value of building lots facing this green undeveloped strip. If, however, growth took place outward from the town and inward from rural areas, this cleared strip could assume the character of a physical barrier between residential developments of different economic levels with unfortunate psychological and sociological impacts on the children involved. The "other side of the track" could be the other side of the pipeline or it could be along the pipeline if the more affluent homeowners shied away from building anywhere near the possible hazards of a leak or rupture.

Mineral Extraction

The primary mineral resource that may be affected by the proposed pipeline is coal, with known coal resources in the vicinity of and underlying the proposed route at both its western and eastern ends. The extent of the coal resource involved is so large, however, that it is unlikely that the presence of the pipeline will constitute any serious constraint to coal production. The same is true of other mineral production, primarily stone, sand, gravel, and clay that might potentially take place along the pipeline route. However, the possibility that emplacement of this pipeline will conflict with surface and underground production of some mineral reserves, primarily coal, must be recognized. The approximate coal lost to surface mining within the proposed right-of-way can be estimated when the area and thickness of coal are known on the basis of 12.12 acres per mile of right-of-way and 1,800 tons of coal per acre-foot of coal present. Depending on the necessity for surface support, the impact on underground reserves could be greater and make it difficult to carry on an economic mining operation.

Of perhaps equal importance to the possible loss of mineable mineral resources is the possibility of damage to the pipeline from ground subsidence caused by collapse of underground mines. Where the pipeline is constructed across mined areas, care must be exercised to preclude such an occurrence.

The proposed pipeline route passes over oil and gas fields and associated collection lines in Montana and Ohio. The route also passes over the Fort Union coal formation in both Montana and North Dakota, but not directly through any known mining operation. Existence of this pipeline could well influence decisions to develop a coal gasification industry in North Dakota with considerable expansion of those lands which would be utilized for coal production.

Other areas in which coal production could be affected, include Bureau, LaSalle, and Grundy Counties, Illinois; Coshocton, Guernsey, Harrison, Jefferson, and Tuscarawas Counties, Indiana; and all West Virginia and Pennsylvania counties crossed by the pipeline route. The pipeline crosses through a proposed stone quarry in LaSalle County, Illinois, and will affect mining plans there.

Federal and State Reserves

The impacts of pipeline construction and operation upon land use results from the encroachment of the route on the existing, planned or anticipated usages of the localities through which it passes.

Much of our Federal and State Reserves are in range or grazing land (Agriculture), woodland (Forestry) and/or recreational categories. The specific impacts on these sites are best discussed under their respective headings and will not be duplicated in detail here.

Construction through parks, recreation areas and public lands such as rangelands, wildlife management areas and national grasslands will result in the temporary loss of use within the right-of-way during construction. In most instances, the level of impact will be minor and will not interfere with the use of these public lands set aside for their specific purposes.

In those areas of Bureau of Land Management lands currently under a grazing program, there will be a short-term impact until the right-of-way is revegetated. Once this is accomplished, grazing use will continue basically as before.

The route also crosses a 1.5-mile segment of the Little Missouri River National Grasslands. The crossing location was selected to minimize the amount of national grassland involved. The actual impact will be minor and short-term, as the loss of use will be during the period of actual construction. Once construction is completed, these open space grasslands will, over a period of years, return to their natural state.

Also in the western sector, pipeline construction crosses croplands and grazed rangelands within the Fort Peck Indian Reservation. The construction through rangelands will result in minor, short-term impacts through the loss of crop production and grazing use of these lands during the construction period. Once construction has been completed, and the site revegetated, the right-of-way will return to grazing use. Croplands will return to the management of the landowner. Through disruption of the site, there will be the possibility of reduced productivity for several years until the site stabilizes.

The Federal Fish and Wildlife Service Waterfowl Production Areas are acquired in fee or by easement through agreements with the private landowners. These rights have been acquired in order to protect specific areas for waterfowl nesting, feeding and resting habitat. The landowners may still retain rights to utilize some areas for crop production or limited grazing as long as the use is not in conflict with the area's hydrologic regime. The proposed right-of-way will pass through many of these waterfowl production areas. The major impact to these areas will be through the loss of production during the period of time the site is disturbed. With proper rehabilitation, these sites will return to their original use.

Some State wildlife management areas will be crossed by the proposed route. Most of these areas have been placed under State game management programs to also protect specific areas for waterfowl nesting, feeding and resting places. Like the Federal wildlife areas, the land use impact should be minor and short-term, because once construction is completed, the areas will return to a natural state. The overall impact is the loss of utilization of the route for the construction and revegetation period and there will be no change in land use.

Woodlands are a more predominant feature in the eastern portion of our study area. They are a part of many public recreation areas, parks and trails and form the transition zones along many rivers and streams. These woodland areas are favorite sites for wildlife, both animal and man, and therefore the subject of both existing and future wildlife management areas. They are also a valuable factor considered for a river's qualification to become a part of a State or National Wild and Scenic River System. Many of these woodland sites represent the last remnant of the natural vegetation which once covered a broad area. Its woodland values are wide and varied, to include a habitat for birds and animals, and a recreational use for bird watchers and hunters. Construction of the pipeline right-of-way through these woodlands will result in a change of use to an open corridor. During the life of the project, the permanent right-of-way must be kept clear of brush and trees, the significant components of the woodland setting. Removal of this natural habitat will restrict use of the area by birds and animals. The existence of this natural habitat, in many cases, was the major reason for setting the area aside for its present land use. This change in use to an open corridor represents a long-term adverse effect due to a conflict in use and a disruption of the natural vegetation.

In summary many Federal and State lands remain in a natural state. This includes the esthetic values which go with the natural vegetation that exists. The construction of a pipeline will disrupt or destroy that natural vegetation. The impact period could be measured by the length of time taken for the site to return to its natural state. In the case of croplands or rangelands which will be allowed to return to its former state, this period is relatively short and thus a minor impact. In the case of woodland areas which are not allowed to revegetate to a woodland, the impact is major and long-term.

Recreation

Changes in land use, as a result of the pipeline, of areas now designated as park and recreation areas vary considerably from park to park. For the established parks, future planning will have to consider restrictions or limitations of use within the right-of-way. Some planners will undoubtedly attempt to either hide the corridor or search for innovative schemes to find uses for these areas that do not conflict with the pipeline.

During the construction phase, the pipeline corridor will be closed which may block access to other parts of the recreation area. The noise, presence of heavy machinery and general disturbance will also be a derogatory impact on park activities. Planning and land use changes will occur throughout the parks during construction, but these impacts will generally be severe and short-term in that they will not last more than two seasons.

The most serious exception to the preceding paragraph's conclusion may occur on the Little Missouri River, North Dakota, Wapsipinicon River, Iowa, and Wabash River, Indiana. These three rivers may lose possible qualification for wild or scenic river status because of long range impacts from the pipeline crossings.

Fish and Wildlife

The most critical land use impact from a fish and wildlife viewpoint will be the changes along the route stemming from the clearing of trees and large brush within the permanent right-of-way. For the life of the project and for years beyond, whatever was originally brushy gullies, fringes of trees and brush along streams, bottomland hardwoods, woodlots and upland forest areas within this pathway, will be kept open and devoid of trees and brush. Since these natural food and cover areas are at a limiting level practically all across the country, the land use change to open areas is a most significant one with significant and long-term adverse effects on the diversity of habitats, and the size and diversity of wildlife populations in local areas.

Transportational Facilities

Major Roads

Most appropriate regulating agencies will require heavily traveled State, national and interstate highways as well as railroads to be crossed by either the jacking, boring or tunneling methods. The construction procedure should have no impact, either short or long range, on traffic operations.

With these methods there is usually no damage to the road surface and little interference with the traffic. However, with these methods of construction there is a possibility that settlement of the road surface will occur, especially on those crossings located in areas of high ground water. Any settlement of the road surface will usually be abrupt and involve a short distance along the roadway normal to the pipeline crossing. Local traffic would be interrupted while repair or replacement of the road surface takes place.

In spite of the utilization of reasonable precautionary measures, accidents can occur. If a section of roadway were to collapse, either totally or partially, during or after construction, the roadway would have to be closed to traffic. Accidents could result. These are not predictable and any estimate of losses due to these accidents would be nothing more than an educated guess. Inconvenience caused by out-of-direction travel would relate to interchange spacing, proximity of parallel facility, capacity of that parallel facility and the traffic volume imposed upon the parallel facility.

During construction with one of the above methods there will be some interference and possible delay of traffic on the roadway due to slow moving vehicles traveling on or along the roadway and vehicles entering or leaving the roadway.

Nonfreeway Roads

On nonfreeway roads, the method of construction will, in all likelihood, depend upon the volume of traffic using the road, the general importance of the road, whether or not the road serves as a school bus or mail route and the attitude of the official in charge. In some cases, the line will be bored under the roadway in which case the only attendant inconvenience would be that described above. If the line is placed in an open trench, most highway cuts will require an adequate detour route. The major impact on transportation will be the higher probability of an accident occurring. Traditionally, a higher accident rate is found at a construction or detour site than at a nonconstruction or nondetour site. With the limited data base as would be found on a rural, nonfreeway road, it would be difficult to predict the change in accident rate with any reliability. If a detour route were not required, the level of inconvenience would be related to the added length of travel using the alternate route and the volume of traffic required to use the alternate route. In case of an emergency (accident, illness, fire, etc.) the added travel time could become critical to the success of the emergency effort.

Roadway surface restoration will cause traffic interruptions. If the construction is completed during inclement weather, the road surface replaced at a crossing would probably be of a temporary type until weather permitted permanent replacement. Any temporary road surfacing material requires periodic repair or replacement accompanied with delay to traffic.

Many roads in the area affected by the construction will receive heavy use by vehicles transporting supplies, material and equipment from supply points along the route. A great amount of traffic will be generated by the trucks transporting pipe from the pipe storage areas to various points along the route.

This additional vehicle travel and the heavy loads on many vehicles will cause considerable damage to roads with low standard surfaces and bases. The roads suffering damage will require increased maintenance, repair and possible replacement of surfacing. The possibility of this damage means that traffic disruption and inconvenience could occur over an extended period until restoration is complete.

Due to the type of equipment used and the weight of the pipe, the contractors will seek approval for oversize loads and special permits for heavier than normal loads. Any such loads will increase the possibility of damage to roads. Many of the lower standard roads contain road surfaces which will rapidly fail under these heavy loads. Many of these roads may contain bridges designed for minimum loading and they may be damaged by the heavy loads or will require certain upgrading work by the contractor prior to their use.

Railroads

In probably all instances, the crossing of railroad tracks will be accomplished through a bore. The analysis of impact is very nearly that outlined above for a major road crossing except that, if a collapse were to occur, it would probably happen at a time when a train is crossing the construction site. This is because of the concentrated load imposed by the presence of a train. Also, if such an accident did occur, it would, in all likelihood, be catastrophic.

Airports

No air transportation impact is anticipated.

Water Transportation

The impact to river traffic on navigable streams listed in Section 2.1.3.11 will vary from rerouting on the wider river crossings to complete stoppage on the narrow river crossings. On the wider river crossings construction of the pipeline will probably be accomplished on only a portion of the river's width at one time and traffic can be maintained with little interference by rerouting. On the more narrow river crossings traffic may be completely halted for periods ranging from a few hours to several days.

Based on the river traffic for 1974, the least amount of traffic encountered on the Mississippi River occurs during the months of January, February and March; on the Monongahela River the least traffic encountered is during the months of November, December and July; and on the Ohio River, the least traffic is during the months of July, January and February.

The pipeline will be buried below the scour depth of the rivers at each crossing and once construction is completed, there should be no impact on the river traffic or on the normal flow of water in the rivers.

If during the operation of the pipeline, a leak should occur under one of the river crossings, the impact will be determined by the extent of the damage to the pipeline and the location of the damaged area in respect to the riverbanks.

It is quite improbable, but possible, that should the pipeline develop a large leak under the river crossing, a passing boat could ignite the escaping natural gas and cause loss of life as well as property damage.

General

These comments relate primarily to the construction of the line. The only long range impact which could be anticipated would relate to damage and inconvenience caused by construction-related failures which may not show up for several years. The remedy to these problems would be a reconstruction effort with attendant impact similar to that experienced in the original construction. Another possible problem would occur if a highway or railroad reconstruction effort called for a significant change in grade which might require a regrading of the existing pipeline. The resulting problem would be design and construction oriented, not operational. Problems with maintenance could be avoided if a procedure were adopted to place the pipeline in a sleeve under, at least, all major road and railroad facilities.

Transmission Facilities

The proposed route crosses many buried and overhead transmission facilities. These facilities can suffer damage if good, safe, construction practices are not followed.

All known underground facilities such as oil, gas, telephone, water and sewer lines must be located prior to trench excavation. Care must be taken when exposing these lines during excavation and to adequately support these lines while the pipeline is laid underneath these lines. Damage to certain types of lines can cause property damage, pollution and death.

Damage to overhead lines will not occur if good, safe practices are followed. However, equipment can damage poles or towers and can cause damages if they come in contact with the overhead lines. Contact with powerlines can cause damage to equipment, injury or death of workmen, and disruption of service to customers.

Land Use Planning and Policies

Formal land use planning in the States along the pipeline is in the early stages of development. State legislation that created authority and staffing for statewide land use planning and controls has not occurred in any of the States. Section 2.1.2.11 summarizes the status of local planning in the counties along the pipeline route. Land use mapping and zoning authority are two activities leading to land use planning that are gradually becoming planning tools on the county level. Perhaps the greatest problem at this time for most counties is the lack of adequate funding and staffing.

The impacts on land use planning resulting from the construction and maintenance of the pipeline will be minor. Obviously compatible uses of lands on the right-of-way and adjacent lands, especially near compressor stations, will result in some restrictions of land use. Because most of the land in the corridor consists of grazing and cultivated land little change of use is anticipated.

Expected and Potential Trends

The trends in planning are clearly towards formal land use planning at all levels of government. In future years effectiveness of land use planning can be expected to greatly increase. The presence of this pipeline is just one factor that, along with growing population and resulting human use of land, will lead to closer control of land. For example, physical areas of cities will expand. In certain instances, such as Waterloo, Iowa, and the urban area south of Pittsburgh, Pennsylvania, the pipeline will become a barrier to urban construction. The pipeline presence will either result in a blunting of city expansion, or urban construction and growth will leapfrog the pipeline leaving a green belt along the right-of-way.

3.1.3.12 Cultural Resources

Archeology

The evaluation of the impact of the proposed action on archeological sites along the pipeline route included the consideration of all recorded archeological sites that appear to be in the path of the pipeline corridor. These sites have been included in Section 2.1.3.12. Fifteen sites have been identified in the study corridor and may be damaged by or lost to the construction phase of the project.

Major portions of the proposed route have not been surveyed. Because of the lack of knowledge of archeologic findings it is a safe assumption that a variety of undiscovered sites will be found during construction. Archeological sites are finite, nonrenewable resources and therefore any action which affects the resource can result in direct and permanent impacts. There may also be secondary adverse impacts upon archeologic remains which could include collection of artifacts by the construction and/or maintenance crews. One of the difficulties in identifying new sites or areas which archeologists believe significant is their reluctance to provide specific location or site information. Once sites become public knowledge the possibility occurs that amateur collectors may damage unprotected sites. This factor coupled with the lack of a route survey results in unknown impacts except in the 15 identified sites. Even on these sites, specific impacts may be uncertain because complete investigations have not been conducted.

The potential for damage being done to archeological sites is primarily during the construction phase. The trench and grading to level the right-of-way will be the most significant impact when considering the entire route. Local borrow pits, access roads and construction camps may disturb or destroy sites, especially those that are unknown at the present time.

Regarding the impact that is likely to occur to the 15 sites in the vicinity of the route as presented in Section 2.1.3.12, five potentially will experience major damage. Five others will be damaged less either because of previous disturbance or the nature of the sites. The remaining five sites have not been sufficiently evaluated to determine impact at the present time.

The sites likely to be severely impacted primarily because of lack of knowledge regarding the extent of the areas are:

1) North Cannonball Site - North Dakota

2) Utica Mound Group - Illinois

3) Barney Erikson Site - Illinois

4) Boyles Site - Pennsylvania

5) Little Beaver Site - Illinois

The North Cannonball Site is located at the mouth of the Cannonball River. It is a late prehistoric village site. This is a large site and the extent of it is not known, which is the major concern regarding this site. Because of the topographic continuity of the Missouri River bluff in the vicinity of this site, it is safe to assume that the Cannonball site and possibly other unknown sites will be encountered during construction.

The Utica Mound group, the Barney Erikson Site and the Little Beaver Site are all located where the pipeline crosses the Illinois River at Starved Rock State Park. The Utica Site once included 20 Hopewell mounds. If the pipeline goes through one of the mounds or an associated structure or village, major impact would result. Across the Illinois River to the south and perhaps within the recently expanded Starved Rock State Park, the Barney Erikson Site, a campsite with major data potential, and the Little Beaver Site occur. Little Beaver is a very large multicomponent site which may provide information about cultural adaptation in the Illinois River Valley. The Illinois Archeological Survey has given this site a high priority rating. The fifth site where there is potentially a major impact is the Boyles Site in Washington County, Pennsylvania, south of Canonsburg. Although this site has been surface collected for years, it is still a highly productive area.

The five sites along the route where the impact would likely be less severe than in the sites discussed in the preceding paragraph are: two flint quarries in Dunn Coounty, North Dakota, the Woodruff Farm Site, the Cut or Neal Site and the Robbins Site, all in Washington County, Pennsylvania.

The two flint quarry sites in Dunn County, North Dakota, which are within a quarter mile of the proposed trench are a unique resource with potential significance and present a different kind of problem. Knife River flint has been found in archeological context over a greater part of North America in sites that have an extensive range in time. These two sites are a part of a group of sites that combined, make up an identifiable and distinctive archeological district that is undoubtedly qualified for nomination to the National Register of Historic Places. The pipeline will be laid between the two sites. Although neither site will be directly crossed by the trench, the area around the two sites, especially between them, can be expected to be the location of items associated with these quarries and perhaps others in the area.

The three sites in Pennsylvania have been badly damaged by road construction or, in the case of the Robbins Site, by pipeline construction, and little remains to be studied. While the project will be an incremental impact upon these resources, additional damage should be slight.

The five sites in the path of the pipeline where a lack of available data results in the inability to make a meaningful judgment on impact are:

1)	Alexander Site	Illinois
2)	Alexander Site II	Illinois
3)	Richardson Kame	Ohio
4)	William Alexander Kame	Ohio
5)	Unnamed village site	Ohio

Except for the Richardson Kame, all of these sites have been poorly recorded and very little information is available regarding them. The

Richardson Kame was excavated in 1856 and the extent of the excavation is not known because of poor records.

History

Like archeological sites, significant historic sites are finite, nonrenewable resources and therefore any action which affects these resources can result in a direct, long-term irreversible impact. The likelihood that important historic sites will be found during the construction of the pipeline is considerably less than for archeological sites. Most historic sites along the route are on the surface and are frequently structures. This is less true in the Dakotas where campsites used by Indians and the advancing white man can still be found.

The proposed route crosses one site, the Illinois and Michigan Canal, that is eligible for inclusion on the National Register of Historic Places or its supplements, as printed in the Federal Register. A survey of the route for unknown historic sites has not been done.

Other than additional Indian sites a survey would probably identify farmhouses and outbuildings that may meet Register criteria. For example, log buildings may have had siding of various types put on them which could disguise an important or unique site, building or object. Probably only a trained person could be expected to recognize its values. This type of structure is most likely to occur in the farm belt beginning in Minnesota and continuing to Delmont, Pennsylvania. Although no structures are directly in the path of the proposed route, many farmsteads are in the study corridor. Some jogs in the route are evident to avoid having to destroy or move farm buildings.

Three historic sites have been identified as within the proposed construction corridor. They are the Illinois and Michigan Canal in LaSalle County, Illinois, the Miami and Erie Canal north of St. Marys, Ohio, and Fort Bouis Fur Post in the Missouri River crossing in North Dakota. A short segment of the Miami and Erie Canal in Allen County, 5 miles north of the proposed trench is listed on page 5306, Federal Register's National Register of Historic Places, Volume 40, Number 24, Part II of February 4, 1975. The stretch to be crossed by the pipeline has not been nominated for the Register.

The Illinois and Michigan Canal appears in the February 4, 1975, National Register of Historic Places for Will County. All of the remaining segments are considered eligible for historic landmark designation. The pipeline route crosses one of these segments.

The exact site of Fort Bouis is unknown. Records indicate the Fort was on the east bank of the Missouri River across from the mouth of the Cannonball River. Because of the lack of specific information on this site, the impact is uncertain but it is probable the area around the Fort is rich in items of historic interest even though the exact Fort site is expected to be missed by the pipeline. The impact on this site must be considered unknown at this time.

The Illinois and Michigan Canal is part of the Illinois State Park System. The crossing point of the canal is near the point where the pipeline crosses the Illinois River. Two other State parks will be crossed here as well as important wildlife, archeological, and esthetic areas. There is no doubt that the crossing of the pipeline in this area could cause severe damage on all of these areas. The impact on the canal could depend on whether the pipe will be burrowed under the canal or whether an open cut technique will be used. It is possible that the crossing can be made with only minor damage to the canal itself. Some trees will be cut within the State park resulting in esthetic impact. No locks will be damaged by the construction or operation and maintenance of the route. This fact is expected to significantly lessen the impact upon the canal.

The Miami and Erie Canal in western Ohio follows the St. Marys River in Auglaize County, Ohio. The canal has water in it and appears to be in good condition. This canal has been out of use only about 20 years which accounts for its good state of repair. As was mentioned earlier, a short segment known as the "deep cut" is listed in the National Register of Historic Places. This area is about 5 miles north of the pipeline and will not be impacted by the pipeline construction. No other stretches of the canal have been nominated for possible inclusion in the National Register.

The towpath along the canal has potential for outdoor recreation pursuits such as hiking and walking. The canal is tree-lined, which greatly enhances its value as a future recreation trail. The expected impacts are similar to those of the Illinois and Michigan Canal. Except for the cutting of trees along the canal the impact of the pipeline at the crossing will depend on whether the route goes under the canal by burrowing or through it by open trench. The restoration of canals with a clay bottom can be very difficult. The impact on the canal from this project can be minor if proper procedures are followed. No lock areas exist within the corridor.

Section 2.1.3.12 identifies several other sites in the vicinity of the pipeline route. None will be damaged by the nearness to the construction corridor. Locations of construction camps, access roads, borrow pits and the like are not defined well enough to determine whether these activities will have any impact on historic sites.

3.1.3.13 Recreational and Esthetic Resources

Recreation

The construction corridor of the pipeline will directly impact 10 designated park or recreation areas. In addition, 12 trails or waterways with important recreation values will be crossed. One of these, the Illinois and Michigan Canal, already has State park status. The Wabash River in Indiana is currently in a "proposed for study" category. The other trails or waterways in the study corridor fall in between these examples in that they are not designated recreation areas but are beyond the "thinking" stage. Table 3.1.3.13-1 provides some basic information on the park and recreation areas to be directly impacted while Table 3.1.3.13-2 does the same for the trails and waterways.

Following is an area by area description of the environmental impacts resulting from the pipeline construction and operation upon parks and recreation areas:

West Fork River Greenbelt

This is a new recreation area near Waterloo, Iowa, that consists of open areas and scattered woods, but the most significant feature is the presence of a closed canopy hardwood forest. The pipeline will result in the removal of this forest through a 600-foot long corridor. A mature forest of this type is increasingly rare. For a forest of this type to develop to this stage of maturity takes from 150 to 200 years. The impact on recreation in the forest is one of esthetic value to the area. The

Table 3.1.3.13-1 -- Parks and Recreational Areas

Name of Area	County and State	Managing Agency	Acres	Primary Facilities	Visitation	Potential For Expansion
West Fork River* Greenbelt	Black Hawk, IA	County Conservation Board	218	Nature Trails	New Area	Good
Big Bend State* Conservation Area	Whiteside, IL	State Dept. of Conservation	1,188	Nature Trails Hunting	New Area	Excellent
Starved Rock* State Nature Preserve and State Park	La Salle, IL	State Dept. of Conservation	2,524	Picnicking Lodge Campers Trails	604,211 (1973)	Good
Matthessen State Park	La Salle, IL	State Dept. of Conservation	1,628	Picnicking Trails	198,629 (1972)	Good
Lake Shafer	White, IN	Private	1,291	Amusement Park	Unknown	Poor
Salamonie State* Recreation Area	Huntington, IN	State Dept. of Resources	8,551 (2,855 water)	Camping Picnicking Swimming Boating	717,817 (1974)	Poor
Delaware Reser- voir* State Park	Marion and Delaware, OH	Ohio Dept. of Natural Resources	7,673 (1,300 water)	Camping Boating Facilities Picnicking	1,125,486 (FY 1974)	Poor
Lake Clendening	Harrison, OH	Maskingum Water- shed Conservancy District	6,580 (1,800 water)	Boating Camping	217,000 (1974)	Poor
Mingo Creek Park*	Washington, PA	Washington County Dept. of Parks and Recreation	2,500	Picnicking Trails	600,000 (1973)	Poor
Round Hill Regional Park	Allegheny, PA	Allegheny Dept. of Parks and Conservation	963	Picnicking Trails	300,000 est. (1973)	Good

* Land and Water Conservation Fund money has been used for acquisition and/or development facilities.

Table 3.1.3.13-2 -- Trails and Waterways

Name of Area	County and State (within study area)	Managing Agency	Present Status	Potential for Expansion
Lewis and Clark Trail	Williams, Morton, Emmons, ND	PVT	Designated	Studied for National Trail
Little Missouri River	Dunn, ND	PVT	(1) 5(d) list of PL 90-542 (2) Designated	To be studied for National Wild and Scenic Rivers designation State Scenic River
Railroad Right-of-Way (no name)	Codington, SD	State Game, Fish and Parks	Designated	
Wapsipinicon River (twice)	Clinton, Scott IA	PVT	5(d) list of PL 90-542	To be studied for National Wild and Scenic Rivers designation
Great River Road	Rock Island, IL	PVT	Proposed	Future study has been funded
Rock River Canoe Route	Whiteside, IL	PVT	Designated	
Illinois and Mississippi Feeder Canal	Bureau and Whiteside, IL	State Dept. of Conservation	Proposed	
Illinois and Michigan Canal	LaSalle, IL	State Dept. of Conservation	Designated	
Wabash River Environmental Corridor (twice)	Wabash and Adams, IN	PVT	Study Planned	
Upper Wabash Trail	Wabash, IN	Div. of Outdoor Recreation	Proposed	
Buckeye Trail (twice)	Harrison and Auglaize, OH	PVT	Segments designated	
Muskingum River Corridor	Coshocton, OH	Muskingum Watershed Conservancy	Designated	
Youghiogheny River	Allegheny and Westmoreland, PA	PVT	Proposed	"A" priority for inclusion in State Wild and Scenic River System

recreation area is primarily used for walking and hunting which will need to be suspended in the eastern part of the area during the construction phase and until revegetation occurs. The cutting of the principal access route to the north of the main area will limit visitation to the recreation area. Hunting may be curtailed during the construction period.

Big Bend State Conservation Area (Rock River Acquisition)

This is a new flood plain recreation area along the south bank of Rock River in Whiteside County, Illinois. The plans by the State call for the area to remain primarily in a natural state with hunting, hiking and similar activities featured. The pipeline is proposed to cut through 2,500 feet of closed canopy hardwood forest causing severe esthetic damage to the park. The construction phase of the project may result in either closing the park entirely until work is complete or severely reducing recreation activity especially hunting during that period. The construction impact at the river crossing may result in additional impacts because of a wider corridor, erosion of banks, and reduction of fishing potential.

Starved Rock State Nature Preserve and State Park

Located on the south side of the Illinois River, in La Salle County, Illinois, the park and preserve extends from the river, includes the bluffs that define the valley and extends a short distance into the flat lands out of the valley. The State of Illinois has recently acquired the parcel of land on the bluff that connects the Preserve and Park as an addition to the Nature preserve. The proposed route goes through this new acquisition. Esthetic damage to the park will be severe. A 4,000-foot long corridor of high quality bottomland and upland forest will be cut. Almost all of it is closed canopy hardwood forest. There will also be topographic impact on the face of the bluff. This is a steep and picturesque area that cannot be totally restored.

Human activity within the park during the construction phase will be reduced because of the noise and activity involved. Also the park will be essentially cut in half during this period which is expected to restrict some recreation activity. The construction will also temporarily result in reduced wildlife observation. In total, this park, which depends on mature forest, picturesque bluffs, and wildlife for its popularity, will have all three features badly damaged. The visitation of the park was over 600,000 in 1973. This can be expected to drop during the year of construction by perhaps one-third depending on the length of time construction takes, the time of year it occurs, and whether access to the park is restricted. For example, a 4- or 5-week period starting about July 4 and going into August would cut park visitation at the heaviest use time of the year, especially if road access is affected. The restoration period during the second year should not be a major deterrent to recreational activity within the park.

Matthiessen State Park

This park is adjacent to Starved Rock Park. The corner of the park crossed by the pipeline corridor has been used for cultivated crops in recent years. Most of the recreation activities are to the west of the pipeline crossing. Because of this, the impacts will be minor compared to Starved Rock. No wooded areas will be crossed within the park, nor will established recreation facilities be damaged. The impacts will primarily be the nearby disturbance resulting from construction and the limitation of use of the pipeline corridor after restoration. Unless access to the park will be hindered by the construction, it is unlikely that visitation to the park will be reduced.

Lake Shafer

Lake Shafer, on the Tippecanoe River, in Indiana, is a popular recreation area although no public recreation area exists along the Lake's shore. The major recreation activity is on the west side of the lake several miles south of the pipeline crossing. Impacts on recreation are expected to be limited to boaters who will not be able to use the extreme north end of the lake during pipeline construction. Muddy water may limit fishing in the construction area and make boating less desirable below the crossing for a mile or two.

Salamonie State Recreation Area

This area on the Salamonie River in Indiana is a Corps of Engineers project. The state has a 40-year lease to operate several major outdoor recreation areas on the reservoir. The pipeline crosses the lake at its extreme upper end in an area that gets very little recreation use. The crossing point is primarily a wildlife area which consists of open meadows and scattered stands of trees. Some boating occurs on this part of the lake, especially by fishermen. The impacts will be temporary, lasting basically through the construction phase. Vegetation will be removed along the corridor and wildlife will be disturbed during this period. Boating use of the river will be stopped at the crossing and muddy water conditions below the crossing may hinder fishing as well as the quality of the boating experience.

Delaware Reservoir State Park

Crossed by the pipeline at the upper end of the reservoir, this park in central Ohio is designated for wildlife use. area designated for wildlife use. The impacts on recreational activities should be minor at the reservoir. Some boating mostly by fishermen, exists in this part of the reservoir. Onshore, the wildlife area is the principal use of the land. The State has several test plots established. These are discussed in the Wildlife Section. However, some bird watching and hiking opportunities do exist. During the construction, boaters will not be permitted at the site and some muddy water may reduce activity below the construction area. The recreational activities in the crossing vicinity will be curtailed during construction.

Lake Clendening

Lake Clendening's boundaries will not be crossed by the pipeline but a semi-public adjacent area will experience severe, although short-term, impact. The reservoir is owned by the Muskingum Watershed Conservancy. The area to the south of the lake's boundary is owned by the Boy Scouts of America. Their land is mostly wooded and some of it was stripped years ago for coal. The scouts maintain the area as a natural area and as a result have been granted access and use of Lake Clendening by the Conservancy. Clendening itself will have its southern access limited for a period of time during construction. The scouts will have their access to the Lake cut and the corridor cut through the trees will cause esthetic damage. The extent of scout facilities in the corridor is not known but it is expected some trails will be cut and some camping areas may be destroyed. Both, however, will be generally temporary impacts.

Mingo Creek Park

Located in Washington County, Pennsylvania, this is a 2,500-acre county park that serves as a regional recreation area for the Pittsburgh Metropolitan Area. The pipeline crosses the northern part of the park through woods with scattered open areas. Some of the land to be crossed is designated as a nature area while, to the west, a group and auto camping area is located.

Mingo Creek is a new park and facilities are in various stages of development. However, 600,000 visits were recorded in 1973 so the impact of the pipeline may be significant. There will clearly be an esthetic impact from clear cutting a right-of-way. While this can be partially camouflaged by screening, the rolling topography makes it impossible for completely hiding the corridor from view. A creek is also crossed within the nature area of the park.• This crossing and the generally rolling terrain is expected to require more than the 100-foot wide right-of-way through much of the park. Other than esthetic impact, the construction operation will physically divide the park, damage some sites, and cause a general disturbance that will make the park much less desirable as a place to get away from the city. Most of these impacts will last one season although restoration can be expected to continue through a second season. Visitation at the park can be expected to experience at least a decline during the construction, and there is the possibility the park will need to be closed during the construction period. Should this step be needed, the recreation visits would either be diverted to other areas or not occur at all.

Round Hill Regional Park

This park lies south of Pittsburgh in Allegheny County and, like Mingo Creek, is large, 963 acres, and receives heavy use, 300,000 visitors in 1973. The pipeline crosses the park in an existing utility corridor for a distance of about a half mile. The major attraction at Round Hill is a working demonstration farm. The pipeline route crosses the farm, and while having only a season or two impact on esthetics at the farm, the disruption will greatly impair the activities in this part of the park for the construction period. If the farm is able to remain open to the public during pipeline construction, activities and visitation can be expected to drop drastically.

In addition to the existing park and recreation areas, 13 trails and waterways having outdoor recreation use or potential are crossed by the pipeline. Some basic information is presented in Table 3.1.3.13-2 for these features.

The impacts are mostly esthetic for all of these areas which have been discussed in Section 2.1.3.13. Visitation for recreation activity will probably be affected more at the Illinois and Michigan Canal State Park than at any of the other crossings. The impact here will largely depend on the construction procedure followed. Burrowing under the canal will result in less damage than cutting an open trench. At all of the areas, the cutting of trees will lessen the attractiveness of the trail or waterway. Screening may reduce this impact somewhat. Topography will determine how successful this technique will be.

River crossings will be critical on the Little Missouri, Wapsipinicon, Rock, Wabash, Muskingum, and Youghiogheny, which are all streams that have significant scenic qualities and have either been designated recreation waterways or are being considered for such a designation. The Illinois River at Starved Rock is another critical crossing. Erosion, inability to restore steep bluffs and the necessity to maintain an open corridor through forested areas will be the major impacts. Present recreation use will need to stop during construction but will return to original levels after construction is completed. The Little Missouri, which was recently designated a State scenic river, and Wapsipinicon Rivers both have such outstanding natural qualities that they may be made part of the National Wild and Scenic Rivers System. The pipeline will damage that possibility, especially at the Little Missouri crossing in North Dakota where badland topography will be permanently scarred. Another river, the Wabash, in Indiana is a candidate for a State recreation river system. Serious damage is expected at the crossing near Peru because of the presence of the highly erodible Miami silt loam terrace and the Crosby silt loam. To complicate this crossing problem, exposed bedrock will be encountered on the southeast bluff. These impacts plus cutting and maintaining an open corridor will harm the chances of this river, in this vicinity, being added to the Indiana system of rivers.

Esthetics

Section 2.1.3.13's discussion on esthetics concentrated on scenery, setting, and topography. Other sections of the EIS discuss the esthetic values of the presence of wildlife as well as the impact of noise and dust upon the environment.

The construction phase with its scattering of wildlife, noise, dust, and human activity will be mostly a short-lived disturbance. Esthetically, the most serious impacts will be the long-term effects such as long, straight cuts through timber stands many of which will occur at stream crossings. These cuts fragment the remaining timber land and reduce the attractiveness of the countryside. Frequently the larger areas of timber along the route are being utilized as recreation areas. The esthetic impact in these areas will be greater than in the more remote woods.

Although the applicant indicates that the topography on the construction corridor will be restored to its original contours wherever possible, there will be some areas where change in landscape contours will be clearly noticeable. Perhaps the two most sensitive areas are the breaks along Frenchman Creek in Montana and the North Dakota Badlands. The problem in these areas is soil instability that may prohibit restoration of the natural landscape. It is also likely that revegetation of these areas will be extremely difficult.

The situation in the Badlands is especially critical because the badland region is the site of the Theodore Roosevelt National Memorial Park and the Little Missouri River. Much of the Badland region has qualities that may eventually justify including additional land in the existing National Park. The Little Missouri may have such outstanding qualities that it may qualify as part of the national system of scenic and wild rivers. The State has made it the first selection of the State scenic river system. There is no doubt the pipeline will make the possibility less likely to happen by reducing the esthetic quality of the river and its valley.

Except for wooded areas already discussed, the greatest esthetic values are generally expected to occur at stream crossings where steep or picturesque bluffs occur. Two of the most significant are the Illinois

River at Starved Rock State Park and Nature Preserve in Illinois and the Wabash River in Indiana. The Wapsipinicon River in Iowa is another river with qualities of such significance that it may, like the Little Missouri River, qualify for the national system. The pipeline will cross it twice.

In addition to the areas named and river crossings, other areas were identified in the description in Section 2.1.3.13 as having special esthetic values. They include eastern Knox and western Coshocton Counties, Ohio, the Mingo Creek and Round Hill areas of Pennsylvania. Possum Hollow Run in Allegheny County, Pennsylvania, is another area that has a unique oak forest and scenic setting. No designation or protection is now in effect on this area. The hilly country of eastern Ohio, West Virginia, and western Pennsylvania provides the setting for one of the most picturesque countrysides in the Nation. Unfortunately much of this part of the Appalachian Plateau has been devastated by strip mining and industrial development. The major problem has been the historic tendency to give low priority to land use practices that would maintain the esthetic qualities of the region. Because of this, few areas within the region possess the natural landscape values they once had. The highly esthetic qualities of Knox and western Coshocton Counties, Ohio; the Mingo Creek and Round Hill areas of Pennsylvania were singled out as being relatively unspoiled areas within the region. Mining and industrialization have occurred mostly to the east of the Muskingum River in Ohio.

The impact upon the areas mentioned in the preceding paragraph will be the fragmentation of wooded areas and some permanent alteration of the topography. The construction phase of the project will result in disruption of these rural areas through destruction of vegetation, noise, smoke and dust, all of which are short-term. In certain areas, such as Mingo Creek and Round Hill Park, recreation activity will be restricted or discontinued during the construction period and be limited after construction during restoration of vegetation and facilities such as roads.

3.1.3.14 Air Quality

Gaseous Air Pollutants from Permanent Installations

The only permanent installations that will emit air pollutants along the proposed route are the 12 compressor stations listed in Table 3.1.3.14-1. All the compressors will be driven by 30,000- or 13,500-horsepower gas turbines and will burn natural gas supplied from the pipeline itself.

The principal air pollutant emitted by the compressor stations will be nitrogen oxides (NO_x). Emission rates of NO_x created as a combustion product from gas-fired turbines have been reported in recent publications (see references at end of this section). These rates are given in Table 3.1.3.14-2 along with rates of emission of other pollutants. It is appropriate to adopt an emission rate of 0.50 $lb_m NO_x/10^6$ Btu because this is the maximum rate observed for any gas turbine, and it allows a reasonable safety factor for turbine operation at loads where NO_x emissions are greater than the minimum. It should be noted that NO_x emission rates at 100-percent load are generally about 20 percent higher than at the load corresponding to the minimum NO_x emission rate.

The highest NO_x emission rate measured for any gas turbine corresponds to a concentration of 71 ppm (parts per million) of NO_x in the exhaust gas. When corrected to 15 percent O_2 in accordance with standards proposed by the U.S. Environmental Protection Agency, the highest observed NO_x emission rate is 130 ppm. This significantly exceeds the Federal standard of 55 ppm suggested for large gas turbines.

Table 3.1.3.14-1

Location of Compressor Stations Proposed for Installation Along the Northern Border Route

Compressor Stations	Location of Compressor Station Air Quality Control Region	AQCR No.
CS 2	Miles City	143
CS 4, 6	North Dakota	127
CS 8, 10	South Dakota	206
CS 12	Southwest Minnesota	133
-	Southeast Minnesota - Lacrosse	128
CS 14	North Central Iowa	089
CS 16	Northeast Iowa	088
-	Southeast Iowa	091
CS 18	Metropolitan Quad Cities	069
-	North Central Illinois	071
CS 20	Metropolitan Chicago	067
-	East Central Illinois	175
CS 22	Wabash Valley	084
-	Northeast Indiana	081
CS 24	Northwest Ohio	177
-	Metropolitan Columbus	176
-	Mansfield - Marion	175
-	Zanesville - Cambridge	183
-	Steubenville - Weirton - Wheeling	181
-	Southwest Pennsylvania	197

Table 3.1.3.14-2

Emissions of Air Pollutants from Gas Turbines

Published source	Pollutant	Average Emission Rates $lb_m/10^6$ Btu
Ref. 1	NO_x	0.399
	Hydrocarbons	0.041
	CO	0.111
	Particulates	0.014
	SO_x	
Ref. 2	NO_x	0.31
	Hydrocarbons	0.035
	CO	0.18
Ref. 3	NO_x	0.2

Pollutants other than NO_x will be emitted by the turbines in quantities that will produce only negligible impacts upon the environment. There will be intermittent emissions of natural gas from leaks, venting, and maintenance operations. These will contribute no impact. The quantities are relatively small and the gas is much less dense than air.

The behavior of NO_x emissions in the atmosphere can be estimated from the dispersion correlations compiled by the U.S. Environmental Protection Agency. Data on the atmospheric dispersion characteristics of areas that are representative of regions along the proposed route have been used to estimate the average ground-level concentrations of NO_x in the vicinity of compressor stations. The maximum NO_x level contributed by any compressor station is on the order of 2 μg/m³ at a point about 1 mile north of compressor station in Illinois.

Estimation of maximum NO_x levels that may be expected downwind of a compressor station can be achieved by using formula 3.3 of reference 5. With the dispersion coefficients given by

$$\sigma y = A \cdot x^{B}$$
$$\sigma z = A' . x^{B'}$$

the downwind distance at which the maximum pollutant level will be experienced is

$$x_{max} = 2B' \sqrt{\frac{(H^2) \cdot B'}{(A')^2 \cdot (B+B')}}$$

where H is the effective height of the emitting source, in meters. A "worst case" situation may be considered, assuming a location near Miles City, Montana, under winter conditions, with the assumption of an effective stack height of H = 20 m:

Most stable atmospheric condition, class F, L = 400 m	Most frequent atmospheric condition, class D, L = 1,400 m
x_{max} = 1,560 m	x_{max} = 588 m
(C_{NO_x}) max = 18 μg/m³	(C_{NO_x}) max = 10 μg/m³

where L = height of mixing layer

x_{max} = downwind distance at which maximum pollutant level is experienced, at ground level, and

(C_{NO_x}) max = concentration of NO_x at distance x_{max}.

This estimate is very sensitive to the value of the effective emission eight, H. If the effective stack height of emission release can be increased by 50 percent by means of imparting sufficient velocity to the exhaust gas, then these estimated concentrations are reduced to about 25 percent of the values given above.

This analysis shows that levels of NO_x may possibly contribute a significant fraction of the levels cited in the National Ambient Air Quality Standards for short periods. A similar analysis for other pollutants shows that there is no danger that other air pollutants will approach Federal or State standards.

Air Pollution of Sensitive Areas due to Construction Operations

The sensitive areas along the route, all of which have been identified in Section 2.1.3.14, are river crossings where the river valley is deep enough to trap emissions and create excursions of pollutant concentrations to unacceptable levels. These areas were identified by observers who flew over the length of the proposed route. The estimated petroleum fuel to be expended in construction for all river crossings along the route is 140,200 gallons of gasoline and 1,850,000 gallons of diesel fuel. The maximum expected hourly rate of fuel consumption is estimated to be 136 gallons of diesel fuel and 16 gallons of gasoline, during a given 10-hour working day.

Approximately 60 percent of this fuel requirement will be expended at the five river crossings identified in Section 2.1.3.14.

In order to estimate the impact of construction operations upon the local air quality, the following conditions are assumed:

1) average fuel economy 0.4 lb. fuel per bhp-hr

2) average NO_x emission rate 11.0 g per bhp-hr

3) most stable atmospheric condition (Pasquill class F),

4) wind speed 1.0 m/s, and

5) effective emission release height H = 3 m.

Under the conditions, the NO_x emission rate will be 0.725 gram per second. The maximum NO_x concentration at ground level will occur at a downwind distance of

$$x_{max} = 75.25 \text{ meters}$$

and this concentration will be about

$$(C_{NO_x})\ max = 2.26 \times 10^4\ \mu g/m^3.$$

This example illustrates the extreme case in which atmospheric conditions are the worst conceivable, and where all emissions are generated at a single point. Nevertheless the example shows that pollutant concentrations may reach serious levels if all factors combine to create the appropriate conditions.

Air Pollution of Nonsensitive Areas by Construction Operations

During construction operations along the proposed route a total consumption of 6.5 million gallons of gasoline and 14.3 million gallons of diesel fuel is anticipated. Combustion of this fuel is capable of generating about 8 million pounds of nitrogen oxides (NO_x) and about the same amount of carbon monoxide (CO). Generation of sulfur oxides (SO_x) will be about 0.4 million pounds, and of hydrocarbons about 1.2 million pounds. These figures are based on reported emission factors.

Even assuming the expected worst cases of atmospheric stability and clustering of emitting sources (vehicles), there is no likelihood that NO_x levels will exceed Federal or State standards for any period in excess of a few minutes. Such a pollution incident would require an unreasonable concentration of vehicles for an extended period under the most severe atmospheric conditions: for example, 10 construction vehicles of 10 bhp each, at a single point, under class F atmospheric stability, for 1 hour. This is an unlikely situation.

Fugitive dust is another possible source of air pollution that may result from construction operations. Dust emissions from pipeline construction operations are assumed to be roughly equivalent to emissions arising from highway construction operations. The accepted figure is 1.12 tons dust per acre per month. If a typical time of 4 weeks is assumed for any given site, and the active width of construction vehicle influence is taken as 40 feet, then the potential fugitive dust emission is

$$\begin{aligned} FDE &= (EF)\ (W)\ (T)/43{,}560 \\ &= (1.12)\ (40)\ (1)\ (5{,}280)\ /43{,}560 \\ &= 5.4 \text{ tons per pipeline-mile.} \end{aligned}$$

where
FDE = fugitive dust emission
EF = emission factor (tons/acre/month)
W = width of excavated right-of-way (ft)
T = time of operation (months).

Fugitive dust from vehicle travel over unpaved roads and the construction right-of-way is estimated by using an emission factor of 3.7 lb per vehicle-mile. The non-construction travel, including pipe delivery, equipment and machinery delivery, service travel and worker commuting, is estimated at four times the pipe delivery mileage as calculated earlier, resulting in a fugitive dust emission estimate of

$$\begin{aligned} FDE &= (3.7)\ (71{,}150 \text{ veh.-mile})\ /1{,}138 \text{ mi}/(2{,}000 \text{ lb/ton}) \\ &= 0.12 \text{ ton per pipeline-mile.} \end{aligned}$$

Therefore, the total fugitive dust emission is expected to be about 6 tons per route mile or less. This estimate is probably high because vehicle activity will not extend over the entire 4 weeks between clearing and backfilling that is now anticipated. Furthermore, loamy soils along most of the proposed route are of average dustiness or less. Only in the semi-arid western portions of the route are shales and clays encountered that are expected to be significantly dusty.

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3.1.3.15 Environmental Noise

Construction Phase

The construction phase will produce both indirect and direct noise impacts. The indirect noise impact will be due to the road traffic generated by the project and the direct impact will be the construction site noise. Figure 3.1.3.15-1 graphically illustrates the expected noise ranges for equipment which may be used on the project.

Road Traffic

The primary cause of noise impact due to road traffic will be heavy diesel trucks hauling construction equipment and pipe. Since most of the construction equipment will remain on the site, except when hauled around major waterway obstacles, the pipe hauling operation is estimated to create the largest impact. The storage areas, from which the pipe is to be hauled, have been located and service areas estimated. It appears that the storage areas have been well chosen to avoid major roadways and population centers. The majority of haul roads will be rural dirt roads where, even though the population density is low, the ambient noise levels are also very low so that audibility of the trucks will extend for long distances.

It is not possible to make a detailed estimate of the total noise exposure of the local populace to the hauling truck traffic. However, Table 3.1.3.15-1 lists some estimates which are relevant to assessing this exposure. That table shows the total number of truckloads, the average number per day, the average round trip mileage, and the total road mileage driven; it identifies the larger communities through which some of the pipe hauling equipment may pass (there are several alternative roads for the trucks so the specific routes cannot be identified) and the average number of people exposed in the rural area.

There will be several trips per hour on a normal workday. Using the tables provided in Section 2.1.3.10, the zone of audibility for these trucks is estimated to extend nearly 4,000 feet to either side of the road in these rural areas. The area encompassed in this zone will include residences where auditory cues of truck passage can reinforce annoyance about other factors, such as dust and road destruction, and can lead to complaints. Although the stockpiles are well located to avoid having trucks pass through most high population density areas, there is still some adverse noise impact. Because this impact is so diffuse, there are no existing noise measures that permit quantitative assessment of it. To get a qualitative result, the number of people in local communities subject to truck traffic and the number of people in rural areas also subjected were estimated to

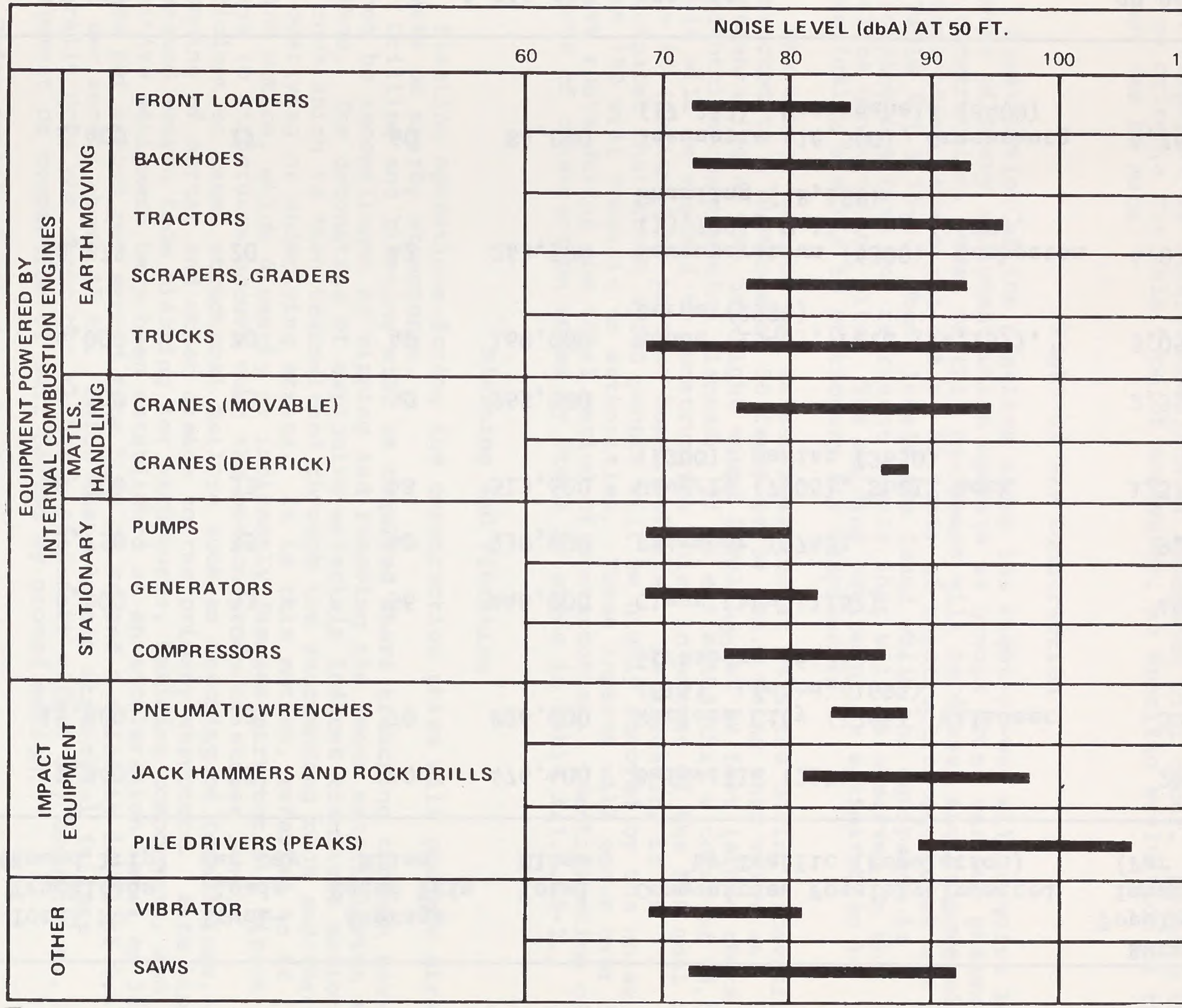

Figure 3.1.3.15-1 Construction equipment noise ranges

Table 3.1.3.15-1 Population Impacted By Pipe Hauling Trucks

State	Total No. Truckloads (Round Trip)	Truck-loads Per Day	Average Round Trip Miles	Total MIles	Communities Possibly Impacted by Traffic (Population)	Rural Population Impacted (Per Trip)
Montana	7,940	33	60	476,400	Bainville (217)	200
North Dakota	11,800	33	70	826,000	Watford City (1768), Killdeer (615), Linton (1695), Strasburg (642)	520
South Dakota	8,000	33	56	448,000	Clear Lake (1157)	400
Minnesota	5,750	33	40	230,000	Fairmont (9745)	925
Iowa	10,700	33	48	513,600	Waverly (7205), Shell Rock (1200), DeWitt (3650)	1,570
Illinois	5,300	25	50	265,000		2,550
Indiana	4,000	20	40	160,000	Monon (1548), Peru (14,139), Berne (2988)	3,050
Ohio, West Virginia	6,275	20	42	263,500	Newcomerstown (4300), Coshocton (13,700), Wellsburg (4600), Wheeling (48,188)	4,070
Pennsylvania	1,400	17	60	84,000	Jeannette (16,500), Greensburg (17,383), Monangehela (8400)	6,760
Total	61,165	--	--	3,266,500	159,640	20,045

average near 8,000 and 2,000 respectively per truckload. Thus, to average over the entire route, about 10,000 people will be in the zone of audibility for each round trip of a hauling truck. Since there will be about 60,000 total trips, it is likely some form of annoyance will occur. Because there are no criteria for this type of annoyance, no specific evaluation of the impact can be made.

Right-of-Way Construction

Construction of the pipeline along the right-of-way will require large numbers of heavy equipment which operate as groups doing various phases of the construction. Most of this equipment will be diesel engine powered. Typical noise levels (in dBA at 50 feet) of construction equipment are given in Table 3.1.3.15-2. These levels are found while the equipment is performing its task and represent levels that will be observed on the pipeline construction site. The welding equipment is estimated to be acoustically similar to stationary air compressors.

The energy mean of L_{eq} values measured at 24 sites during excavation (corrected to a distance of 50 feet) is 84 dBA. Using this value as representative of the day-night sound level L_{dn} at 50 feet (since there is no nighttime construction planned), it is estimated that a total of 13,000 people will be exposed to construction noise in excess of the EPA goal of L_{dn} = 55 (designed to protect human welfare). As a result, it is anticipated that about 4,200 people will be highly annoyed by the noise and about 180 will complain to authorities. These impacts will occur over the entire route during the total period of construction. Quantification of the impacts of construction noise by State is given in Table 3.1.3.15-2.

Blasting and Vibration

Blasting operations during the construction phase will produce direct impacts on nearby structures.

Drilling and blasting will be required where trenching through rock cannot be accomplished by ripping and removing the loose material with a backhoe. The detonation of explosive materials induces transient motion in the rock which is then transmitted through the surrounding rock and through any overlying or underlying strata. It is this motion, referred to as ground motion, which directly or indirectly damages structures. Direct damage to structures occurs when the motion produces stress levels sufficient to cause structural failure such as cracking of foundations, loosening of mortar and other damage to the primary structure. Safe limits of ground motion from blasting for structures, building components, and sensitive equipment have been established at an acceleration level of 38.6 inches per second per second from 5 to 15 Hz and a velocity level of 0.4 inch per second above 15 Hz. Below these levels structural failure generally does not occur but rather a secondary effect may occur; i.e., the settlement or compaction of soil caused by ground motion.

Under sustained vibratory loads or repeated impacts such as caused by blasting operations, the internal structure of soils may change, thereby producing settlement of surface or possibly a reduction in strength. It is well known that loose, saturated cohesionless soils are particularly susceptible to compaction by impacts or vibration.

For example, damage from traffic induced ground motion in medieval cathedrals of England and Wales has been investigated. Predominant cracking and settlement were reported within those structures located adjacent to

Table 3.1.3.15-2 Impact of Pipeline Construction Noise on People

State	Estimated number of people Residing within $L_{dn} > 55$ dB*	Estimated number of people who will be highly annoyed	Estimated number of complaints
Montana	49	20	1
North Dakota	156	54	2
South Dakota	304	96	4
Minnesota	697	234	10
Iowa	1,220	227	17
Illinois	913	330	18
Indiana	1,207	454	24
Ohio, West Virginia	5,217	1,692	66
Pennsylvania	3,285	1,156	40
Total	13,048	4,263	182

*A day-night sound level (L_{dn}) of 55 dB has been identified by the U.S. EPA as the maximum level permissible for protection of human welfare.

The correction factors for normalizing L_{dn} cancel out.

roads even though the ground motion levels were substantially below those specified above as safe limits.

Blasting at river crossings will have a fatal effect on any nearby aquatic animals.

Examination of the proposed route reveals the following areas where blasting may occur:

Iowa

The proposed route crosses the Shell Rock River about 2 miles west of Janeville and then crosses the Cedar River about 1 mile south of Janeville. There are several structures, probably residences, that may be about 500 feet from the potential blasting area. The proposed route also crosses the Wapsipinicon River but there appears to be no nearby structures.

Illinois

The proposed route crosses the Illinois River about 1 mile southwest of North Utica.

Indiana

Blasting of bedrock is anticipated at the east exit from the Wabash Valley near Mill Creek in Wabash County. The applicant estimates that the drilling and blasting will extend for about one-third of a mile through the resistant Liston Creek Limestone. The nearest structure appears to be about 2,000 feet from the blasting area.

Ohio

Blasting may be required for instream trenching along the majority of the proposed route through the Appalachian Plateau.

West Virginia/Pennsylvania

The majority of the route through West Virginia and Pennsylvania will be constructed through bedrock and blasting may be required for instream trenching. This section of the proposed route passes through or near many populated areas, thus, blasting operations will impact many structures some of which are old and susceptible to ground motion damage.

Ground vibration caused by construction equipment and hauling trucks are estimated to be sufficiently small at any vibration-sensitive buildings that no adverse impact can be identified. See Section 3.1.3.2 for the effects of blasting and vibration on creating rockfalls and landslides.

Compressor Station Construction

Construction of the compressor stations entails only small amounts of grading; most of the activity will be hauling of materials and construction of the buildings. Those activities should be of short duration and spread out over several months, starting with clearing the site to installing the compressors. Because of the low population density at rural locations, very few complaints, if any, are expected, and no legal action against the applicant related to noise is expected.

Operation Phase

Compressor Stations

The major potential noise sources of significance during the operational phase of the project are the compressor stations, which will be long-term, continuous, and fixed noise sources.

Table 3.1.3.15-3 shows the estimated impact of gas compressor station noise emissions on people residing nearby. A total of 920 people are estimated to reside within an area impacted by compressor station noise in excess of the U.S. EPA goal for welfare. It is further estimated that 280 people will be highly annoyed, and 16 will complain.

Blowdown

Periodic venting of high pressure gas from the compressor stations or along the line will cause temporary but severe increases in sound level as shown in the table below. These blowdowns will occur because of an emergency or as a part of maintenance check or repairs. Blowdown of a compressor, or a pipeline section ending at a compressor station (unit blowdown) will occur at the station. Blowdown of a pipeline section will occur at each end of the section.

Distance	Station Blowdown*		
(ft.)	16" Valve Vent	10" Valve Vent	Unit Blowdown
100	115 dBA	113 dBA	108 dBA
300	105 dBA	104 dBA	98 dBA
1,000	94 dBA	93 dBA	87 dBA
3,000	84 dBA	82 dBA	75 dBA

*No silencing measures taken.

The maximum noise is estimated to occur over about 45 minutes for the pipeline and 5 minutes for the compressor. Planned station blowdowns are expected to occur about once per year.

Based on this data, ambient levels, and the approximate attenuation data given in Section 2.1.3.15, the noise level from such a blowdown is estimated to be near 70 dBA at 3 miles. Because of its relatively short duration and infrequent occurrence, it will cause annoyance but may not result in complaints to authorities.

References

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Table 3.1.3.15-3 Impact of Gas Compressor Station Noise on People

Station #	# hp	State	Estimated # of People Impacted by a Normalized L_{dn} >55 dB*	Estimated # of People Highly Annoyed	Estimated # of Complaints
2	30,000	Montana	6	2	0
4	30,000	N. Dakota	3	1	0
6	30,000	N. Dakota	8	2	0
8	30,000	S. Dakota	0	0	0
10	30,000	S. Dakota	21	8	1
12	30,000	Minnesota	34	10	1
14	30,000	Iowa	33	9	0
16	30,000	Iowa	33	8	0
18	30,000	Illinois	34	9	1
20	13,500	Illinois	21	7	0
22	13,500	Indiana	256	100	8
24	13,500	Ohio	471	124	5
Total			920	280	16

* A day-night sound level (L_{dn}) of 55 dB has been identified by the U.S. EPA as the maximum level permissible for protection of human welfare. L_{dn} has been normalized to correct for quiet, rural communities (10 dB) and for no prior experience with the noise (5 dB).

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3.1.3.16 Hazards from Pipe Failure

The possibility of loss and damage due to pipe rupture is discussed in the Overview Volume.

4 MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

4.1 ARCTIC GAS PIPELINE PROJECT

4.1.3 Northern Border Pipeline

Introduction

In this section, mitigating and/or environmental control measures proposed by the applicant are discussed and conclusions as to their effect are stated. Additional mitigating geotechnical or environmental control measures not proposed by the applicant, but which, if applied, could significantly reduce adverse environmental effects are also discussed.

4.1.3.1 Mitigating Measures and Monitoring of Construction and Operation of the Project as Proposed by Applicant

The applicant states that the route and system facilities as proposed include measures which were undertaken to enhance the environment or to eliminate, avoid or mitigate the adverse environmental effects of the proposed action.

According to the applicant, measures considered included route selection, design concepts and construction, restoration and maintenance procedures. Route selection was the principal action taken to eliminate, avoid or mitigate adverse impact on the environment. The proposed route was selected after full consideration was given to environmental, engineering and economic factors. The selected route was refined to avoid critical areas and further adjusted to be consistent with local environmental features within the ten state area.

The proposed route described in Section 1.1.3 is considered by the applicant to be a generalized route, which will be subject to change prior to actual commencement of construction. The final route or alignment will be selected in the field and will take into account minor deviations which result from right-of-way easement acquisition, local terrain features and alterations in land use patterns between the initial planning and the onset of construction.

The applicant states that selection of the final right-of-way will incorporate the environmental constraints used in the selection of the generalized route. These entail minimizing the interaction of the pipeline and associated facilities with highly erodible slopes, soils and coulees, woodlots, wetlands and potholes and preserving the local esthetic values particularly at stream and river crossings and in areas where the right-of-way is highly visible. Construction specifications are being developed which will further minimize the environmental impact during construction and will comply with all statutory requirements including the <u>Code of Federal Regulations</u> Title 18, Section 2.69; "Guidelines to be Followed by Natural Gas Pipeline Companies in the Planning, Locating, Clearing and Maintenance of Rights-of-Way and Construction of Aboveground Facilities."

<u>Evaluation</u>: Detailed, site specific, plans for pipeline and facility location, construction design and procedures and rehabilitation measures and techniques are the most important factors in controlling environmental impact. Many potentially significant impacts can be avoided or minimized if the planners have a thorough knowledge of the local situation and technical knowledge of the resources involved. To be most effective, detailed construction-rehabilitation plans should be developed by or in consultation

with an interdisciplinary team with firsthand knowledge of local conditions. The team should include subject matter specialists for each major resource category involved, representatives of the landowner or administrator in the case of public lands, representatives of agencies with responsibilities related to the project and representatives of the public-at-large. The planning program proposed by the applicant is inadequate when measured by this standard.

Areas of concern which are to be monitored include:

1) Flow, pressure, and temperature at compressor stations;

2) Gas accumulations or fire in buildings;

3) Pipeline route:

   a) Pipeline exposure by erosion,

   b) Pipeline mechanical damage,

   c) Changes in population density,

   d) Right-of-way encroachments;

4) Damage by corrosion;

5) Compliance with construction specifications; and

6) Development of landslides, rockslides, and mudflows.

<u>Proposed Monitoring Procedures</u>

Supervisory controls and data acquisition for the pipeline will be accomplished through the use of in-line sensors for the monitoring of flow, pressure, and temperature. The control of each compressor unit can be controlled locally and from a remote dispatch center via the communication system. Within the confines of the console located at each of the compressor stations, the unit will be under the primary control of the discharge pressure controller which will cause the compressor unit to speed up or slow down to maintain a predetermined discharge pressure set point. Override controls on high discharge pressure will limit the discharge pressure controllers to prevent overpressuring the pipeline. Low suction and high temperature controls will be provided for the protection of the compressor station. The local console will also monitor numerous compressor and station functions to prevent damage to equipment. Pipe specifications will meet or exceed "American Petroleum Institute Specifications for High-Test Pipe" and/or "API Specifications for Spiral-Weld Pipe."

<u>Evaluation</u>: The proposed flow, pressure, and temperature monitoring procedures are considered adequate but the indicated design criteria that readings will be measured against are not sufficiently specific to assure that control settings provide adequate safety margins. Actual internal and external stress tolerances of the pipe and welds should be determined and the control mechanisms set well within known tolerances. Accurate information on external stress tolerance of the pipe is needed for effective monitoring of external forces of a seismic nature or from local soil movement. Monitoring of gas composition and contamination, the permissible ranges for each, and procedures to be employed to correct "out of specification" conditions are not covered.

Gas Accumulations

Gas accumulations in a closed or unvented structure will present a potentially hazardous condition. System buildings containing gas transmission facilities (such as compressor buildings) will be equipped with gas detectors with appropriate lights and alarms to alert personnel to the hazardous condition. This would be considered an emergency condition and all appropriate actions specified in the emergency procedures would be initiated. (These procedures will be prepared by the applicant in conjunction with the final design.)

Evaluation: Proposed gas accumulation monitoring measures are considered adequate. Control monitoring and the communication system should be submitted as part of the final design.

Route Surveillance

Periodic aerial surveys will be made of the line to check for activities which might encroach on the right-of-way. In addition, over-the-ground inspections will be made at least on a semiannual basis. These surveys will identify potential pipeline exposure and mechanical damage to the right-of-way and other activities that might constitute a safety hazard. The pipeline route will be checked annually for changes in population density and encroachments. Should human occupancy patterns change, a study will be immediately undertaken to confirm or revise the pipeline's maximum allowable operating pressure in accordance with 49 CFR 192.609, .611 and .613.

Evaluation: The severity of potential hazards associated with pipeline system failure makes monitoring a critical activity that should be conducted rigorously.

The proposed procedures for making personal inspections from the air and from the ground are considered sufficient if flights are avoided over wetlands during waterfowl concentration. Stream crossing profiles should be on hand and areas of highly erodible soils and other potential hazard areas should be identified on an inspection map. Seismic instrumentation should be installed in areas of known seismic activity. The sites should also be noted on inspection maps. A checklist and log of specific observations should be maintained.

Corrosion Control

The pipeline will be monitored for corrosion control. Corrosion protection equipment will be inspected at intervals of not more than 2 months and a permanent record of operational data will be made in accordance with 49 CFR 192.465.

Annual surveys will be made to take pipe-to-soil potential readings and to record influences of foreign pipeline or cable crossings.

Whenever any portion of the pipeline is exposed or cut for any reason, the pipe will be inspected for active internal and external corrosion.

Evaluation: The corrosion monitoring measures proposed by the applicant are adequate but should be part of an overall system corrosion protection plan.

Compliance with Specifications

The applicant will ensure compliance with the specifications by the individual contractors through rigid inspections during construction.

Evaluation: Proposed measures are considered adequate.

Mitigating Measures during Construction and Operation of Project as Proposed by the Applicant

Construction

Clearing and Grading

The applicant states that only minimum right-of-way will be cleared and grading of the right-of-way kept to a minimum in order to preserve and maintain as much of the rootstock of natural vegetation as possible. Trees and saplings not in the trench area will be removed in such a manner as to prevent undue disturbance of the soil mantle or recontouring of the natural ground level. Where stump removal is required, the disturbed area will be stabilized.

Operations will be conducted in such a manner as to minimize the introduction of timber or debris into any body of water.

Clearing operations will be scheduled to minimize the time interval between clearing and the actual construction. The interval between clearing and backfilling will be held to less than 4 weeks whenever possible.

Existing fences will be maintained during construction and will be restored to at least their original condition after construction.

Stringing

The stringing of the pipe consists of unloading pipe transported to the jobsite and placing it along the trench site in a more or less continuous line. Gaps to permit passage of farm stock, equipment and local traffic across the right-of-way will be left as the pipe is strung.

Trenching

The trench will be open an average of 10 days. In areas where open excavation is subject to rapid erosion, it may be necessary to alter the normal construction sequence. One procedure which can be used is to have the pipe sections welded prior to excavation and ready for lowering immediately after ditch excavation.

Gates installed in existing fences will limit access to the area of construction and open ditch. Gaps in the ditch excavation will be left at intervals to provide for movement of farm animals, equipment, and local traffic. Farmers and ranchers may be requested to move livestock to other pasture, if possible, for the duration of construction to protect the livestock from injury. If necessary, watchmen will be assigned to patrol the area during off-hours of construction to prevent access to the ditch by children and livestock.

When required by the individual landowner, the topsoil will be removed by the double trenching method, conserved during construction, protected against loss due to erosion and upon completion of backfilling, the topsoil is properly replaced over the graded or excavated areas.

Excavated material such as rock which is unsuitable for backfilling operations will be disposed of in a manner that is satisfactory to the landowner and in accordance with applicable regulations.

Water will be removed from trenches in high ground-water areas by various methods depending upon the circumstances. In soils with high permeability, sand pointing will be employed. This consists of a series of perforated pipes placed parallel to the trench, which, when pumped, lower the ground-water level and eliminate infiltration. In some other cases, water removal will consist of removal by a portable pump whose intake is within the trench. The intake would be adjusted so that it is located off the trench bottom so as to avoid pumping sediments. Pumping rates will be controlled to minimize entrainment of sediment.

Sedimentation from trench dewatering operations will be controlled by discharging the water into settling ponds constructed within the right-of-way or by filtration. Discharge from these facilities will be to an area of continuous ground cover or a watercourse at a velocity low enough to prevent erosion or stream scour. Where discharge is made into a dry stream, the rate will not be greater than the flow experienced during normal flow periods. Discharge by spraying may be used in cases where discharge to a stream is impractical and a suitable discharge area exists.

Trenching operations through watercourses will be carefully planned to make the final trench cut just prior to pipelaying operations. The flow will be maintained at all canal and stream crossings.

Tile drains and drainage ditches will be restored as soon as possible after pipelaying to prevent adverse effects on farming and productivity of lands adjacent to the pipeline.

Backfilling

Where required by the landowner, the topsoil removed by double trenching will be replaced in the upper part of the trench and across the disturbed right-of-way.

The trench backfill will be solidly compacted at crossings of terraces and levees and at crossings of streams and ditches to minimize erosion.

The right-of-way will be graded to conform to the adjoining area except for the slight crown of soil that normally is formed to compensate for natural subsidence of the backfill.

Trees and other vegetation cleared from the right-of-way will be disposed of in compliance with 18 CFR, Section 2.69. This will be done without undue delay and, as required by laws and regulations, with appropriate measures for the prevention of fires and other hazards. Merchantable material can be cut as firewood, pulpwood or other use in logs of standard size or it may be used by the contractor for construction purposes. The brush and branches and stumps can be piled in selected spots along the right-of-way where it is deemed desirable by the company to provide additional wildlife cover. Brush and slashings can be used as mulch where required in right-of-way restoration.

Unless specified otherwise, all unmerchantable timber and all treetops, trimmings, slash, stumps and brush will be burned to ashes or removed from the right-of-way for disposal in an approved landfill site. The debris will not be pushed off the right-of-way into adjacent timber and it will not be mixed with piles of earth from grading.

Cleanup

Excess spoil material will be used to construct erosion control structures and build check dams and bank stabilization structures where required. The remaining spoil will be spread along the right-of-way.

Excavated material, such as rock, which is unsuitable for backfilling operations will be disposed of in a manner that is satisfactory to the landowner and in accordance with applicable regulations.

All scrap material and other construction debris will be removed from the right-of-way and (1) removed for reuse, (2) recovered for recycling, or (3) disposed of in an approved landfill site. The disposal methods and sites will be determined by the applicant's agent through contact with commerical disposal areas, appropriate authorities of the county, State, and Federal governments and private landowners.

Evaluation: The five aforementioned construction mitigating measures as proposed by the applicant are inadequate or insufficiently described to assure that potential construction impacts would be held to a practical minimum. The range of potential impacts between a best case interpretation of the proposed measures and a worst case interpretation is of very significant magnitude. These kinds of measures need to be incorporated in site specific construction-rehabilitation plans as explained in the evaulation of proposed construction specifications at the beginning of the section.

Hydrostatic Testing

A test plan is required to determine the actual amount of water to be used. This plan will determine the changes in elevation along the pipeline so that testing may be carried out within the parameters set forth by the company. Differences in elevation require the pipeline be divided into intermediate sections (approximately 20 miles each) so that excessive internal pressures will not be induced in the pipeline and conversely, so that the required test pressure is achieved. Following completion of testing, the water is moved from section to section as required to complete testing of that length of line between water sources.

As a part of the test plan, a survey will be made to determine sources of water sufficient to conduct the testing. The principal sources of water to be used in the testing would be the major streams crossed by the pipeline. Specific sources have not been identified.

Water withdrawals will be controlled to prevent any significant changes in water level and/or waterflow. Water withdrawals and discharges will be done in accordance with all applicable regulations. Where possible, water withdrawals from flowing streams will be limited to approximately 10 percent of the streamflow rate and the drawdown from standing bodies of water will be controlled to prevent a significant impact.

The discharge rate can be controlled by prohibiting open end draining of the pipeline. Discharge can be controlled through flow control reservoirs, where appropriate. If discharge is made to a dry waterway (i.e., intermittent stream), the discharge rate will be no greater than the flow experienced during normal flow periods.

Specific water withdrawal and discharge procedures will be included in the preliminary construction specifications currently being prepared.

Evaluation: Water withdrawals and discharges are critical environmental factors in the hydrostatic testing program. The proposed mitigating measures are considered adequate if they are incorporated in the construction specifications in terms of specific withdrawal and discharge rates calculated for each stream or lake involved and specific energy dissipating devices, such as baffles, at discharge points to avoid scouring.

Stream and Major River Crossings

Construction procedures ensure that all stream crossing impacts are minimized as much as is practical. To minimize the time required for the stream crossing, the right-of-way is prepared on either side of the stream prior to the construction of the crossing. Stream crossings are located so that the crossing is perpendicular to the flow and at a location where shear forces are minimal. Temporary erosion control measures are employed any time construction is curtailed for an appreciable length of time. Flow is maintained during the crossing of streams and irrigation canals. The pipeline is laid beneath the scour depth of the streams to prevent subsequent exposure.

The temporary storage of excavated material outside of areas of narrow flood plain forest to limit the clearing of productive flood plain and riparian vegetation will be considered based on the adverse and beneficial environmental effects and economic factors for those cases where significant flood plain vegetation occurs and the streambeds cannot be used for storage of spoil. The requirements for work space at stream crossings are primarily determined by the spatial requirement for fabrication of the length of pipe used in the crossing and not by the needs for spoil disposal. The stream crossing sites have been carefully located to minimize cutting of riparian vegetation. On streams with flood plain forests, where feasible, the construction site and spoil disposal sites will be located beyond the tree line. Areas where tree cutting cannot be avoided will be replanted so that only a minimum width of right-of-way will remain cleared.

Evaluation: Potential environmental impacts associated with pipeline construction across streams are critical. Crossing sites and construction methods should be selected and made part of detailed construction-rehabilitation plans after thorough evaluation of alternatives.

The measures proposed by the applicant do not, by themselves, assure that environmental impacts will be minimized.

Maintenance of Water Quality

Care will be taken to minimize the dumping of timber, debris, and various wastes into watercourses. Pumping water from the pipe trench may be controlled so that the flow rate is sufficiently low to avoid excessive turbidity and the resultant coverage of benthic organisms. Chemical treatment may be applied to soils removed in strip mine lands to reduce the excess acidity that would otherwise be introduced into bodies of water.

Evaluation: Proposed measures are insufficient to assure minimization of impacts. See Section 4.1.3.4, Water Quality, for elaboration.

Noise Abatement

The applicant states that prior to construction, background noise surveys will be made at compressor station sites as may be required. Noise data will be used in the design and layout of the facilities and noise attenuation measures will be incorporated into the facility in terms of both hardware and building construction techniques to reduce the facility noise to acceptable levels at the boundary line of the site.

In addition, he states that a short term highly localized deterioration in noise quality will also occur during the construction phase of the route in the vicinity of the construction spreads. During the operational phase, elevated noise levels will be associated with the compressor stations. The reduction of noise levels is one of the criteria incorporated in the engineering design of the compressor stations and noise levels will be controlled to meet all applicable regulations.

Evaluation: Noise abatement measures proposed by the applicant should be included in construction-rehabilitation plans. They are insufficient, by themselves, to assure minimization of noise impacts. See Section 4.1.3.4 (Environmental Noise, Noise Research and Monitoring) for discussion of specific noise abatement measures.

Solid Waste

The applicant states that all solid wastes generated during the construction and operation phase will be disposed of in accordance with applicable regulations.

See the discussion in Cleanup (above) regarding disposal of scrap material and construction debris.

Evaluation: A site specific solid waste disposal plan is needed to assure minimizing impacts from this source. See Section 4.1.3.4 (Water Resources and Land Use).

Operations

The applicant states that the system will be operated and maintained in accordance with established Federal regulations, principally those set forth in 49 CFR 192 of the Materials Transportation Board Operations.

An operations and maintenance manual detailing operation and maintenance procedures will be prepared prior to initial operation by the Northern Border Pipeline Company and will include tests, inspections, and procedures to ensure that facilities and equipment are maintained in a safe and reliable manner.

Operation and maintenance plans and schedules will be implemented to monitor and ensure safe operation. Markers will be installed to properly locate and identify the pipeline system. Any required repairs to the pipe will be made promptly or, if necessary, the pipe will be replaced. In making repairs, all safety precautions will be observed. Any time the line is cut, the internal surface will be inspected for evidence of internal corrosion.

The right-of-way will be maintained to ensure reasonable access. Access to valve locations will also be maintained. In most cases, the right-of-way will be returned to its previous use. In areas where the right-of-way travels through forested land, an easement will be maintained as grassland.

Maintenance of a grass-covered right-of-way can be accomplished by mechanical methods and/or use of herbicides. Mechanical clearing consists of the use of brush cutters and powersaws at intervals of about 2 to 3 years. The alternative to mechanical methods consists of application of herbicides. The chemical is selected to control specific types of undesirable vegetation and must be applied at times when vegetation is sensitive. A large variety of herbicides are available and their selection and use will be in accordance with manufacturers' recommendations and applicable regulations. The use of herbicides consists of an initial broadcast application with local application during future years. In nonwooded areas, the desirable cover may be maintained by occasional selective spraying.

Combustible and hazardous materials will be stored and handled in the manner prescribed by applicable codes and regulations.

Pertinent records will be maintained at district and division offices. These will include records of necessary operational data, pipeline surveillance, corrosion inspection, leaks and breaks, and any routine or unusual inspections. Adequate records will be maintained so that the history of the system will be available for study.

The land acquired for block valves, microwave towers and compressor stations will be maintained as will the private access roads associated with these structures. Although compressor stations are scheduled to be fully automated, the stations will require water supply and sanitary waste disposal facilities. In most cases, these needs will be met by the development of an independent water supply and waste disposal system in accordance with local and State sanitary regulations.

Design and construction criteria will be incorporated to enhance the system's ability to withstand possible natural phenomena and accidents. Concrete coating and/or pipe weights will be utilized to negate the effect of possible inundation. Several areas of possible subsidence of slides which were revealed by the environmental studies were considered.

<u>Evaluation</u>: Comments pertaining to site specific plans included in the evaluation of monitoring and construction measures apply to the applicant's proposed mitigating measures associated with project operation.

4.1.3.2 Restoration and Enhancement as Proposed by Applicant

Adoption of CFR Title 18 Guidelines

The applicant states that the guidelines set forth in the Code of Federal Regulations, Title 18, Section 2.69 will be followed. Relevant portions of such guidelines will be issued to personnel of applicant and personnel of all contractors and other organizations who will be involved in the construction of the facilities proposed by the applicant. All such personnel will receive instructions in measures to be carried out to protect the environment. These instructions will include familiarization with guidelines and directions that the guidelines must be followed.

Evaluation: CFR, Title 18 was written as a general guide for planning, locating, clearing and maintaining natural gas pipeline rights-of-way and for construction of associated above-ground facilities. The recommendations contained in the document provide useful guidance for planning. However, because it lacks specificity and implementation of the recomendations is conditional, it is insufficient as the sole criterion for planning and inadequate as the mitigation standard.

Detailed Plans

The applicant states that construction specifications are being developed that will include special consideration of the following:

- Operations off the right-of-way
- Associated utilities
- Tile fields
- Trench dewatering
- Topsoil conservation in tillable areas
- Erosion and sedimentation
- Irrigated land
- Recontouring
- Areas with special features
- Watercourses, terraces, and levees
- Stream and minor river crossings
- Cleanup and restoration

Evaluation: The evaluation of proposed mitigating measures associated with monitoring and construction presented in Section 4.1.3.1 apply to the above proposal for rehabilitation planning.

Specific Measures

The applicant proposes to apply a number of specific measures "when appropriate" or "where required" to avoid or reduce environmental impact on particular resource values. The measures proposed are considered sound practices that could be expected to produce the desired results in selected applications. Their effectiveness, however, is dependent upon appropriate application, i.e. to minimize impact, the best measure must be applied to each potential impact problem. The effectiveness of specific measures can be evaluated only on the basis of their inclusion in a detailed site specific construction and/or rehabilitation plan as discussed above.

Some of the specific measures proposed by the applicant that are related to the more significant potential impacts and have fairly general applicability are discussed below.

Preservation of Topsoil

The applicant has stated that when required by the landowners, topsoil will be removed by double trenching, conserved during construction, protected against possible loss due to erosion and, upon completion of backfilling, the topsoil will be properly replaced over the graded or excavated areas.

Evaluation: Storage and replacement of topsoil in the manner proposed is considered the most vital single factor in restoring vegetation and reducing soil erosion, water and air pollution and losses of productive potential. However, limiting the application of this practice to areas where landowners specifically require it does not assure minimizing the adverse effects of soil disturbance associated with pipeline construction. (See Section 3.1.3.4 for description of impacts associated with topsoil contamination.)

Cultivation of Soil Compacted by Construction Equipment

The applicant states that disking, harrowing, or subsoiling where required will ensure that the underlying compaction caused by construction is broken up.

Evaluation: Disking, harrowing, or subsoiling can be effective in alleviating compaction in certain situations. The impact of the soil treatment measure on the existing vegetation is a factor to consider in deciding which, if any, of these measures should be applied to a specific site.

These measures will not correct conditions related to surface disposal of clay subsoil excavated from the trench.

Revegetation

The applicant states the revegetation of the right-of-way is an inseparable part of the project and proposes to use the various methods discussed below, where applicable.

Rangelands will be restored as rangelands and revegetation of the grass cover on the right-of-way will be done with native grasses. Revegetation may be beset by such problems as alkalinity, aridity and erosion which can be mitigated by leaching, mulching, revegetation and protection from grazing during establishment of cover.

Flood plains will be revegetated with a grass cover. Where applicable, this grass cover will consist of native species and, in those areas, where flood plains support shrubs or trees, woody species will be permitted to regenerate on all of the right-of-way except the permanently grass-covered part. Flood plains are favorable sites for restoration due to alluvial soils and available moisture. However, special precautions are required in relation to high water tables, flood and scour potentials. Special features, such as dikes and spurs, will be utilized where it is necessary to protect against scour. Drainage may be necessary to revegetate affected wet areas.

In woodlands, the right-of-way will be revegetated with a grass cover. This grass cover will be maintained on 40 feet of the right-of-way while the marginal areas which have a combined width of 60 feet will be permitted to return to shrubs and trees. Provisions for screen plantings to avoid long-tunnel views will be required where present esthetic values dictate a need for special mitigative measures.

Revegetation with woody cover can be accomplished by removing existing cover in such a way that it can be replanted; natural regeneration; or artificially establishing woody species. The first method can be applied where it involves small trees and shrubs in shelterbelts, hedgerows, plantation and along streams. The second form of revegetation relies on the natural processes and will generally pertain to the temporary part of the right-of-way on which the trees will have been cut with the stumps flush at ground level. In this area, root suckers, shoots and seedling sprouts will establish naturally in addition to regeneration from adjacent seed trees. The third approach involves the planting of nursery-grown seedlings and is reserved only for special situations.

No special restoration techniques are required for brushy areas. Brushy areas would be restored in areas of high wildlife value. Special shrub plantings may require replacement but, in general, restoration will be accomplished by natural succession. Herbicides will not be applied in areas to be restored as brush.

Streambanks may have to be protected by sandbags or properly riprapped with other suitable material. Where possible, the riprap will be covered with soil material and properly seeded. The restoration of these sites is a highly specialized subject and details will be in accordance with permits and the requirements of respective local, State, and Federal agencies.

Insecticides will not be used in the restoration and/or maintenance of the proposed right-of-way.

Limited amounts of herbicides such as 2,4-D or 2,4,5-T will be used, if needed, to combat weeds at the time of right-of-way restoration and, possibly later, to maintain the grass-covered section of the right-of-way. The type of herbicide will be selected as required and applied in accordance with manufacturers' recommendations and applicable regulations. Annual applications of 2,4-D or 2,4,5-T may be required on western rangelands until a permanent cover of native grass becomes a biological method of weed control. Less frequent application will be necessary in the eastern section of the line.

Fertilization will be required for right-of-way restoration. The type and quantities of fertilizers will depend mostly on local conditions, the deficiencies of the soils, and the problems encountered in revegetation. These materials will consist of various forms of nitrogen, phosphorous, or potash and can be applied by broadcasting dry or spraying, using surface apparatus or aircraft.

Critical areas in barren lands and rangelands may require the use of chemical stabilizers to control erosion in preparation for revegetation. The chemical stabilizers will consist of asphaltic materials. This asphalt will anchor a mulch of hay or straw on slopes and embankments. These materials include SS-1 emulsion and RC-1 cutback asphalt and will be applied in accordance with Federal specifications SS-A-674 and SS-A-671, respectively. The stabilizers will be applied by a hand operated boom that applies the asphalt onto the mulch. Depending upon wind velocities and degree of slope, rates of application will range from 3 to 13 gallons per 1,000 feet.

The SS-1 (slow setting) consists of oil, water, and soaps, while the RC-1 (rapid curing) is naphtha and/or fuel oil, water, and soaps. The SS-1 has more water than the RC. These materials will be effective for one growing season in humid areas.

Evaluation: The revegetation measures proposed by the applicant on grasslands, if properly applied in the places where they are the best suited measures, would result in the establishment of satisfactory vegetative cover within the limits of site potential. However, measures proposed for woodlands are considered inadequate. The criteria proposed for their application are not sufficiently explicit to assure effective revegetation. Such measures must be incorporated in a revegetation plan tailored to each site to assure successful revegetation and should include soil stabilization procedures to effect erosion control measures to the maximum practical extent. The plan should involve local expertise such as cited in Section 4.1.3.1.

Restoration of Streambeds and Banks

The applicant states:

> ...stream crossings are located such that the crossing is perpendicular to the flow and at locations where shear forces are minimal... The pipeline is laid beneath the scour depth of the streams to prevent subsequent exposure. ...streambeds are restored to as near their former elevations and grades as practicable... Following completion of the grading operation, the banks of all streams are stabilized and may be riprapped with suitable material and seeded to prevent subsequent erosion. The streambanks are replanted with shrubbery, where necessary, to preserve the shading characteristics of the watercourse and the esthetic nature of the streambanks. The additional work space required at major river crossings is revegetation and allowed to return to preexisting conditions once the crossing is complete.
>
> On streams and minor river crossings, there are two basic approaches to bank erosion control, the choice of which depends on the slope of the banks involved, the waterflow and soil conditions. One approach can be described as a 'revetment' which consists of a footing built below water level, using a cofferdam and, from this footing, building a 'riprap' layer of rock or sacks filled with concrete-earth mixture, up to water level, two layers thick. From water level, this 'riprap' method is continued up the remaining slope or bank of stream one layer thick.
>
> Another method used in erosion control of streams and minor rivers is a 'retaining wall.' This method is simply a concrete, rock or timber wall built from below water level to a point above the high water level. The land side of the retaining wall is 'riprapped' to finish the installation. This method is generally used only on small streams.

Evaluation: The proposed measures should be included, where applicable, in detailed construction-rehabilitation plans. The proposed measures by themselves do not provide the engineering design, methods, techniques and criteria needed to assure satisfactory stabilization and restoration of streambeds and banks.

Water Erosion

The applicant proposes to use one or more of the following procedures or devices to control soil erosion by water.

On sidehill cuts, where the pipeline trench crosses the face of a hill or a mountain, the "French Drain" type could be used. This method entails the trenching of a smaller trench on the uphill side of and at a greater depth than the pipe trench, filling the bottom of this trench with gravel and providing a crossing of the pipe trench with a tile or flume. This prevents excess water from entering the pipe trench, thereby preventing degradation of the hillside caused by surface water buildups and erosion of the pipe trench. This type of control method can be used in many areas and locations.

Another type of control entitled "Terrace Ditch" is simply an earthen dam placed across the right-of-way. The location of this ditch is generally on gently sloping rights-of-way where the trench traverses directly up and/or down the faces of hills. The purpose of the "terrace ditch" is to break up the flow of water down the face of the hill and/or right-of-way.

In other locations, "Sandbag" ditch breakers can be put in the trench to assist in erosion prevention. Sandbags are probably the most common device used in erosion prevention on a pipeline. Their uses are many and they can be put in wherever needed.

"Check Dams" are installed on the pipeline rights-of-way to break up waterflow. The "check dam" is a manmade aboveground barrier built from timber, cleared from a right-of-way, or brought to the site.

Generally, local conditions control their location since they depend on types of soils, degrees of slope, and water volumes. These dams are spaced and located on alternate sides of the right-of-way to break up the flow of water runoff.

The "Cross Ditch" method utilizes an earthen dam built on a 45 degree angle to the right-of-way, with the angle beginning on the uphill side of the right-of-way. The purpose of this type is to divert the water across the right-of-way as quickly as possible to prevent any washing away of the backfill material.

For erosion control on stream and riverbanks, see Restoration of Streambeds and Banks above.

Evaluation: Same as Restoration of Streambeds and Banks above.

Wind Erosion

The applicant proposes to use mechanical and/or vegetative wind barriers where wind erosion prohibits effective soil stabilization and/or interferes with operations along the right-of-way.

The applicant states:

Revegetation constitutes the most desirable and effective method of soil stabilization and erosion control. However, at certain sites, revegetation will not be possible without some wind erosion control measures to reduce surface wind velocities and preserve soil characteristics while establishing a new cover. Several methods described below provide both types of control. The method used will depend upon the specific conditions encountered.

Vegetative barriers such as hedges or shelterbelts may be required in certain situations. Shelterbelts can provide long term protection of pipeline installations such as compressor station sites, which could be affected by wind erosion originating away from the actual construction area. Similarly, slat fences and picket fences can be used as windbreaks where temporary protection is required.

A mulch will be the most frequent and most effective wind erosion control measure used along the proposed route. It may involve the application of a layer of plant residue or other material (straw, hay, brush, jute, etc.) on the surface of the soil. Revegetation of the right-of-way could proceed concurrently to stabilize the area before the mulch deteriorates. On slopes, it may be necessary to construct trap-ridges at intervals of approximately 100 feet. Other practices include tilling at right angles to the direction of the prevailing winds and restoring the topsoil whose content of undecomposed organic matter helps bind the soil particles. In agricultural areas, the stubble left along the right-of-way and the planting of drought resistant species such as rye or sorghum can supply temporary control as a cover crop for grass establishment. A variety of native grasses is also very effective in binding the soil with root growth and in reducing wind velocities at the soil surface.

Evaluation: Same as Restoration of Streambeds and Banks above.

Landscaping to Protect Esthetic Values

The applicant states:

The decision to plant shrubs on streambanks is subject to the following criteria: present values related to riparian cover, the impact on esthetics, other possibilities for mitigation and the site's capacity for natural regeneration.

The primary objective of reestablishing woody streamside cover would be to mitigate the impact on esthetic values of the landscape as it is viewed by users of the stream. A screen of shrubs can shield the right-of-way from view and provide the observer with the illusion of an undisturbed environment. The alternative method of mitigation with respect to relatively scenic streams consists of alignment modification. The decision to modify the alignment or to restore the woody cover will depend on other factors such as the relative merits of distinct crossing points and the constraints in rights-of-way acquisition. Where restoration of woody cover is a preferred method of mitigation, the species will be selected so as to conform with the existing vegetation types.

Trees could be restored in all disturbed areas outside of the permanently cleared portion of the right-of-way. Within the permanent cleaned portion of the right-of-way, screen plantings will consist of shrubs. Since both streambank protection and wildlife are additional considerations, it is probable that screen plantings will include such elements as red-osier dogwood, gray dogwood, silky cornel, Russian olive, nannyberry and cranberry, which are favored for this type of use. These species can be planted as close as 2-3 feet apart with 3-4 feet between rows. In general, spacing will be determined by the growth form and size of the planting stock. The Wapsipinicon River (Iowa), Big Bureau Creek (Illinois), Wabash River (Indiana), Salamonie River (Indiana) and Eel River (Indiana) have been identified as locations requiring mitigation in the form of vegetative screens and/or minor alignment modification during field survey.

Evaluation: The measures proposed by the applicant, taken with a variety of other measures in a comprehensive construction-rehabilitation plan, could assure minimizing the impact on esthetic values. Taken by themselves, with the indicated single application of either alignment modification or establishment of woody cover on selected sites, the proposed measures would not assure complete protection of esthetic values.

Restoration of Fences, Roadways, Drainage Patterns, etc.

The applicant states:

All temporary fences and gates installed at the beginning of the project will be removed, if necessary, and new posts set for permanent field fence. New strands of wire will be stretched and secured to blend into the existing section of fence.

All terraces, levees and watercourses will be restored to preconstruction condition so that they will function as originally intended. Restoration of the right-of-way and the establishment of contours to minimize erosion due to overland runoff are the major responsibilities to be accomplished during the cleanup and restoration phase.

All railroad track beds and road surfaces will be restored to their former condition. The restoration plan for areas adjacent to and on the rights-of-way of the roads and railroads will conform to those plans for the land use type on which the crossing occurs or to those of the preexisting right-of-way as appropriate.

Evaluation: The proposed mitigation measures provide adequate standards for restoration of the subject facilities but they do not indicate how the restoration is to be accomplished in many instances. Site specific plans are needed.

4.1.3.3. Safety and Emergency Measures to be Implemented during Construction and Operation as Proposed by the Applicant

This section highlights activities and occurrences that require safety and emergency measures for the protection of people in the vicinity of the pipeline.

Flammable or Explosive Materials

Explosive Use

The applicant states that he will require the contractor to secure all permits required by and to abide by any Federal, State, or local regulations relating to the storage of explosives. The contractor will supply to the applicant proof of permit acquisitions prior to storing any explosives for use in constructing the pipeline.

Applicant's inspectors will insure compliance with all pertinent regulations including specifically the general OSHA Standards, 29 CFR 1910.109 relating to explosives and blasting agents.

The applicant states that explosives will be necessary along certain parts of the proposed route in order to blast out rock for the trench. "Hi-Velocity Gelatin" is likely to be used for submarine explosions and several hundred feet of ditch will be blasted at one time. The specific locations have not been determined yet.

Evaluation: The hazards of blasting to humans are well known. Consequently, there are numerous regulations, Federal, State, and local, which control their use. Subpart U of the Occupational Safety and Health Act (29 CFR 1926) gives detailed instructions to minimize explosive use hazards, which need not be enumerated here. In addition, Section 4.1.3.4 states that an explosive's use plan be submitted to the appropriate authorities. This plan would permit verification of OSHA compliance as well as provide assurance that nearby structures would not be damaged or that landslides or rockfalls would not be initiated.

Oil and Gas Spills

The applicant states that all wastes will be disposed of in accordance with applicable regulations; however, the subject of spills was not discussed.

Evaluation: There may be occasion, during construction or operation, when flammable liquid petroleum products may be spilled resulting in a fire hazard. Compliance with 29 CFR 1926.150 on fire protection programs, 29 CFR 1926.152 on storage of flammable liquids, and 29 CFR 1926.252 on removal of waste should ensure that such hazards be reasonably minimized.

Grass and Woodland Fires

The applicant states that a firebreak will be graded when the pipeline crosses areas with dry vegetation.

Evaluation: Grass fires in prairie areas and brush fires in wooded areas traversed by the route may occur as a result of construction activities or failure of the pipeline. (See Section 3.1.3.6 for further discussion of this subject.) With an adequate fire protection program in compliance with OSHA and the creation of firebreaks between the right-of-way and the prairie, woods or fields adjacent, such hazard can be greatly reduced. Firebreaks create an additional impact and this must also be mitigated in a similar manner as the right-of-way.

Coal Seams

The applicant states that caution will be exercised to avoid accidental ignition of coal seams encountered during the construction of the proposed pipeline. He states that it may be necessary to provide water-sprinkling trucks to wet down coal seams encountered during both right-of-way preparation and actual ditching operations.

Evaluation: There is a high probability that coal seams will be exposed during trenching in both the Montana-North Dakota coalbeds and in the East Ohio-West Virginia-Pennsylvania coalbeds. The consequence of accidental ignition of these seams may last for many years since burning mines and coal seams exist through the United States that have been ignited up to 100 years ago. Sources of ignition for the project can be welding sparks, electrical shorts, or blown embers from onsite brush fires. Frequent wetting down of such exposed seams is one means of reducing the hazards. Cutting the trench somewhat deeper and bedding with bentonite and then wetting down is superior.

Mechanical Equipment Operations

Welds

The applicant states that welding of pipe joints would be in accordance with Subpart E of 49 CFR 192. Welds are critical to integrity of a pipeline. Excessive stresses applied to the pipe, coupled with a welding flaw can result in pipe rupture.

Evaluation: This measure is considered adequate.

Changes in Location Class

Applicant proposes to conduct population density surveys in accordance with 49 CFR 192. He has collected current data on population density classes.

Evaluation: The proposed measures are considered adequate.

Construction Faults

The applicant states the construction will be in accordance with 49 CFR 192 and rigid inspection will insure compliance with specifications.

Evaluation: These procedures are considered adequate as they apply to this line.

Corrosion

The information on corrosion control furnished by the applicant is discussed in Section 4.1.3.1.

Evaluation: These measures are considered adequate.

Overpressure

The only information furnished by the applicant is shown in Section 4.1.3.1.

Evaluation: Overpressuring of the pipeline can occur over a long term in an attempt to increase flow or over a short period as a transient response to changing flow conditions. In either case, there is potential for pipe rupture. Paragraphs 105, 197, 199, 201 and 203 of 49 CFR 192 cover means for avoiding such danger; these sections must be complied with and appear to be adequate for the present proposed line.

Station Hazards

Information furnished by the applicant is discussed in Section 4.1.3.1.

Evaluation: These provisions are considered adequate except for their lack of a requirement for remote monitoring of safety conditions.

Construction Operations

Trench Collapse

The applicant states that normal ditching procedures dictate that trenching machines be equipped with adjustable blade-type slopers to prevent creeping of the ditch banks. Any required shoring will be in compliance with OSHA (Occupational Safety and Health Act).

Evaluation: OSHA standards are quite detailed and appear to be adequate to provide reasonable safety on the proposed project.

Bridge Failure

The applicant states that low load capacity bridges might be reinforced or the stream forded if other access is not available.

Evaluation: Since much of the pipeline is to be in rural areas, the local bridges may not be adequate to carry the heavy hauling trucks and construction equipment. Failure of these bridges under load can pose a serious safety hazard. Means should be found for determining the actual load capacity of each bridge to be crossed and if it is deemed marginal, means for circumventing the bridge should be developed. For small stream crossings, it may be possible to simply drive around but such action has an adverse environmental impact and should be avoided.

Landslides and Rockfalls

The applicant states that potential areas of landslides or rockfalls will be avoided if at all possible.

Evaluation: The areas of potential landslides and rockfalls along the route should be identified. The discussion in Sections 2.1.3.3 and 3.1.3.2 covers this topic. Trenching into or removal of part of the toe of any landslide deposit, whether stable or active, should be avoided. Where unstable slopes must be crossed, the stabilization methods proposed should be submitted with the final design.

Open Trench

The discussion furnished by the applicant on this subject is shown in Section 4.1.3.1.

Evaulation: Safety hazards of this type are well recognized. Paragraphs 200, 201, and 202 of 29 CFR 1926 regarding signs, signals, flagmen, and barricades apply. These provisions appear adequate to cover construction.

Welding

For applicant's data on welding, see Section 4.1.3.3 (Mechanical Equipment Operations).

Evaluation: Paragraphs 252, 351, and 352 of 29 CFR 1926 control these activities and are considered adequate to ensure reasonable work safety.

Earthquake, Subsidence, Accidental Contact, Landslides, Floods

No specific mitigating measures were proposed by the applicant for these potential hazards.

Evaluation: These occurrences can result in pipe rupture and the consequent safety hazard. This topic is discussed more fully in Sections 2.1.3.3 and 3.1.3.3 and the measures to control and mitigate these dangers appear in Section 4.1.3.4. The monumental impact of a pipe rupture and the procedures for responding to it are not well developed, especially for such a large project as this. Although there are a number of preventive regulations (Paragraphs 167, 171, and 317 of 49 CFR 192 for example), the one addressing response to emergencies (Paragraph 615 of 49 CFR 192, Emergency Plans) simply requires the operator of a transmission line to have written emergency plans and that employees, public officials, customers, and the general public should be acquainted with them. There is no provision requiring that this plan be adequate and in the present case adequacy of response is a serious question. The capability of a rural fire department to adequately respond to a massive pipe rupture, explosion, and fire, either along the line or in a compressor station is seriously in doubt. More than an educational program is required to resolve this problem. What is needed is an identification of the seismic risk, consideration of rerouting and, if rerouting is not done, then the applicant should report on and adopt construction measures designed to withstand the identified seismic effects.

General Measures to be Taken to Reduce the Risks from Hazards

Precautionary Signs, Shields, and Barricades

Applicant states that he would comply with all applicable Federal and State regulations.

Evaluation: Paragraphs 200 and 202 of 29 CFR 1926 detail the types of signs and barricades required and the section totally discusses the requirement for use of these devices during construction activities. The pipeline itself must be clearly marked at road and water crossings and at other points where potential digging may occur, in accordance with 29 CFR 192.707. These measures are considered adequate.

Hazardous Material Areas

Explosive storage msut be in conformance with 29 CFR 1926.909 and 26 CFR 181 and transportation must conform with 29 CFR 1926.902.

The pipe sections, because of their size, weight (8 tons per 40 foot section), and need for extensive manipulation, will pose a potential safety hazard. Pipe storage areas have been identified, access to them must be restricted and stacking must be in conformance with 29 CFR 1926.250.

Evaluation: The applicable regulations cited are considered adequate.

Fire Control Measures

A fire protection program is required during the construction phase by 29 CFR 1926.150.

Evaluation: Fire hazards are discussed in Section 4.1.3.3 (Flammable or Explosive Material) related to flammable materials, grass and woodland fires, coal seams, station accidents, and pipe rupture. Each of these specific areas should be included in such a program.

Emergency Measures

The applicant states that a manual detailing operations and maintenance procedures will be prepared prior to initial operation. The manual will be filed at locations necessary to insure that it be available for ready reference and for use in training operating personnel. An emergency plan outlining steps to be taken in the event of system malfunction or other emergencies will be incorporated in the operations and maintenance manual.

Immediately upon the occurrence of a malfunction or failure, that part, piece of equipment or section of line will be isolated, if necessary. Appropriate action will give priority to the protection of lines and property, returning the pipeline to service, and effecting permanent repairs. Maps, diagrams, and records will be maintained to assure that the operating personnel can immediately determine how isolation may be effected for any part or portion of the system.

The detailed steps required to purge a line, part of a line, or portion of a compressor station will be included in the operation and maintenance manual. These steps will be strictly adhered to when putting any system or part of a system into service or taking it out of service. The operating and maintenance manual will cover emergency shutdown instructions and other emergency procedures.

Pipeline valves will be equipped with automatic self-actuating operators which will isolate segments of the pipeline in the event of a system failure. Compressor stations will be equipped with safety devices to prevent overpressuring the pipeline; additionally, the compressor stations will be provided with safety devices which will shut down and isolate the station upon detection of fire or presence of explosive mixtures of gas in the atmosphere, and will shut down the equipment in the event of a mechanical failure which would endanger the integrity of the equipment.

Manual override emergency shutdown controls are also located at strategic points throughout the compressor station. Each individual compressor station can be locally controlled in the event of communications failure. In no case can loss of communications or computer control cause a compressor to overpressure the pipeline.

Safety devices will be of fail-safe design. This refers to a protective system that incorporates features for automatically counteracting the effect of an anticipated possible source of failure. The system requires the proper functioning of each protective device, such as circuitry connecting the devices, continuity of control power, and signals to the entire system. Failure to satisfy any or all of these requirements would have the same effect as the presence of a bona fide hazardous condition in that the equipment and/or compressor station would be automatically placed in the protected mode. For example, appropriate valves would be closed to shut off the gas supply, others opened to purge the system (the gas would be released to the atmosphere by the blowdown valves and piping) and equipment shutdown or started depending on its function.

Evaluation: The proposed measures together with other measures noted in Section 4.1.3.4 should be incorporated in the emergency plan to minimize risk.

Applicable County, State or Federal Regulations and Codes and Applicable Pipeline Industry Standards

The applicable Federal and State health and safety regulations and codes are listed in Table 4.1.3.3-1. The other applicable regulations and codes are listed in Table 4.1.3.3-2. The applicable pipeline industry standards and codes are listed in Table 4.1.3.3-3.

Table 4.1.3.3-1 Health and safety regulations and codes

GOVERNMENTAL UNIT	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
FEDERAL	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, DEPARTMENT OF LABOR	OCCUPATIONAL HEALTH AND SAFETY STANDARDS (29 C.F.R. 1910).
		SAFETY AND HEALTH REGULATIONS FOR CONSTRUCTION (29 C.F.R. 1926).
	OFFICE OF PIPELINE SAFETY, DEPARTMENT OF TRANSPORTATION	INTERIM MINIMUM FEDERAL SAFETY STANDARDS FOR THE TRANSPORTATION OF NATURAL AND OTHER GAS BY PIPELINE (49 C.F.R. 190).
		TRANSPORTATION OF NATURAL AND OTHER GAS BY PIPELINE; REPORTS OF LEAKS (49 C.F.R. 191).
		TRANSPORTATION OF NATURAL AND OTHER GAS BY PIPELINE; MINIMUM FEDERAL SAFETY STANDARDS (49 C.F.R. 192).
	FEDERAL COMMUNICATIONS COMMISSION	PAINTING AND LIGHTING OF TOWERS (46 C.F.R. 17).
	FEDERAL AVIATION ADMINISTRATION, DEPARTMENT OF TRANSPORTATION	OBSTRUCTION MARKING AND LIGHTING (14 C.F.R. 77).
ILLINOIS	ILLINOIS DEPARTMENT OF LABOR	CONSTRUCTION SAFETY CODE FOR THE STATE OF ILLINOIS 1970.
		ILLINOIS OCCUPATIONAL HEALTH AND SAFETY RULES (1970).
IOWA	IOWA INDUSTRIAL COMMISSION	IOWA CONSTRUCTION REGULATIONS (IC–3, 1968).
OHIO	INDUSTRIAL COMMISSION OF OHIO	SPECIFIC SAFETY REQUIREMENTS OF THE INDUSTRIAL COMMISSION OF OHIO RELATING TO CONSTRUCTION (1968).

Source: Northern Border Project Environmental Assessment; Northern Border Pipeline Company, 1974.

Table 4.1.3.3-2 Other regulations and codes

GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
FEDERAL	FEDERAL POWER COMMISSION	PROCEDURES TO BE FOLLOWED BY NATURAL GAS PIPELINE COMPANIES IN THE PLANNING, LOCATING, CLEARING AND MAINTENANCE OF RIGHTS-OF-WAY AND THE CONSTRUCTION OF ABOVE-GROUND FACILITIES (18 C.F.R. 2.69).
		APPLICATION FOR AUTHORIZATION TO EXPORT OR IMPORT NATURAL GAS (18 C.F.R. 153).
		APPLICATION FOR CONSTRUCTION, OPERATION, MAINTENANCE, OR CONNECTION AT INTERNATIONAL BOUNDARY, OF FACILITIES FOR EXPORTATION OR IMPORTATION OF NATURAL GAS (18 C.F.R. 153.10 – 153.12).
		RATE SCHEDULES AND TARIFFS (18 C.F.R. 154).
		APPLICATION FOR CERTIFICATES OF PUBLIC CONVENIENCE AND NECESSITY AND FOR ORDERS PERMITTING AND APPROVING ABANDONMENT UNDER SECTION 7 OF THE NATURAL GAS ACT (18 C.F.R. 157).
		ACCOUNTS, RECORDS, AND MEMORANDAS (18 C.F.R. 158).
		FEES AND ANNUAL CHARGES UNDER THE NATURAL GAS ACT (18 C.F.R. 159)
		FILING OF COMPANY PROCUREMENT POLICIES AND PRACTICES (18 C.F.R. 160).
		UNIFORM SYSTEM OF ACCOUNTS FOR NATURAL GAS COMPANIES (18 C.F.R. 201).
		UNITS OF PROPERTY FOR USE IN ACCOUNTING FOR ADDITIONS TO AND RETIREMENTS OF GAS PLANT (18 C.F.R. 216).
		PRESERVATION OF RECORDS OF NATURAL GAS COMPANIES (18 C.F.R. 225).
		FORMS (18 C.F.R. 250).
		STATEMENTS AND REPORTS (SCHEDULES) (18 C.F.R. 260).

*APPLICABLE GOVERNMENTAL AND INDUSTRIAL STANDARDS, REGULATIONS AND CODES INCORPORATED BY REFERENCE INTO THE REGULATIONS AND CODES IN THIS LISTING APPLY THOUGH NOT INDIVIDUALLY IDENTIFIED.

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
FEDERAL (Cont'd.)	ENVIRONMENTAL PROTECTION AGENCY	ENVIRONMENTAL PROTECTION AGENCY REGULATIONS ON NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS (40 C.F.R. 50).
		ENVIRONMENTAL PROTECTION AGENCY REGULATIONS ON POLICIES AND PROCEDURES FOR THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (40 C.F.R. 125).
		ENVIRONMENTAL PROTECTION AGENCY REGULATIONS ON TEST PROCEDURES FOR THE ANALYSIS OF POLLUTANTS (40 C.F.R. 136).
	FEDERAL COMMUNICATIONS COMMISSION	INDUSTRIAL RADIO SERVICE (47 C.F.R. 9).
	CORPS OF ENGINEERS, DEPARTMENT OF THE ARMY	PERMIT FOR ACTIVITIES IN NAVIGABLE WATERS OR OCEAN WATERS (33 C.F.R. 209).
		RULES AND REGULATIONS GOVERNING PUBLIC USE OF WATER RESOURCE DEVELOPMENT PROJECTS ADMINISTERED BY THE CHIEF OF ENGINEERS (36 C.F.R. 327).
	BUREAU OF INDIAN AFFAIRS, DEPARTMENT OF THE INTERIOR	RIGHTS-OF-WAY OVER INDIAN LANDS (25 C.F.R. 161).
	BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR	RIGHTS-OF-WAY, PRINCIPALS AND PROCEDURES (43 C.F.R. 2800).
		RIGHTS-OF-WAY FOR MINERAL LEASING PURPOSES (43 C.F.R. 2880).
	FISH AND WILDLIFE SERVICE, DEPARTMENT OF THE INTERIOR	LAND USE MANAGEMENT (50 C.F.R. 29).
		DINGELL-JOHNSON SPORT FISH RESTORATION ACT (16 U.S.C. 777-777K).

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
FEDERAL (Cont'd.)	FISH AND WILDLIFE SERVICE, DEPARTMENT OF THE INTERIOR (Cont'd.)	ENDANGERED SPECIES CONSERVATION ACT OF 1969 (16 U.S.C. 668-668D).
		FEDERAL AID IN FISH RESTORATION ACT (16 U.S.C. 777-77K).
		FEDERAL WATER PROJECT RECREATION ACT (16 U.S.C. 460).
		FISH AND WILDLIFE COORDINATION ACT (16 U.S.C. 661-667E).
	ENVIRONMENTAL PROTECTION AGENCY	NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 (42 U.S.C. 4321-4327).
	FISH AND WILDLIFE SERVICE, DEPARTMENT OF THE INTERIOR	PITTMAN-ROBERTSON WILDLIFE RESTORATION ACT (16 U.S.C. 669-669I).
	ENVIRONMENTAL PROTECTION AGENCY	SOLID WASTE DISPOSAL ACT (42 U.S.C. 3251-3259).
	FISH AND WILDLIFE SERVICE, DEPARTMENT OF THE INTERIOR	UPPER MISSISSIPPI RIVER WILDLIFE AND FISH REFUGE ACT (16 U.S.C. 721-731).
		WETLANDS ACQUISITION ACT (16 U.S.C. 715K).
	BUREAU OF ALCOHOL, TOBACCO AND FIREARMS, DEPARTMENT OF THE TREASURY	REGULATION OF EXPLOSIVES—PURCHASE, STORAGE AND RECORDS (TITLE XI, PUBLIC LAW 91-452) (26 CFR 181).
	ADVISORY COUNCIL ON HISTORIC PRESERVATION	PROCEDURES FOR THE PROTECTION OF HISTORIC AND CULTURAL PROPERTIES (36 C.F.R. 800).
	BUREAU OF OUTDOOR RECREATION, DEPARTMENT OF THE INTERIOR	WILD AND SCENIC RIVER ACT (PL 90-542).
		LAND AND WATER CONSERVATION ACT OF 1965 (PL 88-578).
	NATIONAL PARK SERVICE, DEPARTMENT OF THE INTERIOR	HISTORIC PRESERVATION ACT OF 1966 (PL 89-665).
		EXECUTIVE ORDER 11593, MAY 13, 1971.
INDIANA	INDIANA AIR POLLUTION CONTROL BOARD	OPEN BURNING (APC 2).
		MAXIMUM ALLOWABLE HYDROCARBON EMISSIONS (APC 15).
		PERMITS (APC 19).
		MAXIMUM ALLOWABLE FUGITIVE DUST (APC 20).
	INDIANA STREAM POLLUTION CONTROL BOARD	WATER QUALITY STANDARDS FOR WATERS OF INDIANA (SPC IR-3).

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
INDIANA (Cont'd).	INDIANA STATE ADMINISTRATIVE BUILDING COUNCIL	BUILDING CODES FOR THE STATE OF INDIANA: BUILDING RULES AND REGULATIONS, VOL. I (1969).
	INDIANA STATE HIGHWAY COMMISSION	STANDARD SPECIFICATIONS (INDIANA STATE HIGHWAY COMMISSION 1971).
		STATE HIGHWAY COMMISSION POLICIES COVERING THE USE AND OCCUPANCY OF PUBLIC HIGHWAY RIGHTS-OF-WAY BY UTILITIES (INDIANA STATE HIGHWAY COMMISSION 1971).
	COUNTY DRAINAGE BOARDS	INDIANA DRAINAGE CODE OF 1965 (INDIANA ACTS OF 1965, CH 305).
	ADAMS COUNTY	ADAMS COUNTY ZONING ORDINANCE (P2–1967).
	CASS COUNTY	CASS COUNTY ZONING ORDINANCE.
	HUNTINGTON COUNTY	HUNTINGTON COUNTY ZONING ORDINANCE.
	JASPER COUNTY	ZONING ORDINANCE OF JASPER COUNTY, INDIANA (1964 AMENDED).
	MIAMI COUNTY	MIAMI COUNTY ZONING ORDINANCE.
	NEWTON COUNTY	ZONING ORDINANCE, NEWTON COUNTY, INDIANA (1972).
	WABASH COUNTY	WABASH COUNTY ZONING ORDINANCE (1965).
	WELLS COUNTY	WELLS COUNTY ZONING ORDINANCE (1970).
	WHITE COUNTY	WHITE COUNTY ZONING REGULATIONS.

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
ILLINOIS	ILLINOIS POLLUTION CONTROL BOARD	AIR POLLUTION CONTROL REGULATIONS (I.P.C.B. REG. CH.2).
		WATER POLLUTION CONTROL REGULATIONS (I.P.C.B. REG. CH. 3).
		NOISE POLLUTION CONTROL REGULATIONS (I.P.C.B. REG. CH. 8).
	ILLINOIS DEPARTMENT OF TRANSPORTATION	POLICY ON THE ACCOMMODATION OF UTILITIES ON RIGHTS-OF-WAY OF THE ILLINOIS STATE HIGHWAY SYSTEM (ILLINOIS DEPARTMENT OF TRANSPORTATION).
		POLICY FOR ACCESS DRIVEWAYS TO STATE HIGHWAY (ILLINOIS DEPARTMENT OF TRANSPORTATION, 1964).
		OVERSIZE AND OVERWEIGHT PERMIT MOVEMENTS ON STATE HIGHWAYS (ILLINOIS DEPARTMENT OF TRANSPORTATION, 1972).
	BUREAU COUNTY	ZONING ORDINANCE FOR BUREAU COUNTY, ILLINOIS (1968).
	GRUNDY COUNTY	ZONING ORDINANCE, GRUNDY COUNTY, ILLINOIS.
	IROQUOIS COUNTY	IROQUOIS COUNTY, ILLINOIS, ZONING ORDINANCE.
	KANKAKEE COUNTY	KANKAKEE COUNTY ZONING ORDINANCE (1967 WITH AMENDMENTS).
	WHITESIDE COUNTY	WHITESIDE COUNTY ZONING ORDINANCE.

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GOVERNMENTAL UNIT	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
IOWA	IOWA AIR QUALITY COMMISSION	IOWA RULES AND REGULATIONS RELATING TO AIR POLLUTION CONTROL (IOWA DEPARTMENT REG. 136 B).
	IOWA NATURAL RESOURCES COUNCIL	IOWA CODE CHAPTER 455A RELATING TO WATER RESOURCES (1966).
	IOWA STATE CONSERVATION COMMISSION	CONSTRUCTION PERMIT – REGULATIONS – COMMERCIAL CONCESSIONS (SEC. 111.4, CODE OF IOWA 1973).
	IOWA STATE HIGHWAY COMMISSION	UTILITY ACCOMMODATION POLICY OF THE IOWA STATE HIGHWAY COMMISSION (REVISED 1973).
	BLACK HAWK COUNTY	BLACK HAWK COUNTY ZONING ORDINANCE.
	BREMER COUNTY	ZONING ORDINANCE, BREMER COUNTY, IOWA.
	BUTLER COUNTY	ZONING ORDINANCE, BUTLER COUNTY, IOWA (1968).
	CEDAR COUNTY	ZONING ORDINANCE, CEDAR COUNTY, IOWA (1959).
	CERRO GORDO COUNTY	ZONING ORDINANCE, CERRO GORDO COUNTY, IOWA (1971).
	CLINTON COUNTY	CLINTON COUNTY ZONING ORDINANCE (1971).
	FRANKLIN COUNTY	ZONING ORDINANCE, FRANKLIN COUNTY, IOWA (1968).
	KOSSUTH COUNTY	ZONING ORDINANCE, KOSSUTH COUNTY, IOWA.

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
IOWA (Cont'd.)	LINN COUNTY	LINN COUNTY, IOWA, ZONING ORDINANCE (1973).
	SCOTT COUNTY	ZONING ORDINANCE, SCOTT COUNTY, IOWA.
MINNESOTA	MINNESOTA POLLUTION CONTROL COMMISSION	AMBIENT AIR QUALITY STANDARDS (MINNESOTA REG. APC 1).
		DEFINITION, PROVISION FOR RECREATIONAL FIRES, ACCESS TO PREMISES VARIANCES, CIRCUMVENTION AND SEVERABILITY (MINNESOTA REG. APC 2).
		PERMITS, EMISSION SOURCE MONITORING, MEASUREMENT OF AIR CONTAMINANTS, ANTI-DEGRADATION (MINNESOTA REG. APC 3).
		PREVENTING PARTICULATE MATTER FROM BECOMING AIR-BORNE (MINNESOTA REG. APC 6).
		OPEN BURNING RESTRICTIONS (MINNESOTA REG. APC 8).
		CRITERIA FOR THE CLASSIFICATION OF INTERSTATE WATERS OF THE STATE AND ESTABLISHMENT OF STANDARDS OF QUALITY AND PURITY (MINNESOTA REGS. WPC 14 & 15).
		STANDARDS FOR QUALITY AND PURITY OF EFFLUENTS DISCHARGED TO INTERSTATE WATERS (MINNESOTA REGS. WPC 23).
	MINNESOTA DEPARTMENT OF NATURAL RESOURCES	RULES AND REGULATIONS OF THE DEPARTMENT OF NATURAL RESOURCES (MINNESOTA REGS. NR 1–118).
	MINNESOTA DEPARTMENT OF HIGHWAYS	RULES AND REGULATIONS FOR UTILITIES ON TRUNK HIGHWAYS UNDER CHAPTER 500, LAWS OF 1959 (MINNESOTA REG. HWY. 33).
		A POLICY FOR THE ACCOMMODATIONS OF UTILITIES ON STATE TRUNK HIGHWAYS (MINNESOTA DEPARTMENT OF HIGHWAYS, DECEMBER 31, 1970).
		POLICY FOR CASING CARRIER PIPE AT ROAD CROSSINGS (MINNESOTA DEPARTMENT OF HIGHWAYS, MAY 7, 1969)
	YELLOW MEDICINE WATERSHED DISTRICT COMMISSION	RULES AND REGULATIONS OF THE YELLOW MEDICINE WATERSHED DISTRICT (1972).

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
MINNESOTA (Cont'd.)	COTTONWOOD COUNTY	COTTONWOOD COUNTY, MINNESOTA, ZONING ORDINANCE NO. 3 (1971).
	JACKSON COUNTY	JACKSON COUNTY, MINNESOTA, ZONING ORDINANCE (1969).
	LINCOLN COUNTY	LINCOLN COUNTY SHORELAND ORDINANCE (1973).
	LYON COUNTY	LYON COUNTY, MINNESOTA ZONING ORDINANCE.
		SHORELAND MANAGEMENT ORDINANCE.
	MARTIN COUNTY	MARTIN COUNTY, MINNESOTA, ORDINANCE NO. 1.
	MURRAY COUNTY	ZONING ORDINANCE, MURRAY COUNTY (1972).
		ORDINANCE FOR THE MANAGEMENT OF SHORELAND AREAS, MURRAY COUNTY, MINNESOTA (1973).
MONTANA	MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES	MONTANA AIR QUALITY REGULATIONS (MONTANA ST. REG. 90–001 ET. SEQ.).
		MONTANA WATER QUALITY STANDARDS (MAC 16–2.14 (10) – S14480).
		MONTANA DISCHARGE PERMIT REGULATIONS (MONTANA ST. REG. 53.100).
	MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION	WATER RESOURCES, FLOODWAY MANAGEMENT BUREAU (MONTANA ADMIN. CODE CH. 14B).
		MONTANA CONSERVATION DISTRICT LAW AND AMENDMENTS (1973).

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
NORTH DAKOTA	NORTH DAKOTA STATE DEPARTMENT OF HEALTH	AIR POLLUTION CONTROL REGULATION, GENERAL PROVISIONS (R23–24–01).
		AIR POLLUTION CONTROL REGULATION, AMBIENT AIR QUALITY STANDARDS (R23–25–02).
		AIR POLLUTION CONTROL REGULATION, OPEN BURNING (R23–25–04).
	NORTH DAKOTA STATE WATER POLLUTION CONTROL BOARD	WATER QUALITY STANDARDS FOR SURFACE WATERS OF NORTH DAKOTA.
	NORTH DAKOTA STATE DEPARTMENT OF HIGHWAYS	A POLICY FOR ACCOMMODATION OF UTILITIES ON STATE HIGHWAY RIGHT-OF-WAY (1971).
		RULES AND REGULATIONS FOR ACCOMMODATION OF UTILITIES ON COUNTY FEDERAL-AID SECONDARY HIGHWAYS IN THE STATE OF NORTH DAKOTA (1971).
	EMMONS COUNTY	ZONING ORDINANCE, EMMONS COUNTY, NORTH DAKOTA.
	MORTON COUNTY	ZONING ORDINANCE, MORTON COUNTY, NORTH DAKOTA.
OHIO	OHIO POWER SITING COMMISSION	INSTRUCTIONS FOR PREPARATION OF POWER SITING APPLICATIONS AND TEN YEAR FORECASTS.
	OHIO ENVIRONMENTAL PROTECTION AGENCY	OHIO GENERAL AIR POLLUTION REGULATIONS (O.E.P.A. REG. AP–2–01 THROUGH AP–2–09).
		OHIO REGULATIONS FOR CARBON MONOXIDE, HYDROCARBONS, PHOTOCHEMICAL OXIDANTS (O.E.P.A. REG. AP–5–06 THROUGH AP–5–08).
		OHIO REGULATIONS FOR OXIDES OF NITROGEN (O.E.P.A. REG. AP–7–01 THROUGH AP–7–06).
		OHIO PERMIT SYSTEM REGULATIONS (O.E.P.A. REG. AP–9–01 THROUGH AP–9–09).

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
OHIO (Cont'd.)	OHIO ENVIRONMENTAL PROTECTION AGENCY (Cont'd.)	OHIO OPEN BURNING REGULATIONS (O.E.P.A. REG. AP–12–01 THROUGH AP–12–06).
		OHIO WATER QUALITY STANDARDS (EP–1–01 ET SEQ.).
	OHIO DEPARTMENT OF TRANSPORTATION	PERMITS TO USE OR OCCUPY HIGHWAY RIGHT-OF-WAY (DEPARTMENT OF TRANSPORTATION DIRECTIVE 20–A).
	OHIO DEPARTMENT OF INDUSTRIAL RELATIONS	HIGH BUILDING CODE OF OHIO.
PENNSYLVANIA	PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES	PENNSYLVANIA AIR POLLUTION GENERAL RULES (PENNSYLVANIA D.E.R. REGS. CH. 121).
		PENNSYLVANIA STANDARDS FOR CONTAMINANTS (PENNSYLVANIA D.E.R. REGS. CH. 123).
		PENNSYLVANIA AIR POLLUTION SOURCE RULES (PENNSYLVANIA D.E.R. REGS. CH. 127).
		PENNSYLVANIA STANDARDS FOR SOURCES (PENNSYLVANIA D.E.R. REGS. CH. 129).
		PENNSYLVANIA AMBIENT AIR QUALITY STANDARDS (PENNSYLVANIA D.E.R. REGS. CH. 131).
		PENNSYLVANIA WATER QUALITY CRITERIA (PENNSYLVANIA D.E.R. REGS. CH 93).
		SOIL EROSION AND SEDIMENTATION CONTROL MANUAL (1973).
		POLICY CONCERNING RIGHTS-OF-WAY OVER STATE FOREST LANDS (F.W.F.M. – 32, 7–67).

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
PENNSYLVANIA (Cont'd.)	PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES (Cont'd.)	RULES, INSTRUCTIONS AND INFORMATION CONCERNING WATER OBSTRUCTIONS (F.W.W.R.–23, 1972).
	PENNSYLVANIA DEPARTMENT OF TRANSPORTATION	GENERAL PROVISIONS AND SPECIFICATIONS REGULATING OCCUPANCY OF STATE HIGHWAY RIGHT-OF-WAY (M–945–B).
		PENNSYLVANIA DEPARTMENT OF TRANSPORTATION SPECIFICATIONS (FORM 408).
	PENNSYLVANIA DEPARTMENT OF LABOR AND INDUSTRY	PENNSYLVANIA BUILDING REGULATIONS FOR PROTECTION FROM FIRE AND PANIC.
	ALLEGHENY COUNTY	AIR POLLUTION CONTROL (ALLEGHENY COUNTY HEALTH DEPARTMENT RULES AND REGULATIONS, ARTICLE XVIII).
		FORWARD TOWNSHIP ZONING ORDINANCE.
	WASHINGTON COUNTY	CANTON TOWNSHIP ZONING ORDINANCE.
		CARROLL TOWNSHIP ZONING ORDINANCE.
		CHARTIERS TOWNSHIP ZONING ORDINANCE.
		FELLOWSHIP TOWNSHIP ZONING ORDINANCE
		NORTH STRABANE TOWNSHIP ZONING ORDINANCE.
	WESTMORELAND COUNTY	HEMPFIELD TOWNSHIP ZONING ORDINANCE.
		NORTH HUNTINGTON TOWNSHIP ZONING ORDINANCE.
		PENN TOWNSHIP ZONING ORDINANCE.
SOUTH DAKOTA	SOUTH DAKOTA AIR POLLUTION CONTROL COMMISSION	AIR POLLUTION CONTROL REGULATIONS FOR THE STATE OF SOUTH DAKOTA (1972).

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GOVERNMENTAL UNITS	RESPONSIBLE SUBDIVISION	REGULATION OR CODE
SOUTH DAKOTA (Cont'd.)	SOUTH DAKOTA ENVIRONMENTAL PROTECTION AGENCY	WATER POLLUTION CONTROL (CH. 46–25, SOUTH DAKOTA COMPILED LAWS 1973).
	SOUTH DAKOTA DEPARTMENT OF HIGHWAYS	SOUTH DAKOTA DEPARTMENT OF HIGHWAYS UTILITY ACCOMMODATION POLICY (1972).
	BROOKING COUNTY	BROOKING COUNTY ZONING ORDINANCE.
	DAY COUNTY	DAY COUNTY ZONING ORDINANCE.
	HAMLIN COUNTY	HAMLIN COUNTY ZONING ORDINANCE.
	MC PHERSON COUNTY	MC PHERSON COUNTY ZONING ORDINANCE.
WEST VIRGINIA	WEST VIRGINIA DEPARTMENT OF NATURAL RESOURCES	ADMINISTRATIVE REGULATIONS OF THE STATE OF WEST VIRGINIA FOR WATER QUALITY CRITERIA ON INTER AND INTRA STATE STREAMS (1970).
	WEST VIRGINIA DEPARTMENT OF HIGHWAYS	WEST VIRGINIA POLICY ON THE ACCOMMODATION OF UTILITIES ON STATE HIGHWAY RIGHTS-OF-WAY.

Source: Northern Border Project Environmental Assessment, Northern Border Pipeline Company, 1974.

Table 4.1.3.3-3 Pipeline industry standards

ORGANIZATION	DOCUMENTS
AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) ALL CURRENT STANDARDS ISSUED BY USASI AND ASA HAVE BEEN REDESIGNATED AS AMERICAN NATIONAL STANDARDS AND CONTINUED IN EFFECT.	1. ANSI A21.1 "THICKNESS DESIGN OF CAST-IRON PIPE (A21.1–1967). 2. ANSI A21.3 "SPECIFICATIONS FOR CAST-IRON PIT CAST PIPE FOR GAS" (A21.3–1953). 3. ANSI A21.7 "CAST-IRON PIPE CENTRIFUGALLY CAST IN METAL MOLDS FOR GAS" (A21.7–1962). 4. ANSI A21.9 "CAST-IRON PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS FOR GAS" (A21.9–1962). 5. ANSI A21.11 "RUBBER GASKET JOINTS FOR CAST-IRON PRESSURE PIPE AND FITTINGS" (A21.11–1964). 6. ANSI A21.50 "THICKNESS DESIGN OF DUCTILE-IRON PIPE" (A21.50–1965). 6a. ANSI A21.52 "DUCTILE-IRON PIPE' CENTRIFUGALLY CAST, IN METAL MOLDS OR SAND-LINED MOLDS FOR GAS" (A21.52–1965). 7. ANSI B16.1 "CAST IRON PIPE FLANGES AND FLANGED FITTINGS" (B16 1 1967). 8. ANSI B16.5 "STEEL PIPE FLANGES AND FLANGED FITTINGS" (B16.5–1968). 9. ANSI B16.24 "BRONZE FLANGES AND FLANGED FITTINGS" (B16.24–1962). 10. ANSI B36.10 "WROUGHT-STEEL AND WROUGHT-IRON PIPE" (B36.10 1959). 11. ANSI C1 "NATIONAL ELECTRICAL CODE, 1968" (C1–1968).
AMERICAN PETROLEUM INSTITUTE	1. API STANDARD 5L "API SPECIFICATION FOR LINE PIPE" (1967, 1970 EDITIONS). 2. API STANDARD 5LS "API SPECIFICATION FOR SPIRAL-WELD LINE PIPE" (1967, 1970 EDITIONS). 3. API STANDARD 5LX "API SPECIFICATION FOR HIGH-TEST LINE PIPE" (1967, 1970 EDITIONS). 4. API RECOMMENDED PRACTICE 5L1 ENTITLED "API RECOMMENDED PRACTICE FOR RAILROAD TRANSPORTATION OF LINE PIPE" (1967 EDITION). 5. API STANDARD 5A "API SPECIFICATION FOR CASING, TUBING, AND DRILL PIPE" (1968 EDITION). 6. API STANDARD 6A "SPECIFICATION FOR WELLHEAD EQUIPMENT" (1968 EDITION). 7. API STANDARD 6D "SPECIFICATION FOR PIPELINE VALVES" (1968 EDITION). 8. API STANDARD 1104 "STANDARD FOR WELDING PIPE LINE AND RELATED FACILITIES (1968 EDITION).

Source: Northern Border Project Environmental Assessment; Northern Border Pipeline Company, 1974.

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ORGANIZATION	DOCUMENTS
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)	1. ASME BOILER AND PRESSURE VESSEL CODE, SECTION VIII "PRESSURE VESSELS, DIVISION 1" (1968 EDITION). 2. ASME BOILER AND PRESSURE VESSEL CODE, SECTION IX "WELDING QUALIFICATIONS" (1968 EDITION).
AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)	1. ASTM SPECIFICATION A53 "STANDARD SPECIFICATION FOR WELDED AND SEAMLESS STEEL PIPE" (A53–65, A53–68). 2. ASTM SPECIFICATION A72 "STANDARD SPECIFICATION FOR WELDED WROUGHT-IRON PIPE" (A72, 64T, A72–68). 3. ASTM SPECIFICATION A106 "STANDARD SPECIFICATION FOR SEAMLESS CARBON STEEL PIPE FOR HIGH-TEMPERATURE SERVICE" (A106–66, A106–68). 4. ASTM SPECIFICATION A134 "STANDARD SPECIFICATION FOR ELECTRIC-FUSION (ARE)-WELDED STEEL PLATE PIPE, SIZES 16 IN. AND OVER" (A134–64, A134–68). 5. ASTM SPECIFICATION A135 "STANDARD SPECIFICATION FOR ELECTRIC-RESISTANCE-WELDED STEEL PIPE" (A135–63T, A135–68). 6. ASTM SPECIFICATION A139 "STANDARD SPECIFICATION FOR ELECTRIC-FUSION (ARE)-WELDED STEEL PIPE (SIZES 4 IN. AND OVER)" (A139–64, A139–68). 7. ASTM SPECIFICATION A155 "STANDARD SPECIFICATION FOR ELECTRIC-FUSION-WELDED STEEL PIPE FOR HIGH-PRESSURE SERVICE" (A155–65, A155–68). 8. ASTM SPECIFICATION 211 "STANDARD SPECIFICATION FOR SPIRAL WELDED STEEL OR IRON PIPE" (A211–63, A211–68). 9. ASTM SPECIFICATION A333 "STANDARD SPECIFICATION FOR SEAMLESS AND WELDED STEEL PIPE FOR LOW-TEMPERATURE SERVICE" (A333–64, A333–67). 10. ASTM SPECIFICATION A377 "STANDARD SPECIFICATION FOR CAST-IRON AND DUCTILE-IRON PRESSURE PIPE" (A377–66). 11. ASTM SPECIFICATION A381 "STANDARD SPECIFICATION FOR METAL-ARE-WELDED STEEL PIPE FOR HIGH-PRESSURE TRANSMISSION SERVICE" (A381–66, A381–68). 12. ASTM SPECIFICATION A539 "STANDARD SPECIFICATION FOR ELECTRIC-RESISTANCE WELDED COILED STEEL TUBING FOR GAS AND FUEL OIL LINES" (A539–65). 13. ASTM SPECIFICATION B42 "STANDARD SPECIFICATION FOR SEAMLESS COPPER PIPE, STANDARD SIZES" (B42–62, B42–66).

Source: Northern Border Project Environmental Assessment; Northern Border Pipeline Company, 1974.

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ORGANIZATION	DOCUMENTS
AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)	14. ASTM SPECIFICATION B68 "STANDARD SPECIFICATION FOR SEAMLESS COPPER TUBE, BRIGHT ANNEALED" (B68–65, B68–68). 15. ASTM SPECIFICATION B75 "STANDARD SPECIFICATION FOR SEAMLESS COPPER TUBE" (B75–65, B75–68). 16. ASTM SPECIFICATION B88 "STANDARD SPECIFICATION FOR SEAMLESS COPPER WATER TUBE" (B88–66). 17. ASTM SPECIFICATION B251 "STANDARD SPECIFICATION FOR GENERAL REQUIREMENTS FOR WROUGHT SEAMLESS COPPER AND COPPER-ALLOY TUBE" (B251–66, B251–68). 18. ASTM SPECIFICATION D2513 "STANDARD SPECIFICATION FOR THERMOPLASTIC GAS PRESSURE PIPE, TUBING, AND FITTINGS" (D2513–66T, D2513–68). 19. ASTM SPECIFICATION D2517 "STANDARD SPECIFICATION FOR REINFORCED THERMOSETTING PLASTIC GAS PRESSURE PIPING AND FITTINGS" (D2517–66T, D2517–67). 20. ASTM SPECIFICATION A372 "STANDARD SPECIFICATION FOR CARBON AND ALLOY STEEL FORGINGS FOR PRESSURE VESSEL SHELLS" (A372–67).
MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)	1. MSS SP-25 "STANDARD MARKING SYSTEM FOR VALVES, FITTINGS, FLANGES, AND UNION (1964 EDITION). 2. MSS SP-44 "STEEL PIPE LINE FLANGES" (1955 EDITION). 3. MSS SP-52 "CAST IRON PIPE LINE VALVES" (1957 EDITION).
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	1. NFPA STANDARD 30 "FLAMMABLE AND COMBUSTIBLE LIQUIDS CODE" (1969 EDITION). 2. NFPA STANDARD 58 "STORAGE AND HANDLING, LIQUEFIED PETROLEUM GASES" (1969 EDITION). 3. NFPA STANDARD 59 "LP GASES AT UTILITY GAS PLANTS" (1968 EDITION). 4. NFPA STANDARD 59A "STANDARD FOR THE PRODUCTION, STORAGE, AND HANDLING OF LIQUEFIED NATURAL GAS (LNG)" (1971 EDITION).

Source: Northern Border Project Environmental Assessment; Northern Border Pipeline Company, 1974.

4.1.3.4 Additional Measures

Measures not specifically proposed by the applicant but that could significantly reduce environmental impacts if applied are discussed in this section. The construction schedule measure which affects several categories is given and consideration is given to each resource category discussed in Section 3.1.3.

Construction Schedule

The construction of the pipeline should be carefully scheduled to coincide with ideal conditions to minimize impacts on soil, wildlife, and crops. This is considered to be a major mitigating measure.

In general, scheduling is one of the critical factors in wind and water erosion and revegetation efforts.

Construction of the pipeline through the pothole country between September 1 and March 1 would avoid high water table problems. This would reduce the impacts on soils, vegetation, and nesting waterfowl. It would enhance revegetation efforts started in late fall or early spring and make it easier to compact the trench backfill. This schedule will result in the need for cold weather hydrostatic testing. Compaction of the backfill is essential to avoid the permanent draining of potholes.

Crossing crop land in Montana, North Dakota, South Dakota, Minnesota and Iowa during the fall and winter, after the crops have been harvested, which is also the drier part of the year, would reduce crop loss up to 25 percent in the year of construction. Since most of the western rangeland is of the summer type, impacts on range and cattle would also be reduced.

On cropland in Illinois and the other eastern States, impacts could be reduced by crossing them during the drier summer months.

Impacts in or near recreation areas could be reduced or eliminated by scheduling construction during the "off season."

Crossing some rivers or streams during low flow periods could reduce impacts on them, while crossing others during normal flow periods would be best. As a result each stream or river crossing should be individually evaluated for the best season for crossing, where practical construction could be so timed.

Considering the above advantages, a detailed schedule, which would be designed to minimize the major impacts, should be prepared and approved before construction begins.

Climate

No additional mitigating measures suggested.

Topography

Worked-out sand and gravel pits and other borrow pits should be restored to approximate original topographic contours.

Waste piles of modest volume could be shaped to blend with local topography and revegetated when landowners agree.

Geology

Geologic conditions that can present earthquake hazards usually can be avoided by minor route deviations. Pipeline alignment modifications could avoid sediments of glacial Lake Dakota in South Dakota. Old landslide deposits in the Appalachian Plateau Province can also be avoided through similar modifications.

Soils

As stated and discussed in Section 4.1.3.2, the applicant has expressed adoption of the Federal Power Commission's Guidelines for pipeline project restoration (CFR Title 18, Section 2.69) that topsoil will be restored where required by individual landowners. These measures by themselves do not provide adequate protection for erosion control or the restoration of cropland to preproject production levels. Topsoil should be double trenched for the entire route unless it can be demonstrated that spreading subsoil on the surface will have little impact on productivity of the corridor. This measure is the most important single action affecting problems of revegetation, erosion and loss of productivity.

Since CFR Title 18 is written as a guide, it lacks specificity and implementation is not mandatory. Therefore, these guidelines must not be the sole basis for construction and restoration practices. To minimize impact on soils, the best available measure must be applied to each potential impact problem. These measures must be made part of a detailed, site specific construction and/or rehabilitation plan. The plan should also evaluate the pipeline for all conditions of operation on local ground temperature as to its effect on local drainage problems.

Stripped and waste earth materials should be either removed from the right-of-way or, in certain cases, utilized on the site. Careful route selection should minimize the generation of these materials. Removal should include: (1) disposal at a sanitary landfill or (2) use as fill material where impact would be negligible. Use on the right-of-way should be limited to potentially productive soil material that does not contain rocks over 1 inch in diameter or is not excessively acidic. Temporary access over streambanks should be made through use of fill ramps rather than by cutting through streambanks, unless otherwise approved. Ramps should be removed upon termination of use and materials should be disposed of in accordance with the Waste Management Plan.

Water Resources

There are several measures that can be taken to mitigate the adverse effects on water quality. Water quality laws exist all along the route and compliance with them will materially assist in avoiding environmental degradation. Control of water pollution should include discharges of chemicals, metals, acid or radioactive materials, debris, toxic substances, dissolved or suspended solids, coloring materials, materials which will change the biochemical oxygen demand or materials which will change the temperature or increase the odor of a body of water. The most significant impact on the environment will occur during the construction phase and the primary one will be the increased turbidity of the streams crossed. Sediment laden water will drive out aquatic macrophytes and smother benthic organisms in the affected area downstream. For much of the route, the sediments would be fine so there is no practical means of filtering the sediment before it passes downstream. Thus, the most effective mitigating measure is to minimize the amount of sediment stirred up by minimizing the amount of equipment in the streams. Mobile ground equipment should not be operated in lakes, rivers, or class III, IV or V streams unless such operation is approved in writing.

Another means of mitigation is to reduce or eliminate the use of materials near bodies of water that can significantly degrade the water quality. In particular, lubricants, chemicals, metals, acids, herbicides, pesticides, or toxic substances should not be used near watercourses. Only nonpersistent and immobile types of pesticides, herbicides, and other chemicals should be used. Application should be approved in writing prior to use.

All pesticides, herbicides, and other chemicals, including maintenance materials such as oil, should be disposed of in a manner that will avoid environmental impact. The waste management plan should include disposal of these materials. Maintenance and repair work of equipment can be done away from streams. Human wastes should be contained as mentioned above to avoid reducing the oxygen level in the local waters. Unrestrained dumping of these materials can cause long-term degradations of water quality, particularly when oil, pesticides or herbicides become mixed with suspended sediments and drop onto the bottom of the body of water.

Testing of bottom materials prior to dredging an underwater channel can uncover bottom materials that are already polluted by earlier dumping. Removing this material from the stream or river during construction and placing it in a safe landfill can avoid further degradation in water quality.

Groundwater quality in the pothole region of North Dakota, South Dakota, and Minnesota may be degraded to some extent if the pothole seals are broken by the pipeline trench. This impact could be mitigated by prevention of pothole drainage through appropriate trench-sealing methods.

Vegetation

Rehabilitation of disturbed areas will require timely and successful revegetation. Along the right-of-way, a great variety of conditions will be encountered. Revegetation plans will need to be tailored to each different site condition. The applicant states..."revegetation will be based on the advice, guidelines, and regulations of the appropriate authority."

If soil and productivity losses are to be minimized and vegetation is to be restored to predisturbance levels, a variety of measures will be required to overcome conditions created by pipeline construction.

Conservation practices to prevent water from washing away new seeds may include diversions, terraces, mulching, etc.

Where wind erosion is a serious hazard, mulching or matting may be necessary to protect spoil piles before seeding and to protect seeds and seedlings after revegetation. There will be a need to identify areas where revegetation cannot be accomplished in one or more growing seasons, and measures will need to be taken to prevent erosion in the interim period.

Species selection will be extremely important since reconstituted sites may differ significantly from surrounding areas. Where it is desirable to reestablish natural plant communities, seed and plant materials for native species may be difficult to obtain.

Widespread revegetation with introduced species could establish monoculture communities that would seriously affect existing ecosystems. Plants with high palatability factors could cause high concentrations of both livestock and wildlife along the reseeded right-of-way. This upsets the normal grazing pattern and frequently destroys the new vegetation along the right-of-way.

On woodlands, the total 100-foot wide right-of-way should be permitted to return to shrubs and trees.

For best results in revegetation and erosion control efforts, locally available expertise should be fully utilized. Criteria for revegetation and land rehabilitation are available from local soil conservation districts, county extension offices, State universities, Federal and State agencies and others.

The proposed route through the Ordway Memorial Prairie in McPherson County, South Dakota should be adjusted to completely avoid the preserve. This action would completely mitigate the impacts on this area's relict vegetation as well as on the antelope herd which inhabits the preserve. The route should deviate to the east, north of State Highways 10 and 45 paralleling the northern boundary of the preserve. (Figure 4.1.3.4-1.)

Wildlife

Protection of Fish and Wildlife

The lack of detailed information on the exact locations of the proposed route, access roads, spoil areas, borrow areas, storage and preparation sites makes the formulation of specific measures to mitigate fish and wildlife and other environmental losses very difficult. Mitigation might best be achieved by the establishment of technical review teams and construction monitoring teams for various stretches of the pipeline. These teams could include State and Federal fish and wildlife biologists, archeologists, soil scientists, and other resource personnel familiar with local conditions and values.

The technical review teams should participate in the selection of the exact alignment of the route, in the choice of access routes, spoil areas, borrow areas, etc., and in the selection of land reclamation or resource replacement alternatives. Since construction impacts can be magnified or decreased depending on the attitude of the contractor and his employees, monitoring teams should work closely with the contractors during construction.

These on-the-ground specific mitigation decisions cannot be made on the basis of a very general survey of the possible path of the proposed route and without any indication of the off-route locations, such as borrow areas, to be impacted. There are some general mitigation procedures adaptable to various types of situations which will be encountered during construction which can be described.

The preferable mitigation procedure on potholes and other wetland areas is to make minor route changes to avoid these very valuable and rapidly vanishing wildlife areas. In detailed route planning, these areas should be avoided. However, if the proposed route is followed across the pothole country, it may not be possible to avoid all potholes. Where potholes will be involved, construction activities should not take place in the critical breeding and brooding period May through July. While the applicant states generally that drainage patterns and the values of potholes impacted will be

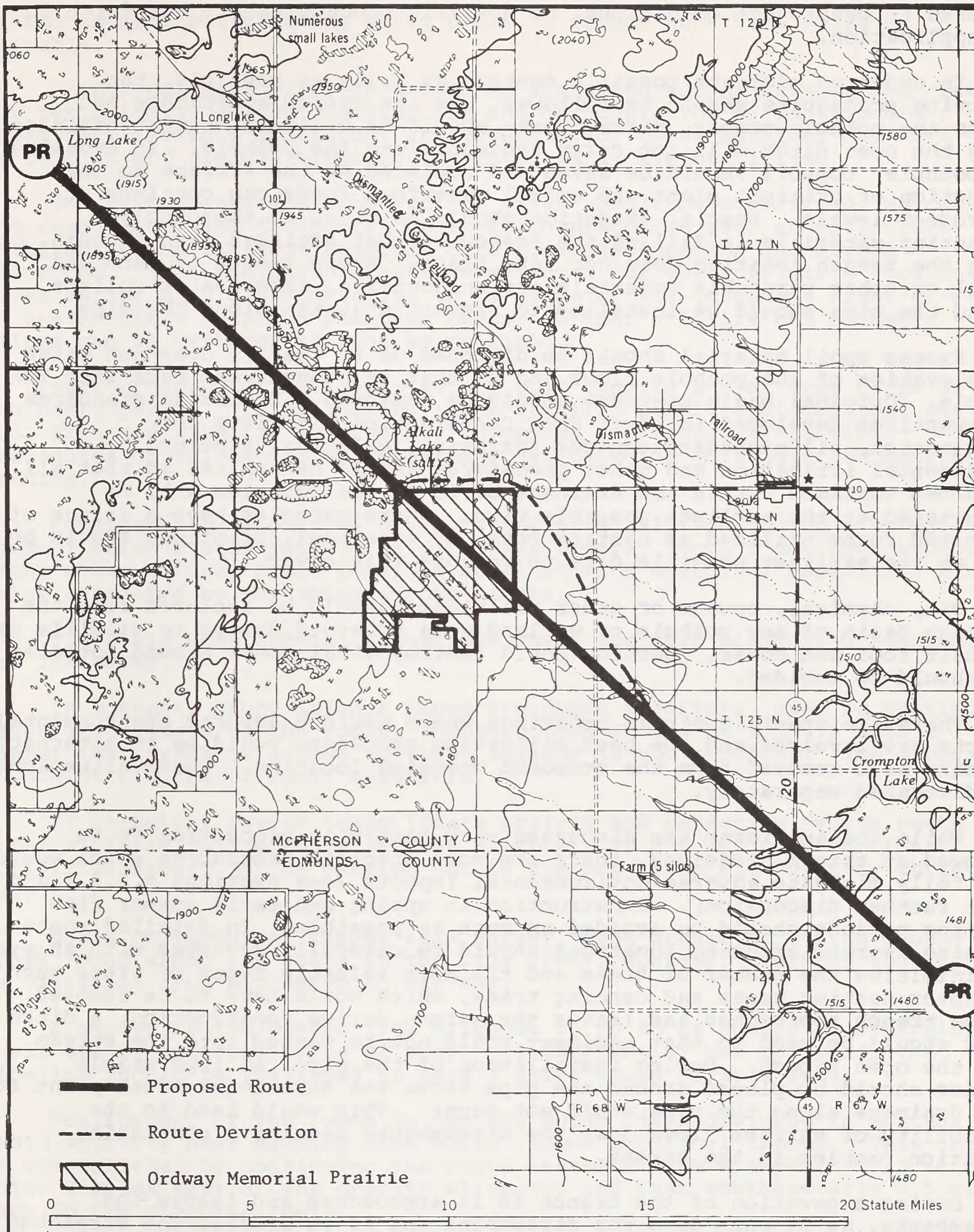


Figure 4.1.3.4-1 Ordway prairie route orientation

restored to preproject conditions, no specific procedures are set forth in the application.

In order to mitigate possible damages as fully as possible, the following procedures should be followed. As the trench approaches and leaves the pothole proper, ditch blocks should be utilized so that drainage along the open ditch will not carry sediment into the pothole. In crossing the pothole, topsoil should be saved and replaced at the surface so that production of critical plant and animal waterfowl foods can continue at preproject levels. Special attention should be given to thoroughly compacting materials in filling the trench so that drainage down through, or along the trench location does not take place. Where lenses of sand and gravel or other permeable materials are encountered, impermeable collars around the pipe should be installed to prevent drainage along the pipe.

Excess spoil material should be disposed of so that it does not raise the elevation of the pothole floor and so that it cannot wash back into the pothole. Original basin contours should be restored. Utilizing standards and practices developed in local Soil Conservation Districts for revegetation, all necessary contour furrowing, mulching, seeding, supplemental irrigation and other procedures should be applied so that all disturbed surfaces within the drainage basin of the potholes will be revegetated at the earliest possible time. Where potholes have a fringe of brush and forbs utilized as nesting cover by waterfowl, plantings should be made at the earliest possible date to restore this cover.

Oil, chemical, sewage or other pollutants should be excluded from the drainage basin of any pothole or wetland area to avoid damage to wildlife or to their food and cover. Burning could destroy vital cover around potholes and should be avoided.

There are specific stream crossings where serious adverse environmental impacts are involved and the best mitigation procedure would be an alternate crossing well removed from the proposed crossing location. These situations are discussed separately.

While the applicant has discussed very generally procedures to be followed at stream crossings, there are more specific procedures which would more fully mitigate adverse environmental impacts (see Sections 4.1.3.1 and 2 for further discussion). Construction in spring and early summer fish spawning periods should be avoided as much as possible. In detailed route planning, stream crossing locations should be carefully reviewed with an eye to minimizing the number of trees and the more valuable types of trees such as raptor nesting trees and denning trees, which would have to be removed. As the trench approaches and leaves the stream during construction, a ditch block should be used so that sediment would not be washed into the stream from the open trench. During installation of the pipe, an impermeable barrier should be placed around the pipe above the streambank break point so that drainage along the pipe would not occur. This would lead to the possibility of surface flows down the streambanks causing a continuing siltation problem in the stream.

During excavation of the trench as it approaches and leaves the streambanks, as it cuts down the streambank and as it crosses the streambed itself, all excavated material should be stored so that it will not wash into the stream in the event of rainstorms. No material should be stored on the streambed where a sudden freshet could result in extensive and long-term downstream sedimentation damage. In filling the trench, the streambanks should be thoroughly compacted and topsoil replaced to ensure early recovery of these control areas. The streambed should be surfaced with material identical to or no more erodible than the original substrate. Where bedrock is encountered and blasting takes place, a rubble substrate would be suitable.

Downstream silt barriers should be installed across streams and cleaned out periodically during construction and on completion of construction. Where very erodible conditions are encountered, these barriers may have to be left in and cleaned periodically until banks are stabilized.

The streambanks and construction sites should be stabilized, mulched and revegetated and necessary conservation practices such as diversions utilized at the earliest possible date to reduce erosion and stream siltation. Tree and shrub plantings selected for their wildlife food and cover values should be installed up to edges of the permanent right-of-way at the earliest possible planting season so that wildlife and esthetic values can be restored as soon as possible.

Each crossing of navigable waters will require a U.S. Army Corps of Engineers permit. In evaluating these specific permit applications, the U.S. Fish and Wildlife Service may recommend additional mitigation procedures or relocation of crossing sites based on more detailed onsite studies.

Consideration should be given to the possibility of using a satellite communication system instead of microwave towers. Such a decision would, among other things, avoid possible conflict with wildlife, especially birds being attracted by the white strobe lights.

There are some special situations where specific mitigation measures are indicated.

In Montana, oxbow islands above Frenchman Reservoir, used by nesting geese are crossed by the route. Construction should be done in such a manner that predator access to these islands is not provided. The oxbows should be cleared of spoil materials.

If technical review teams locate prairie and peregrine falcon nests in close vicinity to the route between Mileposts 10 and 28, construction activities should not be carried out in the area from mid-February through July.

Based on technical review team survey, sage grouse strutting ground areas found along the route in the Lime Creek, Montana, drainage should not be disturbed from mid-March to mid-May.

A survey of the buttes from Milepost 83 to 85 is needed to determine their use by breeding birds of prey. If substantial use is found, the pipeline should be realigned to pass 2 miles south of this area.

Realignment of the route in the Big Muddy Creek drainage in Montana to avoid activity near Manning Lake would reduce waterfowl impact. This could be accomplished by continuing the route eastward from Milepost 140.5 to a point 3 miles east of the present alignment and then southeasterly 2.5 miles back to the proposed route.

An erodible sandhill area is located between Mileposts 149 and 152. A rerouting half a mile south would avoid a fragile prairie community.

The very considerable adverse impacts at the Mississippi River crossing site noted earlier could be avoided to a major extent by moving the crossing about 2 miles downstream to River Mile 497. Here the river is about 1-mile wide and there are no bottomland sloughs involved. An upstream alternative crossing would be severely destructive of bottomland habitat.

In Minnesota, the State's Coon Creek Wildlife Management Unit is crossed by the route. Some minor realignment could considerably reduce the environmental impact and should be planned with the State. The State's Lyons and Ivanhoe Wildlife Management Units are also adversely impacted by the route alignment and an alternate routing around these State areas should be planned. These areas were specially selected and set aside to provide for wildlife purposes. If their use and potentials are impaired, replacement areas should be purchased by the applicant and deeded to the State.

In Illinois, the wildlife values of the Big Bend State Conservation area will be reduced by pipeline construction through this reserve. Rerouting the pipeline to pass south of this area would eliminate this problem (see Figure 4.1.3.4-2). Without such a realignment, the State's long range management plans for the area will be disrupted and options severely limited. Acquisition of additional lands by the applicant could be required to replace the lost potentials of the area.

The proposed alignment in crossing Pecumsaugan Creek runs through an unusual area recommended for State purchase by the Illinois Natural Preserves Commission. Discussions with the owner are underway. Also involved in this segment of the route is critical habitat of the endangered Indiana bat which hibernates in nearby Black Ball Mine.

On the south side of the Illinois River, this segment of the route crosses land recently acquired by the Illinois Department of Conservation which will be dedicated as a connecting section between two sections of the Starved Rock Nature Preserve and State Park.

Also crossed is a corner of Matthiesen State Park. A realignment around this area is the only feasible mitigation procedure to avoid substantial wildlife, vegetation, and recreation losses. This realignment could cross higher up on Pecumsaugan Creek and proceed easterly to cross the Illinois River east of the Starved Rock Nature Preserve. A technical review team should work out details of the realignments.

In Ohio a realignment is necessary to avoid losses to research areas in the Delaware Reservoir Wildlife area. Years of research cannot really be compensated for if research plots are destroyed and only a cooperative search for a new alignment will prevent serious damage.

Acquisition of Land and Waters

Where national wildlife refuge lands; State wildlife areas; National, State or local recreation areas; or other public use areas lie in the path of the final pipeline route and it is determined after study of detailed construction and operation plans by the managing agency that there will be a loss to the purposes for which these lands were acquired by the public, then additional lands or waters should be acquired by the applicant and title transferred to the managing agency. The model for this arrangement would be the Land and Water Conservation Fund requirement for replacement of federally assisted recreation areas. Where suitable lands and waters are not available in the immediate vicinity, compensatory lands and waters in other locations selected by the agency could be substituted. Where development of existing public areas would in the opinion of the managing agency provide adequate compensation, the applicant should fund such development.

Acquisition of Rights in Lands and Waters

Where wetlands under Federal easement for waterfowl production are traversed by the pipeline and drainage takes place in spite of restoration attempts, then easements on comparable wetlands areas selected by the U.S. Fish and Wildlife Service should be acquired by the applicant and such easements transferred to the Federal Government.

Ecological Considerations

No additional measures proposed.

Economic Factors

No additional mitigating measures proposed.

Sociological Factors

Special provisions should be made to compensate communities, especially small rural ones, for additional costs incurred in providing additional community services during the influx of population generated by the proposed project.

Land Use

Waste Disposal

There are a number of measures that should be taken to mitigate the adverse impacts associated with the disposal of waste, primarily during the construction phase. Because waste disposal is site specific, only several alternatives can be given, the specific one will depend upon the locale. Several of these mitigating measures have been incorporated into the guidelines found in Chapter 1 of Title 18 and Section 192 of Title 49, Code of Federal Regulations.

The only practical means of handling such site specific activities as waste disposal is to develop a management plan. A waste management plan should be developed and submitted to the responsible agency based on a detailed assessment of the waste problems at the stage of proceedings where it is feasible to make a detailed evaluation. This plan should set forth policy and such details as are necessary to minimize environmental degradation.

Specific mitigating measures to be included in this plan are given below.

Trees and Brush

This material should be removed from rights-of-way without undue delay and may be disposed of in several ways: (1) by burning where permitted and subject to pollution mitigating measures given above; (2) by mechanical chipping and mulching; (3) by disposal at a sanitary landfill; (4) by burial along the right-of-way where permitted; (5) by stockpiling of brush for small game cover; (6) by sale of logs to commercial operators for construction use or firewood; and (7) by logging for pipeline construction needs. It should not be allowed to block streamflows, contribute to flood damage, result in streambed scour or other erosion.

Excess Construction Materials

These materials should be removed from the right-of-way and there are several means of disposal available. They are: (1) reuse at other points of the construction; (2) disposal at a sanitary landfill; (3) sale to salvage dealers; (4) burning where applicable and where permitted; (5) burial on or near the right-of-way where permitted; and (6) offer the materials to the local population.

Human Generated Wastes

Associated primarily with the construction phase will be large numbers of people who will generate both solid and liquid wastes. The handling of these wastes cannot be left solely to the small communities adjacent to the construction right-of-way because in many instances, these communities cannot or will not be able to handle the problem, specifically in the financial sense. To mitigate this impact, waste management factors should be considered prior to selection of any housing for employees or support personnel. To mitigate the solid waste collection problem, it may be possible to: (1) hire a commercial hauler or use the subcontractor as a hauler or (2) leave the material on the site. To facilitate disposal, the applicant could: (1) use existing garbage disposal systems such as sanitary landfills; (2) use landfills specifically developed by the applicant to handle the wastes from the transitory construction crews; or (3) attempt to recycle or reuse those materials which can be recycled. Burning or burial by the applicant should also be considered in conjunction with the wastes generated directly by the construction itself.

Liquid wastes from the construction crews and their supporting personnel and dependents will generally be handled by existing sewage systems. It may be necessary in certain cases for the applicant to provide facilities to handle this problem. Acceptable measures could be: (1) contractor installed systems; (2) septic tanks and leach fields; (3) tank systems which can be periodically pumped and then removed at the end of construction; or (4) pit privies for field use.

Urban Development and Expansion

Figure 4.1.3.4-8 illustrates a route deviation south of Pittsburgh, Pennsylvania. This area represents the most densely populated segment of the pipeline. The route deviation would mitigate the potential conflicts of the proposed route with the existing and potential urban development taking place to the south of Pittsburgh. It would also mitigate conflicts with utility lines accompanying the present and future development.

Archeology and History

1) Inventory historical, architectural, archeological, paleontological, and other cultural sites in the project corridor and in areas to be affected by the project such as borrow pits and access roads.

2) Evaluate all sites, buildings, districts and objects identified in the inventory (described above) using National Register criteria.

Figure 4.1.3.4-8 Pennsylvania route deviation

3) Nominate all federally owned sites that appear to qualify to the National Register.

4) Seek a determination from the Secretary of the Interior under Executive Order 11593, Section 2B and the ACHP (Advisory Council on Historic Preservation) procedures for the protection of historical and cultural properties regarding (a) sites that are questionable and (b) sites that appear to qualify that are located on non-Federal land.

5) All sites identified as eligible or listed in the National Register should be treated in accordance with the procedures of the ACHP as published in the Federal Register of January 25, 1974, codified in Title 36 CFR, Section 800.

6) Assign an archeologist to each construction unit involved in excavation. Delegate to him full authority to stop the work for a reasonable period until such important remains as might be found can be investigated.

7) Require applicant to fund any archeological, historical, architectural, paleontological, or cultural investigations necessary to clear the project with regard to mitigation agreed to by the ACHP or made necessary in the event of discovery once the project is underway.

8) Require that the archeologists hired to perform the onsite function meet minimum professional and ethical standards proposed by the profession. The final judgment regarding whether or not these are met should rest with USDI Consulting Archeologist in the Office of Archeology and Historical Preservation, National Park Service.

9) Require the applicant to provide for the salvage of artifacts unavoidably disturbed by construction by a professional team under National Park Service supervision.

Recreation and Esthetics

1) Consideration should be given to rerouting of the pipeline to avoid recreation areas such as West Fork River Green Belt, Iowa; Big Bend State Conservation Area, Illinois; Starved Rock and Matthiessen State Parks, Illinois; Mingo Creek Park, Pennsylvania; Round Hill Regional Park, Pennsylvania; and Salamonie State Recreation Area, Indiana. Figure 4.1.3.4-2 illustrates a possible route adjustment around Big Bend State Conservation Area. Figures 4.1.3.4-5 and -8 illustrate route deviations which include the avoidance of Starved Rock State Park and Mingo Creek and Round Hill Parks respectively.

2) Where rerouting of pipeline is not practical and where the recreation area has been acquired or developed with the assistance of Land and Water Conservation Fund money, applicant must comply with Section 6F of PL 88-578 (Land and Water Conservation Fund Act of 1965) regarding USDI Secretary approval of conversion of use of federally assisted recreation areas. This will apply at West Fork Green Belt, Iowa; Big Bend State Conservation Area and Starved Rock State Park, Illinois; Salamonie State Recreation Area, Indiana; and Mingo Creek Park, Pennsylvania.

3) Where recreation areas cannot be avoided, restoration of the right-of-way should be done so as to provide the recreational opportunities that were present before construction. This will include rebuilding road systems that have been damaged, replacing facilities, and re-establishing vegetation that screen the open right-of-way through the park.

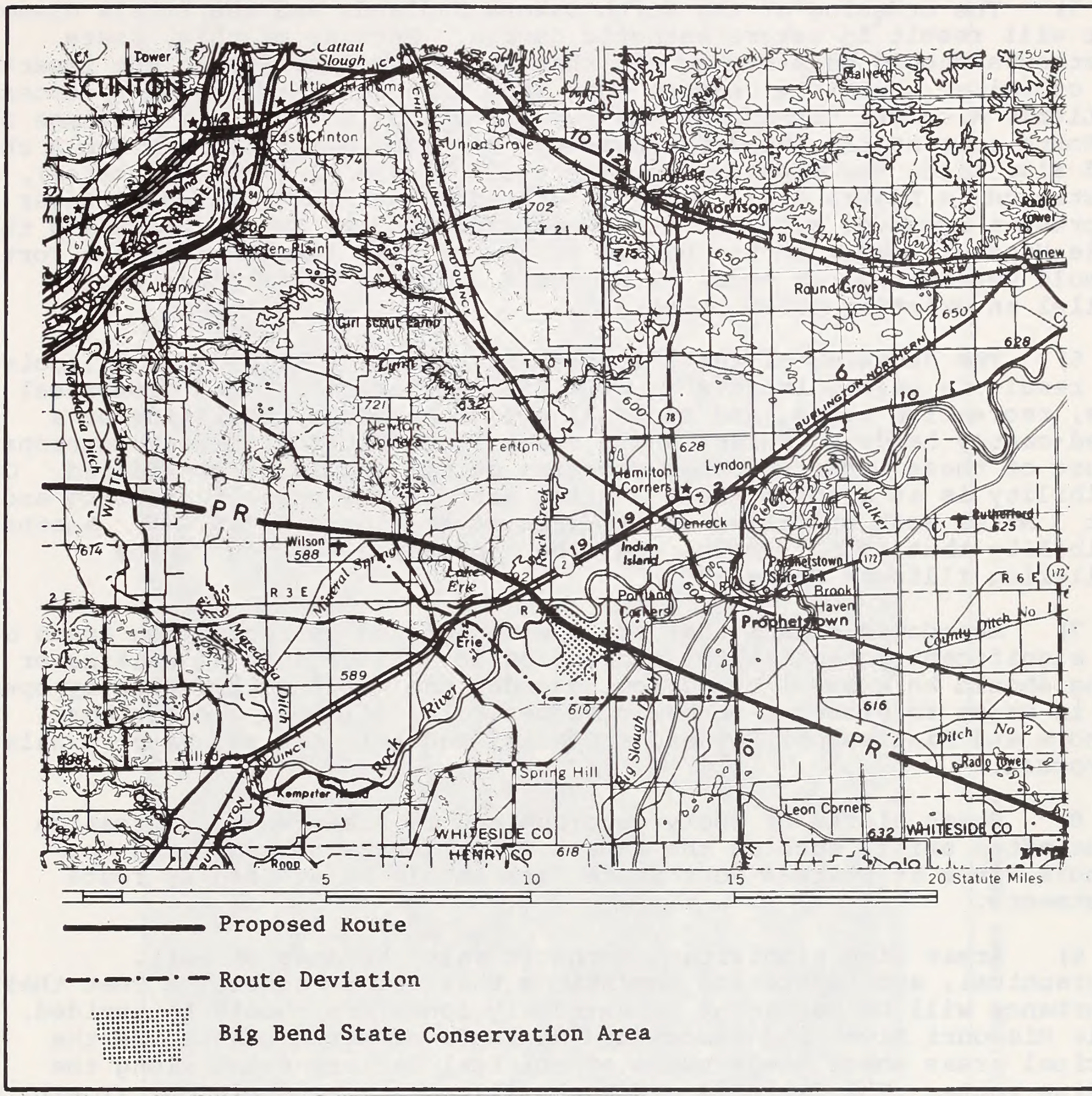


Figure 4.1.3.4-2 Big Bend State Conservation Area route deviation

4) The applicant should take necessary steps to avoid closed canopied hardwood forest areas where they occur within designated park and recreation areas and at river crossings where recreation and esthetic values are significant.

5) The crossing of the North Dakota Badlands and the Little Missouri River will result in severe esthetic damage. Because of this, route adjustments should be searched out that would avoid or lessen the impacts of this crossing. Possible changes that should be considered are (a) crossing the Little Missouri River near the U.S. 85 bridge at the east entrance of the North Unit of the Theodore Roosevelt National Memorial Park (this change would also allow the pipeline to pass south of the Killdeer Mountains), as illustrated in Figure 4.1.3.4-3; (b) crossing the Little Missouri River at the present crossing site but via suspension bridge, and (c) crossing the Little Missouri where it has become an arm of Lake Sakakawea in the Fort Berthold Reservation as shown by Figure 4.1.3.4-4. This route would parallel an existing Amoco pipeline.

6) The crossing of the Illinois River in LaSalle County, Illinois, will result in severe impacts on wildlife, archeological and historical sites, recreation areas, and regional esthetic values consisting of a closed-canopy hardwood forest and a steep river bluff with rock outcrops. Because of these impacts, other crossing points should be considered. One possibility is at a point about 7 miles east of the present crossing and about 3 miles west of Ottawa as illustrated by Figure 4.1.3.4-5. Another possibility that is not shown, would be a crossing south of Utica paralleling Illinois Route 178.

7) Abandoned canals that are now designated as recreation areas or have significant potential for recreation activities such as walking or hiking should be crossed by burrowing under the canal rather than by open cut, in order to preserve esthetic values. The Illinois and Michigan, Illinois and Mississippi Feeder, and Miami and Erie are the major canals to be crossed.

8) Steep bluffs or rocky outcroppings in areas where recreation values often exist, such as the Wabash River (west crossing) and the Illinois River at Starved Rock State Park should be avoided by route adjustments.

9) Areas with significant esthetic value because of soil, topographical, and vegetation conditions that are so sensitive that their disturbance will be permanent or extremely long term should be avoided. The Little Missouri River and associated Badlands of North Dakota are the principal areas where these types of critical factors exist along the pipeline route. The Illinois and Rock (Illinois), Wapsipinicon (Iowa), and Wabash (Indiana) are key rivers. A route change that would eliminate the two Wapsipinicon River crossings is shown on Figure 4.1.3.4-6. Figure 4.1.3.4-7 provides a possible solution to the crossing of the Upper Mississippi River Wildlife and Fish Refuge and the crossing of the Big Bend State Conservation Area.

10) Esthetic values can be protected somewhat by placing telephone and power lines to pipeline facilities underground. Maintenance cost could also be reduced by using underground lines.

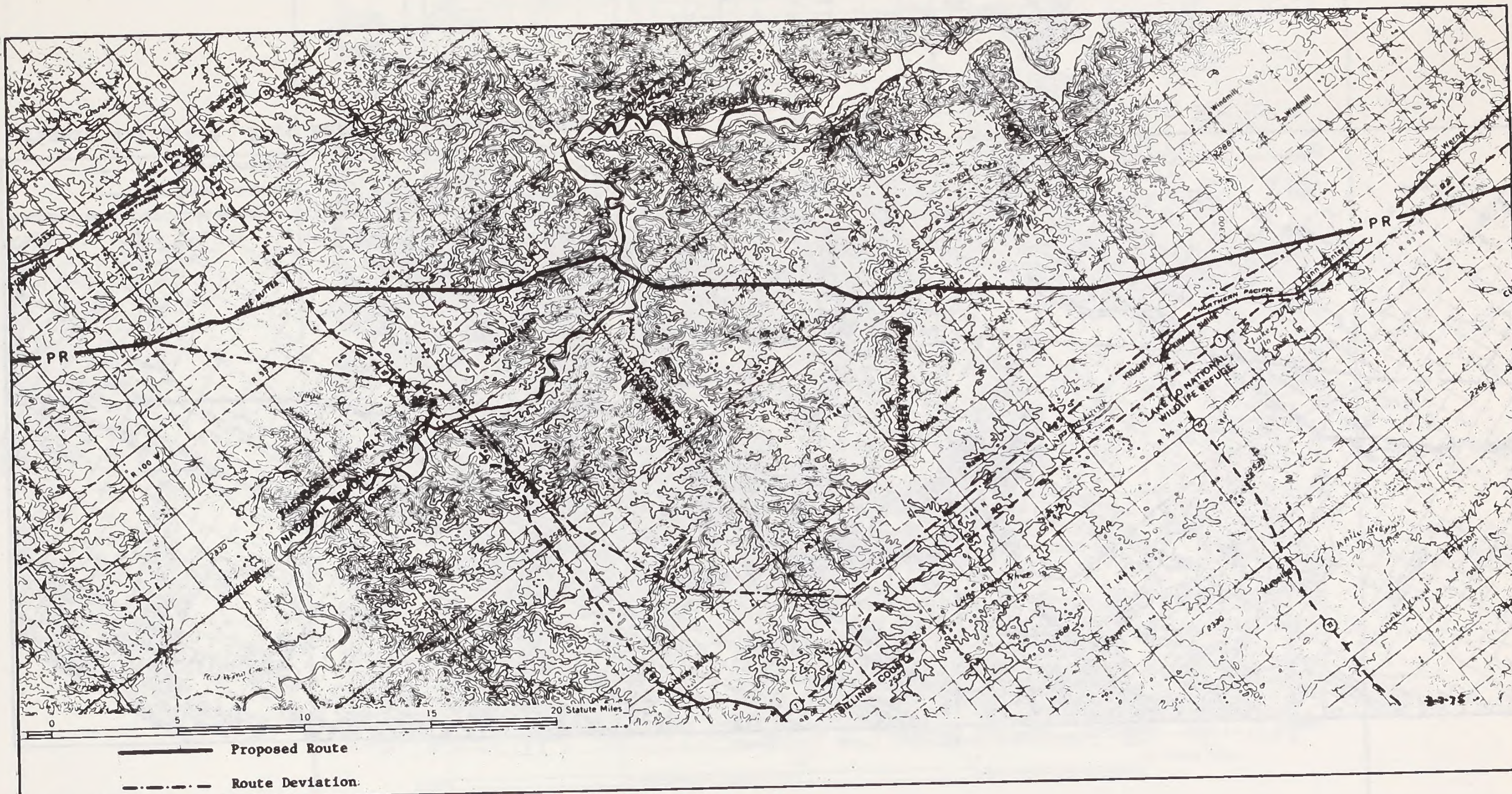


Figure 4.1.3.4-3 Highway 85 bridge route deviation

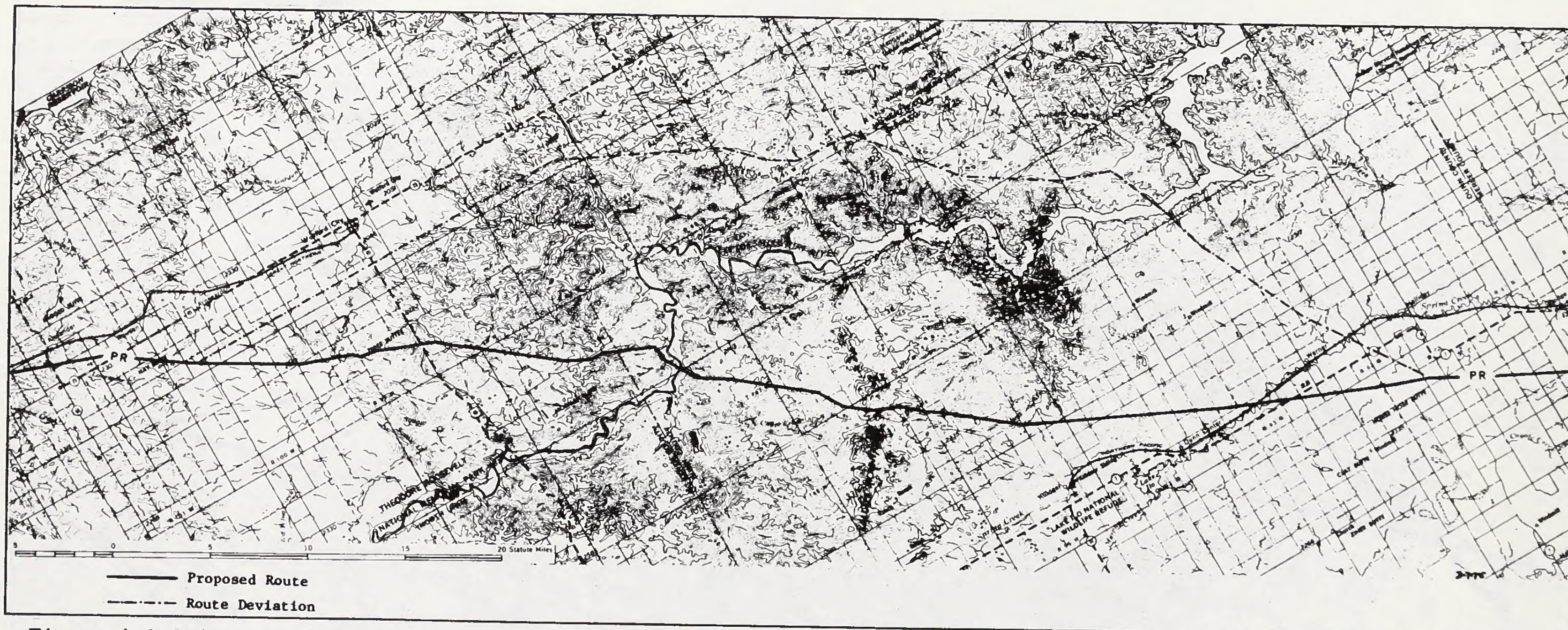


Figure 4.1.3.4-4 Fort Berthold route deviation

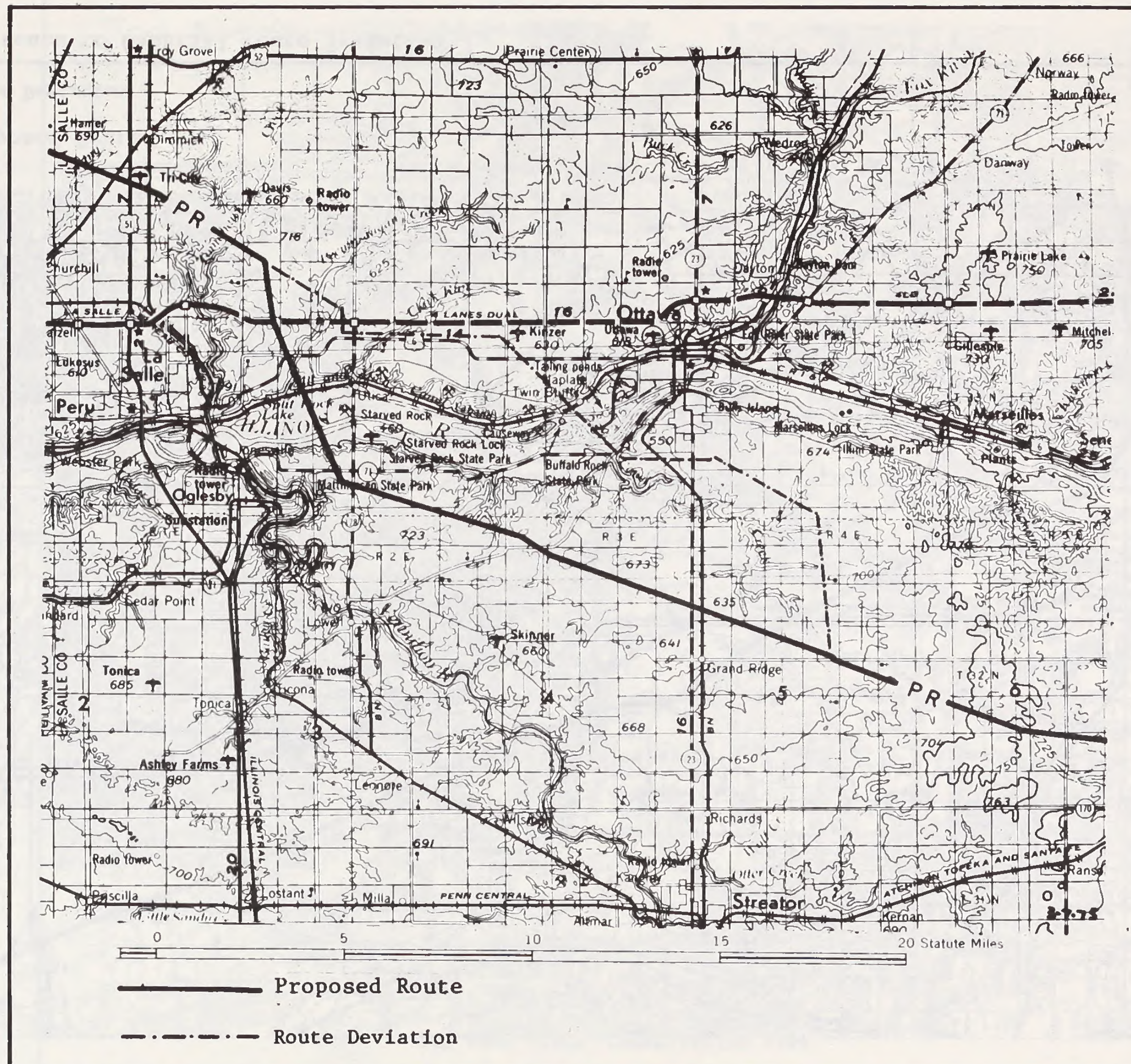


Figure 4.1.3.4-5 Illinois River crossing

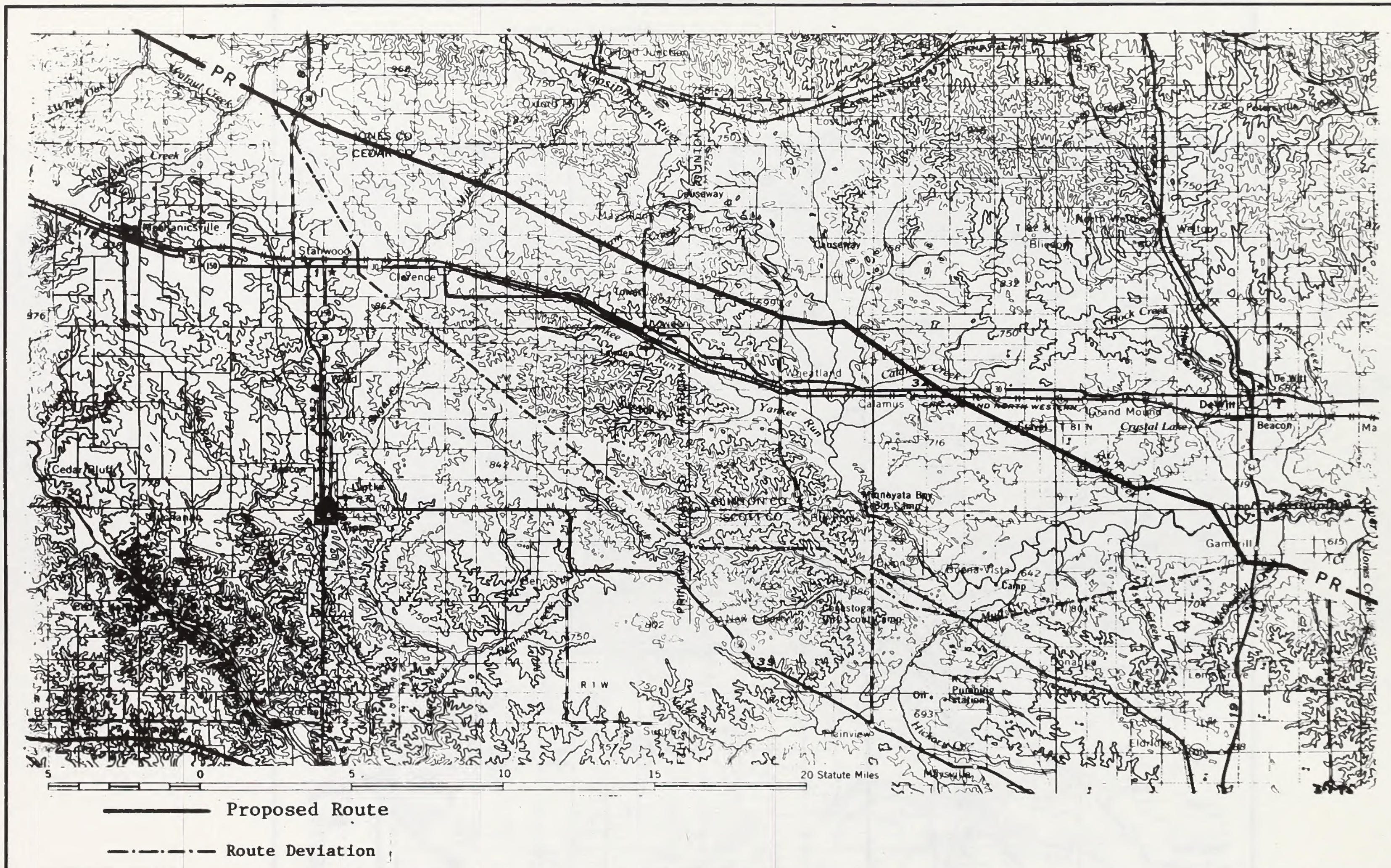


Figure 4.1.3.4-6 Clarence to Gambrill route deviation

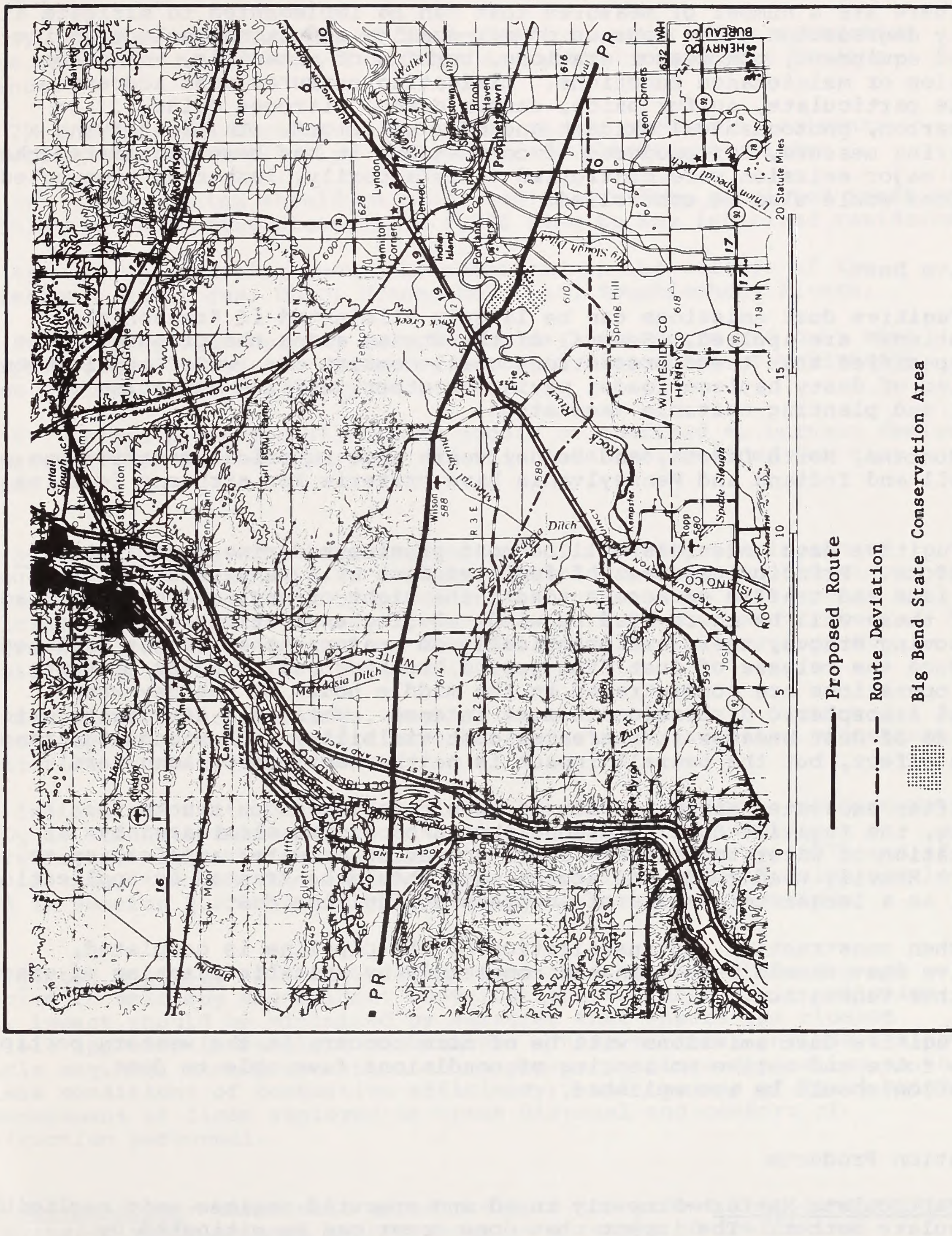


Figure 4.1.3.4-7 South Mississippi River route deviation

Air Quality

Pollution Control Measures

There are a number of measures that can be implemented to mitigate air quality degradation. The sources of air quality reduction include engine-powered equipment, compressor stations, burning of materials, and other operation or maintenance functions. Mitigating measures must address visible particulate, sulfur oxide, carbon oxide, nitrogen oxide, hydrocarbon, photochemical oxidant and odor emissions. In identifying a mitigating measure, for products of combustion, it has been considered that if the major emission were controlled satisfactorily, lesser but connected emissions would also be controlled.

Fugitive Dust

Fugitive dust emissions can be largely eliminated if "reasonable precautions" are applied. Several of the States along the proposed route have specified that these precautions shall consist of: water application; covering of dusty haulage loads; paving or other dustfree surfacing of roads; and planting suitable vegetation.

Montana, North Dakota, and Pennsylvania have numerical restrictions on dustfall and Indiana and Pennsylvania have criteria for airborne fugitive dust.

Fugitive dust emissions will be most prominent during construction operations. Principal sources of fugitive dust will be excavation operations and traffic on access roads, the right-of-way, and haulage roads. All of these will be aggravated by wind. During excavations and primary earthmoving stages, there are practically no measures that can be employed to reduce the release of dust from ground breaking and transfer of earth. These operations are concentrated in the middle hours of the day when natural atmospheric dispersion is most intense. This is a disadvantage in the case of dust because it increases dust visibility and extends the range of the effect, but the overall impact is neither serious or long term.

After excavated earth and debris have been loaded on trucks for hauling, the fugitive dust emissions should be almost eliminated by application of water to roadways and by covering or water application to loads. Heavily used roads and access ways should be treated by application of oil as a longer term means of suppressing fugitive dust.

When construction and installation of the pipeline is completed, fugitive dust should be eliminated completely by suitable planting of grass and other vegetation.

Fugitive dust emissions will be of more concern in the western portions of the route and active monitoring of conditions favorable to dust generation should be accomplished.

Combustion Products

Particulate Matter--Properly tuned and operated engines emit negligible particulate matter. The impact that does occur can be mitigated by requiring proper vehicle engine maintenance. The gas turbines of the compressor stations will emit no particulates during the operation phase, and no mitigating measures are required.

Open burning of debris can emit significant amounts of particulate matter as well as constitute a safety hazard. An adequate fire protection plan is essential. Emissions from open burning should be minimized by adopting the following procedures:

1) Employ open burning of land-clearing wastes and construction wastes only when no sanitary landfills are within reasonable hauling distance.

2) Avoid open burning of dangerous (e.g., chemicals, solvents, pesticides, explosives), oily, asphaltic, and plastic materials.

3) Open burning should be conducted as far from populated areas as possible and in no case closer than 1,000 feet to any inhabited residence.

4) No open burning should be permitted in the valleys of the Mississippi, Muskingum, Ohio, Monongahela, and Youghiogheny Rivers.

5) Employ open burning only during daylight hours and only when atmospheric conditions are conducive to rapid dispersion of pollutants (class C atmospheric stability or better).

6) Fires for personal comfort should be confined to burners designed and manufactured for that purpose and which use fuel refined for that purpose.

Nitrogen Oxides--The Principal method of reducing the impact of nitrogen oxide emissions is to maximize their dispersion in the atmosphere. Generally, this is achieved by providing exhaust stacks that are as tall as possible. Dispersion is necessary because there is no demonstrated, commercially available technology that will significantly reduce NO_x emissions from engines fired by fossil fuels.

Sensitive river crossings, such as those mentioned in Section 3.1.3.14, resist dispersion and therefore must be protected by avoiding concentrations of emission sources (vehicles).

Indiana and South Dakota have laws that limit absolute emission rates of NO_x as a function of energy consumed, for gas-fired turbines. Manufacturers claim that these limits will be achievable by 1977, and if this is true, then the the impacts from NO_x will be reduced below the levels cited in Section 2.1.3.14 and will require no further mitigation.

Carbon Monoxide--Although carbon monoxide (CO) emissions are not expected to make any significant contributions to ambient air pollution, their impact should be minimized by measures that ensure the closest possible approach to complete combustion. These measures include tuning of vehicle engines, steady operation of compressor engines (operating at the optimum conditions of combustion efficiency), and the use of "good practice" in management of fires employed in trash disposal and comfort of construction personnel.

Hydrocarbons--These will appear only to the extent that construction and transfer vehicles emit hydrocarbons as a result of inefficient combustion of fuel (diesel or gasoline). Therefore, their impact should be reduced by the same techniques employed to reduce carbon monoxide emissions. There is no significant emission of hydrocarbons from gas turbines, so no mitigating measures are necessary here.

Air Pollution Alerts

In the eastern sections of the pipeline route, the likelihood of severe air pollution incidents is greater than for the western sections. If alerts are given, all mobile equipment should cease operation for the duration of the alert and all fixed installations shall carefully monitor their facilities to ensure compliance with local law.

Environmental Noise

The primary noise impact is sound emitted by engine powered heavy vehicles, thus the primary mitigating measure should be a requirement that all diesel engine-powered vehicles or equipment be equipped with mufflers. Since the U.S. Environmental Protection Agency has recently adopted noise standards for trucks used in interstate commerce, these standards should be applied to all offsite diesel engine-powered trucks.

All onsite engine-powered equipment should be equipped with mufflers that are equivalent to high quality mufflers used on diesel trucks. Since there is a wide variety of equipment to be used, it is not possible to specify individual muffler types or to set standards on noise levels to be met. It is not suitable to require mufflers without specific muffler performance requirements, since many pieces of construction equipment have "mufflers" but they are completely ineffective in reducing noise. The use of mufflers will also reduce the noise exposure of equipment operators and nearby construction personnel to meet OSHA noise limits.

Air compressors should meet U.S. Environmental Protection Agency standards.

Annoyance from construction noise is greatest during the evening hours. In order to mitigate the disturbance, construction should be avoided between 9 p.m. one day and 6 a.m. the next.

Since blasting results in environmental noise of serious nature and ground vibration of large magnitude, control of explosives used is important. A valuable means is to write an explosives management plan which is submitted to the proper agency when detailed knowledge of the need for and the potential adverse effects of any blasting is known. This plan should set forth policy; include blasting techniques and locations; and include methods for avoiding rockfalls, landslides, damage to structures, people and wildlife, particularly aquatic. Minimizing charge size and blasting only during the day should be required.

Noise from the compressor stations will be the only environmental noise problem during the normal operational phase. The operating noise will be continuous and for the most part will intrude on extremely low ambient levels, contributing a permanent and significant degradation of the environment in a circular area surrounding the station. For mitigation of this noise, several factors must be considered: the degradation, the absolute levels, the variability of the sound and the range of audibility.

All of the 12 proposed stations will be constructed in essentially rural or underdeveloped areas which presently are very quiet. The distances at which the 30,000-hp stations will impact residences with a normalized Ldn greater than 55 dB can probably be reduced from 6,650 to 4,900 feet by acoustically treating the compressor building and by treating the turbine intakes and exhausts with additional silencing equipment (beyond the standard manufacturer's measures). This distance reduction would be about 5,300 to 3,800 feet for the 13,500-hp stations. These measures are estimated to reduce the number of people impacted by a normalized Ldn greater than 55 dB by 19 percent, the number of people highly annoyed by 12 percent, and the number of complaints by 25 percent. These attenuation measures should be engineered to reduce the sound levels of the stations by a minimum of 8 dBA.

Stations 22 and 24 are estimated to impact 727 people with day-night sound levels in excess of the U.S. EPA goal for welfare (55 dBA). This is 79 percent of the total number of people impacted by noise emissions from all 12 stations. It is estimated that the impact of these 2 stations could be reduced to a total of 30 people by locating the stations from 5,400 to 7,500 feet east or west (along the line) of the proposed locations. (Refer to Table 4.1.3.4-1 for further details.) These location changes would result in an estimated reduction of the total number of people impacted by noise emissions from the 12 stations from 920 to 223; a 86 percent reduction. Similarly, the number of people highly annoyed and the number of complaints expected to result from operation of the 12 stations would be reduced by 87 and 91 percent, respectively.

The compressor stations to be installed in the State of Illinois will have to meet the State noise regulations. To do this, either engineering noise control must be applied or more property must be procured. Although the applicant has provided no details of its characteristics, the stations are expected to be like others of their kind, at least acoustically, so it is reasonable to estimate that the technology exists to control compressor station operating noise. All stations should be designed to meet the night standards of the State of Illinois. The trend in State noise control legislation has been to regulate stationary noise sources and eventually all stations will have to meet standards similar to those of Illinois. Thus, it would be more cost effective to implement the noise control during the design phase; or at least make allowance for future installation of muffling equipment.

The noise within a compressor station could exceed the limits of the Occupational Safety and Health Act which is 90 dB(A) for 8 hours. Since the noise will be steady and continuous, the 8-hour provision is relevant. The station can be designed to bring these levels down below statutory limits. There is strong pressure to reduce the limit to 85 dB(A) by the Environmental Protection Agency. Thus, for any station in which it is expected that an employee will work for 8 or more hours in any day, the station should be designed for a maximum level of 85 dB(A).

All gas vents should be equipped with muffling devices designed specifically for the reduction of supersonic jet noise which would occur when vents are used. This particular noise source is very intense and would be heard for long distances without a muffler.

Noise Research and Monitoring

Prior to the initiation of compressor site construction, ambient noise monitoring is proposed by the applicant to insure the compressor stations have little noise impact on the surrounding area. In particular, ambient noise monitoring will be necessary in order to reduce the zone of audibility of these stations. Such data will be useful in designing the station noise control features. In addition, the predicted zone of audibility will be useful if provided to city or county land use agencies for use in avoiding future residential development in the near vicinity of these stations.

Table 4.1.3.4-1 Change in the Impact of Gas Compressor Station Noise on People as a Function of Station Location

Station Number	Location	Estimated # of people impacted by a normalized $L_{dn} > 55dB$	Estimated # of people highly annoyed	Estimated # of complaints	Estimated decrease in the # of people impacted by a normalized $L_{dn} > 55dB$*	Estimated decrease in the # of people highly annoyed*	Estimated decrease in the # of complaints*
22	Proposed	256	100	8	0	0	0
	6300 ft. east along line**	11	3	0	245	97	8
	5400 ft. west along line	34	9	0	222	91	8
24	Proposed	471	124	5	0	0	0
	5400 ft.east along line**	19	5	0	452	119	5
	7500 ft.west along line	26	7	0	445	117	5
Total Mitigation of ** Location Changes					697	216	13

*Decrease with respect to the proposed station location.

Use of Explosives

The shock of blasting can be controlled to a significant degree by various technical means. Perhaps the most common of these is the use of millisecond delays between each of several parts of a single blasting event. By doing this, the maximum velocity of any given particle of rock can be kept to less than 2 feet per second. Such a procedure should be implemented by the applicant to be within all State maximum velocity restrictions and to minimize rockfall hazards.

Hazards from Pipeline Failure

Abandoned Mine Location

The proposed pipeline route passes through an area of known underground mine workings in eastern Ohio. The extent of abandoned underground mine workings is typically poorly known. The possible hazard to the pipeline from surface subsidence caused by the collapse of old underground workings must be recognized. Every effort should be made to identify such potential hazards and the route adjusted to avoid them or provide pipe support sufficient to withstand the stress of subsidence.

Block Valve Failures

Because of the massive volume of natural gas in the pipeline, a serious safety hazard would occur if the mainline block valves failed to close following a line rupture; 49 CFR 192.179 specifies the separation of the block valves and requires that the valve be readily accessible and protected from tampering. Compliance with this regulation will not be sufficient to ensure adequate safety. There should be test procedures to ensure that both the signal system and the automated mechanical valve closing system are operative.

Proximity to High-Voltage Transmission Lines

The pipeline will cross several power transmission lines and the right-of-way will abut transmission lines for approximately 12.5 miles. There are several potential hazards associated with this. During construction of the pipeline, hazardous potentials can be developed on mechanical equipment or the pipeline if the equipment is improperly grounded. Ground mats and insulating gloves may be necessary if proper grounding cannot be guaranteed. During the operation phase, the electromagnetic field of the transmission line can induce potentials on the pipeline that will result in an accelerated corrosion rate and an increased potential for leaks. A proper cathodic protection system can reduce this adverse effect. Corrosion is discussed further in Sections 4.1.3.1 and .4. Fault currents caused by the voltage surges of lightning or powerline faults can cause arcing and will create temporary excess potentials on the pipeline that can be reflected in danger to any personnel in contact with it. The fundamental frequency of the line (60 Hz) and its harmonics will induce fields in any buried communication lines. If any of these buried lines are inadequately shielded and are used for transmitting safety information, for example, safety signals to mainline block valves, there may be a safety hazard. Since no decision has been made on such buried cables, the hazard is only a potential one.

Special precautions are required when blasting operations take place near high voltage transmission lines and should be a part of the explosives management plan. Procedures to be followed include first, the blasting operations must be controlled so that the lines will not be damaged by flying debris; second, avoid the use of conventional electric blasting caps and other electrically sensitive detonation devices which cannot be used in the vicinity of high-voltage transmission lines. Detonation of blasting agents will have to be accomplished by the use of either Shunted Safety Fuses or Exploding Bridgewire Detonators which are insensitive to electric fields.

Special Safety Measures

1) The applicant did not discuss the following items: Eye and face protection, welding goggles, ear defenders, hardhats, dust filters, x-ray guards, and ventilation will have to be provided where necessary to prevent injury in compliance with 29 CFR 1926 during construction. Power-operated handtools must comply with paragraph 302; construction equipment must meet the requirements of Subparts N and O. Life jackets must be supplied to crews on major river crossings (1926.106). During operation, employees are to be protected by compliance with 29 CFR 1910, the Occupational Safety and Health Act.

2) The applicant did not discuss safety aspects of the microwave towers. Although no specific heights are known as yet for the microwave towers, their separation distance suggests they will be between 200 and 300 feet high. In rural areas, these towers will likely be the tallest structures and will be difficult to see; therefore, they will pose an air safety hazard to low flying aircraft. Day and night marking as an obstacle must be done in conformance with Federal Aviation Administration regulations.

Consideration should be given to the possibility of using a satellite communication system, thus eliminating microwave towers and attendant facilities.

3) Responsibility for clearly defined segments of the pipeline, including compressor stations, should be established to ensure prompt response to emergencies.

4) To guarantee the fastest possible response to the pipeline corridor, access plans to the entire route should be prepared and made readily available. Vehicles capable of transporting men and material through the most severe physical conditions along the access routes must be maintained on standby basis.

5) A backup UHF communication system should be available in the event of failure of the primary system.

6) Additional monitoring capability should be identified for major and widespread disasters such as floods and earthquakes.

7) Pipeline features that will require special equipment, personnel or procedures to repair should be identified and availability established.

8) A training program to prepare employees for emergency conditions should be conducted at regular intervals.

9) The establishment of a plan for systematically notifying company, community, and government officials in case of emergency should be prepared.

10) Following an emergency situation, steps should be taken to investigate the causes to prevent future recurrences.

5 ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

5.1 ARCTIC GAS PIPELINE PROJECT

5.1.3 Northern Border Pipeline

Introduction

The following discussion summarizes the unmitigated adverse effects that will remain if the proposal is implemented and the effective mitigating measures discussed in Section 4 are applied.

Summary of Major Unavoidable Environmental Impacts

Although most of the anticipated impacts may be mitigated by the measures outlined in Section 4, many impacts can still be expected to occur. The major unavoidable impacts expected by the construction, operation, and maintenance of the proposed pipeline follow.

Soil contamination from construction cannot be entirely avoided. The severity will frequently depend on depth of the topsoil. Agricultural production during the year of construction will be totally lost unless a nongrowing season schedule is followed. In addition, the restoration of the original productivity of the soil will take at least several years to accomplish.

Vegetation along the entire construction right-of-way will be destroyed. Difficulty in revegetation will be experienced along the route. Fragile areas will require extended periods of time before satisfactory revegetation can be accomplished. In addition, permanent structures and roads will result in permanent clearing of vegetation.

The right-of-way through forested areas will be impacted for the long term with the removal of trees and shrubs.

Wind and water erosion will be initiated or accelerated at various places along the route.

Wildlife such as waterfowl and shore birds will decline in numbers if wetlands are permanently dried up as a result of construction. Also, nesting habitat for ground birds will be reduced and some birds will be lost.

Straight-line right-of-way cuts through woodlands and evidence of the pipeline ascending steep bluffs will constitute long-term esthetic impacts.

Visual impacts of aboveground disturbance (i.e., trench mounding) and permanent structures will be most apparent in forested areas and open grasslands and less on cultivated lands.

Alteration of remaining habitat types in intensively cultivated areas will reduce the diversity and abundance of wildlife species in these areas. Direct loss of animal numbers will be minimal but habitat loss will be incremental.

Although preconstruction surveys will be conducted, historic, archeologic, and paleontologic resources will be impacted because of the certainty of the trenching uncovering previously unknown sites.

Increased sedimentation in water bodies and courses will affect water quality. Also waste and chemical pollutants can be expected to find their way into streams and lakes. Interruption of waterflow will also occur.

Land use options will be impacted by permanent right-of-way and attendant facilities.

Property taxes on the physical plant will add revenues to local governments through whose jurisdiction the pipeline passes.

Withdrawal of lands from production for the short term, as well as on a permanent basis, will have an adverse impact on local economies.

Adverse impacts will occur because of intense, short term surges of demand for housing, demand for services, and increased competition for recreation, education, transportation, and entertainment.

Air quality will decline during construction and during operation of compressor stations. While this will generally be a minor problem, it is incremental to the decline of existing air quality.

Ambient noise levels will be increased during construction and during operation of compressor stations.

Microclimates in the vicinity of compressor stations will be impacted by station water vapor emissions.

Climate

No significant impacts on the macroclimate are anticipated. Adverse effects to microclimates along the pipeline will be minimized through mitigation measures but air degradation, siltation from erosion, accelerated water runoff and soil temperature changes induced by the gas pipeline will have minor short-term effects on the microclimate of soil organisms at or near the surface. These impacts are discussed in Sections 3.1.3.1, 4, 6, and 14.

Topography, Geology and Soils

Topography

Section 3.1.3.2 identifies impacts on the topography that will be the result of an increased potential for, and acceleration of, various natural processes that can affect the topography along the proposed route.

Adverse effects to the topography that are caused by the construction and operation of the pipeline, if it is built, should be minor if sound construction practices are used and if recommended mitigative measures are employed and carefully followed.

The expected impacts that may not be fully neutralized by mitigative measures are: (a) erosion by surface runoff, (b) scour by streams, (c) changes in surface form, (d) longitudinal and lateral migration of meanders, (e) changes in surface drainage, (f) erosion by wind, (g) seasonal flooding by streams, and (h) sedimentation by runoff and streams.

The adverse effects of the first two impacts are more difficult to mitigate than the others, and the residual effects of the two may possess greater importance to the integrity of the pipeline, and thus to the surrounding environment.

a) Erosion by surface runoff is in part a natural process and in part may be accelerated by the construction of the proposed pipeline. The ridge of loose soil above the trench is especially subject to erosion by surface runoff. The erosion will have the secondary effects of destroying revegetation and causing unsightly exposures of raw earth.

The residual adverse effect of erosion is most likely to occur along the 635 miles of the proposed route from approximately northcentral Iowa to central Ohio. The 385 miles from the Canadian border to the second crossing of the Missouri River and the 160 miles from central Ohio to the eastern terminus are somewhat less likely to experience difficulty. The remaining 440 miles in South Dakota and Minnesota probably will be least affected.

b) Scour of the channel floor or walls of streams and rivers may result during the "open trench" phase of construction. This scour should be temporary. Locally it may have moderate impact, even if mitigating measures are carefully followed.

In addition, bank scour, a natural process of streams associated with seasonal flooding, may cause moderate to severe impact, unless mitigating measures are fully effective.

c) Changes in surface form, such as the ridge of backfill over the trench, are in part desirable, and in part necessary. The ridge is a mitigative measure intended to compensate for natural compaction of the backfill with time.

d) Longitudinal and lateral migration of meanders in a valley is a natural process and will not be wholly prevented by proper construction or careful use of mitigation measures. The process rate may be increased at some stream crossings by construction activity and may increase even though mitigation measures are used.

e) through h) The remaining items may not be fully neutralized by mitigative measures. They can be treated as a group because (1) the initial impact is minor to negligible, (2) one or more mitigative measures proposed in Section 4 may reduce their impact, and (3) the residual effects are minor to negligible.

Geology

Section 3.1.3.3 identifies some expected adverse impacts of the pipeline on the geology. The adverse impacts will range from negligible to moderate in degree and will be little affected by improvement of construction methods or by careful use of mitigative methods.

The expected impacts that cannot entirely be neutralized by mitigative measures are: (a) fracturing of bedrock during trench excavation, (b) consumption of geologic resources, and (c) limitation of production of geologic resources. That part of each adverse impact that cannot be fully neutralized constitutes a residual effect.

Soils

Adverse impacts which cannot be avoided will be imposed upon the soil resource along the entire proposed route. Approximately 20,000 acres of soil will be disturbed along the 100-foot wide right-of-way during construction of the pipeline. Another 1,074 acres will be affected by construction of operations facilities. Further soil disturbance will be significant in the construction of access roads and at sites used for pipe and equipment storage.

The most severe impacts to soil will occur where construction activities require excavation of topsoils. The two major activities requiring topsoil excavation are leveling of the 100-foot wide right-of-way and preparation of the pipeline trench. Where natural topography is relatively flat, topsoil excavation for right-of-way leveling will be minimal. On steep slopes, topsoil will be severely affected by leveling operations. Even where minimal disturbance is necessary, adverse effects will result from compaction by heavy machinery, stockpiling of spoil piles, and leakage of fuels, lubricants, etc.

On agricultural lands, which comprise 75 percent of the right-of-way, soil compaction can be mitigated through special farming operations such as chiseling or deep plowing. On rangelands and other areas containing natural plant communities the effects of compaction may be long lasting.

The excavation of the pipeline trench will require removal of topsoil over an 8- to 10-foot wide strip along the entire route. This will affect over 2,000 acres of land. In addition, subsoils and substrata material must be excavated to depths of 7 to 10 feet. Approximately 100 million cubic feet of this material will be displaced by the pipeline.

Planned mitigation measures include stockpiling and replacement of topsoil where required. The requirement to replace topsoil will depend upon stipulations imposed by governmental agencies where the route crosses public lands and upon the desires of individual landowners on private lands. The disposition of surplus materials displaced by the pipeline will also depend upon government stipulations and landowners' wishes. Topsoil replacement and offsite disposition of surplus soil materials will not be done unless it is required by the landowner. Soil materials such as cobbles, gravel and heavy clay remaining after backfilling would be disposed of offsite. Where soil material is of reasonably good texture, it would be spread across the right-of-way.

Since mitigation measures will depend upon future negotiations, the exact adverse impacts resulting from soil disturbance cannot be accurately predicted. During the year of construction, 14,525 acres of cropland will be out of production without implementation of suggested mitigating measures. This could result in the following losses in crop production: corn--472,000 bushels, soybean--80,070 bushels, small grains--88,000 bushels, hay--5,320 tons. The monetary value of lost crops is about 3 million dollars. In the western range segment of the pipeline about 3,200 acres of soil on grazing land will be disturbed and will be out of production during the construction year. This will result in a loss of about 800 animal unit months of grazing.

The continuing impacts resulting from soil disturbance will vary with the intensity of mitigation. Where topsoils are carefully stored and replaced, normal production levels may be restored the year after construction. Where subsoils are mixed with topsoils or left unmixed on the surface, reduced productivity will be in proportion to the quality of material left on top. Soil Conservation Service personnel in the Midwest, based on personal experiences, predict that most subsoils on the glacial plains will produce only 40 to 60 percent of normal yields for at least 3 years. On some soils having high clay content or other severe limiting factors, normal production cannot be restored for many years.

Soil related impacts will have similar effects on production of western rangelands. Where the topsoil is not returned to the surface, the reconstituted soil material will lack the soil micro-organisms and nutrients required to support the original vegetation. The degree to which new vegetation can be reestablished will depend upon the quality of material left on the surface and the conservation practices applied. Under the best conditions, several years will be required to establish a full stand of vegetation. Where substrata material has severe limiting factors, full production of range forage may not be reestablished for many years. On lands left with inadequate vegetative cover, soil erosion from wind and water will be a significant adverse impact. As described in Section 3.1.3.4, soil loss rates increase on steep land and vary with soil types.

Soil losses from wind erosion may reach rates of 20 to 50 tons/acre/year and will be particularly significant in the Northern Great Plains region. Along this segment of the pipeline, high winds are common, soils are erosive, and the pipeline route is in line with the prevailing wind direction. Adverse effects can be mitigated to some degree with temporary conservation measures but complete control is unlikely.

Water Resources

Section 3.1.3.5 identifies impacts on surface water resources that may be caused by construction of the proposed project. Adverse effects to water resources will occur despite sound construction methods and careful use of recommended mitigative measures. The residual adverse effects may range from major to minor.

Such adverse effects as remain will begin with the initiation of construction and continue into the operational phase.

Surface Water

The expectable impacts that may not be wholly neutralized by mitigative measures are (a) diversion of surface runoff, (b) sedimentation of stream channel floor and walls, (c) erosion of channel floor and walls, (d) partial filling of stream channel by sedimentation, and (e) degradation of public water supply resources. The evaluation of each of these impacts is based on general estimates.

a) Diversion of surface runoff, mainly slope wash but including rills and rivulets, will be caused in many places by the very permeable backfill of the trench, and possibly by the ridge built above the trench to compensate for natural settling.

Diversion of surface runoff will begin with initiation of right-of-way preparation and may continue indefinitely. The diverted flow will thus be continuing and permanent in character. It will consist of that part of the runoff which is not controlled by the mitigation measures, largely due to the imperfection of the mitigation process.

b) Sedimentation on the floor and walls of stream channels may reduce the rate of infiltration of water from the stream into an adjacent aquifer. The sedimentation would be caused mainly by construction activity in the channel, disturbing bottom and wall sediments. Disturbance would be largely unmitigated. The adverse effect should be moderate to minor.

Sedimentation on the floors and walls of stream channels will begin with clearing vegetation on the channel banks within the right-of-way and will mainly cease with completion of backfilling of the trench in the channel floor. The sedimentation will be essentially continuous during this time; it could be permanent in effect but subsequent erosion may remove it.

c) Erosion of the channel floor and walls may be a result of construction activity on the channel floor or adjacent banks. It is caused in part by the construction process and in part by the undesirable changes in channel profile and form.

In itself it may not be important, but it could be a significant factor in initiating or increasing the rate of normal meander migration. Thus the residual adverse effect may range from minor to moderate.

Erosion of channel floors and walls will begin with clearing vegetation on the channel banks. Erosion caused by the construction will probably terminate with the completion of construction, but if this has triggered an increase in the rate of natural erosion, the process may continue for many years despite the cessation of construction. It may, therefore, be either temporary or essentially permanent. The adverse impact probably will be minor, but may become moderate.

d) Partial filling of the stream channel by deposits of sediment churned up by construction at a stream crossing site may occur. The amount of sediment from this cause probably will be negligible in terms of flow disruption or changed water level. Partial filling of the stream channel by sediment resulting from construction at stream crossing sites will be a one-time effect of a temporary nature. It perhaps could have a negligible effect on ground water. The impact of turbidity and sediment deposits on stream biota will be variable, and detailed quantifications are not available. The impact on organisms will be minimal from construction during winter and summer months.

e) Degradation of some public water supplies by increased turbidity is likely. The Monongahela River intake of the Western Pennsylvania Water Company is reported to be less than 2 miles downstream from the pipeline crossing. Other intakes are at various greater distances. The residual adverse effect may be great on one intake and range downward to none on others. The effect depends on various factors including the nature of the stream, the type of intake, and the distance from the disturbance.

Degradation of public water supplies by increased turbidity will begin with initial activity adjacent to the channel walls and continue until construction is completed and the last turbidity dispersed. Thus, the adverse effect will be one-time and temporary. Excessive pumping of water from small streams or lakes could disturb water supplies needed to support aquatic life, promote erosion in dry channel waterways, and introduce pollutants into previously clean streams or waterways.

Ground Water

Expected impacts on the ground-water resources that may not be wholly neutralized by mitigative measures are: (a) beheading by the trench, whether open or backfilled, of shallow recharge flow from the upper part of a basin or the upper part of a shallow ground-water supply; (b) increased pollution by dissolved and undissolved solids; (c) reduced yield of ground-water supply from sediments adjacent to a stream caused by reduced movement of water from a stream into the adjacent sediments; and (d) destruction of springs and wells in the right-of-way by construction equipment.

a) Beheading of shallow recharge flow may occur because the trench, whether open or backfilled, acts as a gravel-filled ditch (French drain) wherever the trench is not parallel to the direction of surface slope. This may reduce ground-water supplies in aquifers thus beheaded, lower the water table, lower the level of water in wells, and reduce the flow of springs. Mitigation includes careful compaction of the backfill.

The degree of impact of this residual effect will be negligible to minor except to the owner of that spring or well which suffers loss of yield; to him it may have great impact.

b) Increased pollution by dissolved and undissolved solids may result from movement of ground water through the trench backfill and from stream discharge into adjacent sediments partly filling the stream valley. Thorough compaction of all backfill could reduce the former, and silt and clay raised by instream construction operations when settled out onto the surface of the channel floor and walls would reduce movement of water from the stream. The impact of the residual effect will be minor.

Increased pollution by dissolved and undissolved solids will begin with excavation of the trench and in the stream channel. In the trench, pollution could continue indefinitely; in the stream it could continue until the aftereffects of instream operations have passed.

In the trench, the effect will be continuing and permanent. In the stream, the effect will be temporary and one-time, unless maintenance operations require additional instream work.

c) A reduced yield of ground water from sediments adjacent to a stream channel is expected if recharge flow from the stream into the sediments is reduced. The reduction could be caused by clay and silt, disturbed by instream construction operations, settling out downstream and effectively plugging the sediments that form the walls and floor of the channel.

The impact of this residual effect will be negligible except to an individual well owner to whom the impact is serious.

The reduced yield of ground water from sediments adjacent to a stream channel may begin any time after plugging by silt and clay has occurred. How long the interval is will depend on various factors including the degree of plugging, the demand for water in the aquifer and other sources of recharge. The impact may be considered as one-time, but long term in character.

d) The destruction of a spring or well in the right-of-way by the movement of construction equipment probably will occur at few localities along the proposed route. Such wells and springs commonly serve as water supplies for grazing stock. Mitigation presumably would involve negotiation with the landowner and drilling a well to serve as a replacement.

The impact of such loss relative to the corridor as a whole will be negligible, but to the owner of the land or stock such a loss could be serious.

In summary, residual adverse effects on water resources would be primarily short term, mainly during the construction period of about 1 year, and would diminish with the success of the vegetative rehabilitation as discussed in the next section.

Vegetation

Construction Impacts

The major adverse effects to vegetation which cannot be avoided will occur during construction. In order to install the proposed pipeline along the 1,600-mile route, approximately 20,000 acres of land must be disturbed for construction right-of-way. An additional 1,074 acres will be disturbed for operations facilities, including compressor stations, communication towers, block valves and measuring stations.

An indeterminate area will undoubtedly be disturbed for other related activities such as access roads, pipe and equipment storage areas and temporary housing facilities required by workers.

Adverse impacts to vegetation fall into two broad categories--natural plant communities and cropland. Approximately three-fourths of the proposed route (1,200 miles) will traverse croplands. Since cropland vegetation is not retained over long periods, the adverse effects incurred by the pipeline will be more of an economic and sociological nature than an environmental one.

Approximately 14,525 acres along 1,200 miles of the proposed route right-of-way are presently devoted to intensive agriculture. During the construction year most of this land will not produce a crop. While crop losses on individual farms will not be significant in relation to total farm production, the cumulative loss over the entire pipeline right-of-way is quite significant.

As discussed under Soils, the estimated loss of major crops includes: corn--472,000 bushels, soybeans--80,070 bushels, small grains--88,000 bushels and hay--5,320 tons. These crops have an estimated value of 3 million dollars.

Crop production will continue below present levels for several years until the relatively sterile subsoils attain a level of fertility and structural quality conducive to normal crop growth.

Estimated crop losses by states are shown in Section 3.1.3.11.

Natural plant communities will be crossed along 357 miles of the proposed route. Approximately 256 miles of the natural plant communities disturbed are in the western range region extending from the United States-Canada border to Minnesota. The remaining 100 miles will cross woodland plant communities in the eastern deciduous forest region (76 miles) and various types of waterway and flood plain plant communities (24 miles) crossed by the pipeline along the entire route.

Of special significance are the wetland plant communities to be disturbed during construction. These areas are extremely important for wildlife, especially waterfowl.

The proposed route centerline traverses wetlands from Montana to Illinois.

A mitigation measure proposed by the applicant is to avoid wetland areas wherever possible by minor route changes. This practice should reduce substantially the actual wetland areas crossed. Specific wetland areas that can be avoided will not be known until onsite surveys are made. Even where crossing wetlands is avoided, however, the pipeline trench on adjacent lands might affect wetlands through the interception or obstruction of ground-water flows.

Wetlands Crossed by Proposed Route

State	No. Wetlands	Acreage in Right-of-Way
Montana	65	121
North Dakota	20	33
South Dakota	307	198
Minnesota	26	25
Iowa	20	25
Illinois	20	30
Total	458	432

The degree of adverse effects on vegetation will vary with construction methods required to meet site conditions. On sloping land, the preparation of a level right-of-way will require excavation of topsoil and total destruction of existing vegetation. Where the topography is flat, low growing vegetation will be left except where the trench is excavated. Even where native sod is left, the movement of heavy construction equipment and stockpiling of spoil piles will cause severe damage.

In the western range region, approximately 3,200 acres of native grasslands will be impacted to varying degrees. About 320 acres along the trench will be destroyed by trench excavation.

In the Midwest, native plant communities are extremely rare. Permanent pastures containing both native and introduced grasses occur sparsely along drainage ditches, streams and marshes, and other areas where farming is not feasible. An estimated 800 acres of these grasslands will be crossed by the proposed route from Iowa to central Ohio. About 80 acres will be destroyed by trench excavation.

In the Ohio River Valley, approximately 700 acres of permanent pastures similar to those encountered in the Midwest will be traversed by the pipeline. About 70 acres will be destroyed by trench excavation. Because of the more rugged topography of the Ohio River Basin, significant areas of vegetation will be destroyed in leveling the right-of-way.

Adverse impacts to deciduous forest communities will be significant in Indiana, Ohio, West Virginia, and Pennsylvania. Adversely impacted forests include scattered woodlots, bottomland hardwoods along drainages, and the upland forests of the Allegheny Plateau.

Woodlands Traversed by the Proposed Route in the Ohio River Basin (Acres)

	Woodlots	Bottomland Hardwoods	Upland Deciduous Forests
Indiana	65	30	--
Ohio	130	13	337
W. Virginia	2.5	0.5	54
Pennsylvania	37	3	230
Total	234.5	46.5	621

Most of the forests crossed contain second or third growth trees averaging about 50 years of age. Preparation of the right-of-way will require removal of all trees from the 100-foot wide right-of-way.

Impacts from tree removal will include both loss of protecting ground cover and esthetic degradation. Loss of esthetic values will be particularly significant at stream crossings because of the higher recreation use in flood plains and along streams.

Stream Crossings Requiring Removal of Hardwood Trees

The following are the principal rivers and streams where hardwoods may be encountered. From Iowa east, most streams of any size also can be expected to be lined with hardwoods.

Montana - Frenchman Creek, Poplar River

N. Dakota - Little Missouri River

S. Dakota - None

Minnesota - Redwood River, Elm Creek

Iowa - Cedar River, Shellrock River, Wapsipinicon River (2), Mississippi River

Illinois - Illinois River, Pecumsaugan Creek, Rock River, Green River, Big Bureau Creek, Little Vermillion River, Tomahawk Creek, West Fork Mazon River, Iroquois River

Indiana - Curtis Creek, Tippecanoe River, Iroquois River, Carpenter Creek, Eel River, Wabash River (2), Treaty Creek, Salamonie River

Ohio - St. Mary's River, Six-Mile Creek, Auglaize River, Great Miami River, Rush Creek, Scioto River, Olentangy River, Whetstone Creek, Alum Creek, Big Walnut Creek, Sugar Creek, Ford Creek, Licking River, Muskingum River, Center Creek, South Fork, Long Run

W. Virginia - Buffalo Creek

Pennsylvania - Chartiers and Little Chartieres Creeks, Mingo Creek, Monogahela River, Youghiogheny River, Possum Hollow Run

Operations Impacts

Following construction activities, the applicant plans to revegetate all disturbed areas except those devoted to cropland agriculture or areas containing permanent facilities.

Along the pipeline, a 40-foot wide strip will be maintained free of tall growing trees or shrubs to provide ease of quick access and for observation of the line from the air. In the western range region where tall trees or shrubs are not commonly part of the natural plant communities the 40-foot maintenance strip should appear no different than the rest of the right-of-way area or the surrounding countryside after revegetation establishment.

In the deciduous forest areas, however, maintenance of a tree-free strip will create adverse impacts throughout and beyond the life of the project. If additional measures concerning tree and shrub establishment are followed, the impact on forests would still be long term.

While soil stabilization may be accomplished in 1 or 2 years by reseeding grasses and legumes, the esthetic values related to trees will require at least 50 years to reach the stage existing before construction.

Techniques are available to successfully revegetate under all of the conditions encountered along the proposed pipeline route. Intensive revegetation and conservation practices will be necessary to successfully revegetate areas with harsh site factors. The applicant has stated his intent to fully comply with revegetation guidelines contained in 18 CFR Section 2.69 and to utilize local expertise in revegetation techniques. This should assure the reestablishment of vegetation, however, diminishing impacts from soil erosion will continue for several years until new plant communities are fully established.

Where operation facilities such as compressor stations, communication towers, etc., are installed, vegetation will be destroyed and eliminated from the landscape for as long as the facilities remain. These areas have not been specifically located, so the area of native vegetation that will be affected is not known.

Wildlife

There are a series of temporary adverse effects on fish and wildlife resources which, even with the most extensive mitigation efforts, cannot be avoided if the pipeline is constructed. These are connected primarily with the clearing of the construction right-of-way and with the construction of stream crossings. The noise, smells, activity, and stripping of vegetation and topsoil will disrupt natural activities not only within the construction right-of-way but for some distance on either side. Where potholes and wetland areas cannot be avoided, nesting of waterfowl, shorebirds and other wetland related species will be disrupted until original water and vegetation conditions are restored. There will be some temporary reduction in population sizes of these species particularly if dry conditions prevail during and subsequent to construction and wetlands nesting habitat is reduced.

The nesting of birds in range areas, in brushy gullies, in flood plains, in woodlots and in forest areas will be disrupted since the major construction season coincides with the nesting season for most birds. There can be no pipeline route of 1,600 miles which could practically avoid all such natural nesting habitats. For open, more easily revegetated areas this loss of wild bird production might last only one or two seasons while losses associated with brush and tree destruction on the temporary right-of-way could last for many years until suitable habitat is reestablished. Along with this loss of habitat quantity and quality will be a reduction in the size and diversity of bird populations directly along the route.

There will be a similar effect on the various populations of small mammals (rodents, fur bearers, small predators) associated with these disrupted habitats. Where antelope and mule deer, primarily in the western segment, and white-tailed deer in the middle and eastern segments of the proposed route depend on the cover and browse provided by disrupted natural habitat areas, there will be a reduction in potential herd sizes lasting until some comparable vegetation is reestablished.

Each stream and river crossing will have unavoidable adverse effects on the aquatic biota since there will be some measure of disturbance and significant increases of turbidity and sedimentation even with the most conscientious mitigation efforts. There will be a temporary reduction in basic productivity; the reproduction of many species will be greatly curtailed for at least one season for a considerable segment of the stream below the crossing, and feeding and growing conditions for fish and invertebrates will be lowered in this segment for at least one growing season.

These unavoidable adverse effects relating to the construction period and immediately thereafter will cause temporary reductions in the size and diversity of many terrestrial and aquatic animal populations from mice to crayfish, but the more serious and long lasting of the unavoidable adverse effects are those which relate to the eradication for the life of the project of all brush and trees from the permanent right-of-way. Even if the pipeline were abandoned and natural habitat segments along the permanent right-of-way were allowed to revert to natural vegetation, it would take many more years to reestablish some semblance of lost habitat values. It was suggested in Section 4 that technical review teams participate in the final and detailed route selection to avoid wetlands, woodlots, bottomland hardwoods, etc. Even with a determined effort to minimize such conflicts there will be hedgerows, shelterbelts, fringes of brush or hardwoods along streambanks, etc., which will be crossed by the route. There will be losses of natural habitat areas and corresponding losses in the diversity of plant and animal populations and long-term losses in the opportunity for citizens to use and enjoy this diversity.

Ecological Considerations

The most long-term residual impact on ecological inter-relationships will be habitat changes in the cleared corridor through wooded areas. The creation of a grassland habitat through manipulation will result in a long-term change of biological community in the corridors and adjacent areas. This amounts to a new ecosystem. This induced change may adversely affect the original community but will also benefit the new community inhabiting the grasslands and edges created as well as overall diversity within the larger system.

The main difference between these wooded areas and other disrupted systems (e.g., native grasslands, streambanks, streams and rivers, etc.) is the long-term change that will occur in the wooded areas. The time required for woody species to mature slows natural succession and prevents the community from achieving a climax state until well after the project life.

Other disturbed ecosystems will move more rapidly toward climax communities after disturbance.

The proposed project may also affect other communities where it has the potential of destroying essential features of ecosystems and where these features cannot be restored either naturally or by man. Examples are the possibility of draining potholes and the destruction of vegetation through fragile areas such as the Little Missouri badlands.

Economic Factors

It is believed that there will not be significant adverse effects on local economies because of construction of the Northern Border Pipeline. There will be some short-term dislocation in employment, and some construction or other economic activity will be postponed because of pipeline construction demands on the local labor force and local suppliers. These effects will be neither large nor persistent. There will be longer term adverse effects in agricultural land put out of production for varying periods of time. The amount of productivity involved is relatively small.

Individual landowners and local governmental jurisdictions may suffer adverse economic effects if they do not contract wisely with the pipeline construction companies for complete restoration of or compensation for the damages that will be caused by construction activities on their individual property or jurisdiction.

Sociological Factors

Unavoidable adverse sociological effects on local communities along the proposed pipeline route will be relatively light and short term. They will consist largely of short-term demands on local facilities such as housing, recreation, and public services and facilities. These demands will disrupt local activity and service delivery patterns for a matter of weeks or months. The severity of these adverse effects will obviously be greater on smaller communities in the more sparsely inhabited western sector of the route. It is conceivable that the cost of providing community services (police, health, welfare, sewage, water, streets, etc.) to construction crews could impose an unreasonable financial burden on small communities. A few improvident communities or individuals may still expand capital facilities to accommodate the temporary demands of construction crews and find themselves burdened with over capacity which would constitute a longer term adverse effect.

Land Use

The use of land along the proposed pipeline will be restricted to those activities that are compatible with the operation, maintenance, and safety requirements. Because most of the right-of-way passes through agricultural land, these restrictions will not affect future activity. The limitation to use will occur where urban areas expand to the vicinity of the corridor or in special use areas such as park and recreation areas. In these situations the permanent corridor will remain open. Unless specifically mitigated by such measures as route deviations, urban or industrial growth will have to take into account the land use limitations.

Archeology, History, Recreation, and Esthetics

Archeology

Section 3.1.3.12 identifies 15 archeological sites along the proposed route that are in the study corridor. Because much of the corridor has not been surveyed, undiscovered sites are certain to be encountered. Archeological resources are finite and irreplaceable. The damage or destruction of a site or artifacts is permanent. Available information on these sites and the corridor is presented in Section 2.

The disturbance or destruction of these sites will reduce the available knowledge of prehistoric cultural periods in the region. Because many of the sites have not been investigated thoroughly, no one can be certain whether or not new knowledge can be gathered from these sites. Of known archeological sites, the three at the Illinois River crossing in LaSalle County are of special importance. These are the Utica Mound Group, consisting of Hopewell mounds on the north side of the Illinois River, and the Little Beaver and Barney Erikson sites on the south side of the river. There are five other sites whose location is only generally known and where almost no information has been collected. These are the two Alexander sites in Iroquois County, Illinois, the Richardson Kame and William Alexander Kame in Hardin County, Ohio, and an unnamed village site in Licking County, Ohio.

A secondary impact resulting from the pipeline construction will be the possible vandalism of archeological sites, particularly those discovered and left unprotected by the pipeline construction crew, by artifact and souvenir hunters. Many sites or potential sites have remained protected because the public was unaware of them. The unnamed village in Licking County, Ohio, is an example of this type of protection.

History

Three historic sites could be damaged by construction of the proposed project. However, the route has not been surveyed and therefore other sites will doubtlessly be encountered along the corridor. Two are canals--the Illinois and Michigan in LaSalle County, Illinois, and the Miami and Erie in Auglaize County, Ohio. Neither will be severely damaged providing the pipe is laid by burrowing under the canal. Should futher engineering study determine this procedure is not feasible, the historical integrity of the canals will be lost even though replacement may be largely successful. No locks will be damaged at either crossing.

The location of the Fort Bouis Fur Post, North Dakota, the third site, is not definitely known. The impacts will be similar to those on archeological sites already discussed. That is, the Fort is a finite and unrenewable resource that is not replaceable. Destruction or any damage to the site will be permanent. In this particular case, the site may have unusual value because much of the history of the upper Missouri River Basin was submerged by the rising waters of the main stem reservoirs created by dams constructed in the 1950's.

Recreation

The parks along the pipeline corridor were established largely because of natural attractiveness or uniqueness. Access to water and proximity to urban population centers also were factors, but specific sites were selected with an eye towards physical qualities. The loss or damage of these physical features results in the parks being less desirable, which can be expected to be reflected in their future popularity. If mitigating measures, particularly route adjustments, outlined in Section 4 are followed, impacts on these parks and their physical features will be completely avoided.

Esthetics

Considering the different basic esthetic values along the route, the greatest likelihood of esthetic damage is on the northern plains where human activity serves as a multiplying negative effect upon esthetic values. In addition to the general impact of crossing the prairie, the crossing of the North Dakota Badlands and the Little Missouri River will result in significant damage to esthetic values. Very little human activity has occurred in this area, largely because of steep slopes and unstable soils, which has left the Badlands intricately weathered and having wilderness characteristics. These fragile features will be the basis for severe impacts from the project. The steep slopes cannot be restored and the tunnel views along the right-of-way will be apparent. This area of North Dakota appears to be the most critical area for esthetic values and impact along the entire pipeline route.

In Section 2, 21 areas were identified as having significant esthetic values. Most are wooded river valleys and areas of scattered lakes. The esthetic impacts will not be severe in some instances. Rounding of steep river bluffs and cutting and maintaining swaths through wooded areas, however, will result in esthetic values being lowered. The most sensitive area east of the Mississippi River may be the crossing of the Illinois River, because of the hardwood bottoms and the rock outcrop. Impacts on esthetically important areas would be significantly reduced by following route deviations outlined in Section 4.

Air, Noise, Water and Solid Waste

Air Quality

Construction Phase

The collection of large amounts of diesel and gasoline engine powered equipment, both onsite and as transportation equipment, will cause highly localized emissions of air pollutants during the period of construction. The applicant does not explicitly propose any mitigating measures but some are suggested in this EIS to control fugitive dust emission and open burning. If these measures are applied, the residual negative impacts on the immediate project area will be minor. Dust emission will still be a factor affecting crop production along the right-of-way, the degree of impact depending upon the effectiveness of dust control measures. Dust emission on local dirt roads carrying heavy traffic will also remain and may contribute to annoyance.

Presuming that reasonable care is taken to maintain vehicle engines, the air pollutants emitted, particularly NO_x, will be significant in total quantity but distributed along the entire pipeline and limited in time so that concentrations will not exceed air quality standards.

Along five major river crossings (Mississippi, Muskingum, Ohio, Monongahela, and Youghiogheny), construction vehicle emissions could occur when weather conditions are suitable for entrapment. This condition could create an excursion of concentrations to levels above the air quality standards in the local surrounding area. This impact could occur under all mitigating measures, except shutdown of construction.

Operation Phase

There are three sources of residual air quality impact: compressor stations, venting and pipe rupture. An unavoidable by-product of moving large masses of gas will be the rejected heat and combustion products from the compressor stations. These pollutants will add only small increments to the gradually deteriorating environment caused by the addition of other small incremental sources. As a single contribution to air pollution, the compressor stations will be measurable but minor. However, as one of many additive small sources, the contribution is significant. The compressor stations will exceed the NO_x emission standards of South Dakota and Indiana, unless manufacturers can develop mitigating measures for gas turbine emissions (see Section 4.1.3.4).

Occasional venting may or may not create an air pollution problem depending on the situation. The small and perhaps slow release of gas from a compressor station may not create an impact but the emergency venting of the system will rapidly release large quantities of gas at a localized area. Somewhat equivalent to that is a pipe rupture where over 135 million cubic feet of gas may be released. Cooling because of adiabatic expansion can make the released methane more dense than air until it is thermally mixed.

Stratification can occur under stagnant air conditions; thus, in low lying areas, with an inversion layer, a critical condition could be reached. The history of pipeline failure suggests that such a monumental negative impact has a small but finite chance of occurring. The increasing tensions of modern society must raise the probability of pipeline failure to an overt act and it is unlikely that the perpetrator of any destruction would recognize or care about the fire or air quality aspects.

Noise

Even if all suggested mitigation measures are implemented, increased noise levels would still occur as a result of the proposed action.

Assuming trucks are brought into compliance with the recently promulgated EPA regulations, they will still produce sound levels between 86 and 90 dBA at 50 feet (depending on their speed) in otherwise quiet rural communities. This impact would not be highly localized, but it would affect large numbers of people (about 160,000) over the entire period of construction.

Construction equipment with properly fitted mufflers will still produce high sound levels in the vicinity of the construction site, ranging from 76 to 101 dBA, but it is presently economically impractical to quiet them further.

The 12 new compressor stations will impact any residences within approximately 3,800 to 4,900 feet (depending on station horsepower) with a normalized L_{dn} of 55 dB, even with an acoustically treated compressor building and additional silencing turbine intake and exhaust. This means that a total of approximately 744 people will be residing within an area impacted by normalized day-night sound levels in excess of the U.S. EPA goal for human welfare. Approximately 280 people will be highly annoyed, and about 16 households will make complaints. If the proposed locations for Stations 22 and 24 are changed as suggested in Section 4.1.3.4 and the above attenuation measures are implemented, then the number of people residing within a normalized L_{dn} greater than 55 dB will be reduced to 155.

It is probably feasible to muffle blowdown noise by approximately 30 dBA. Even with this degree of attenuation, the blowdown would be audible for several miles. This would be a long term but very infrequent noise impact.

Solid Waste

Construction Phase

Construction will generate large amounts of waste, as will the personnel involved in the construction. Much of the site waste can be disposed of by appropriate methods, the best of which would be in a sanitary landfill. As long as the material is removed in this way, there should be no residual impact. The spreading of rocky excavated earth along the right-of-way could cause a significant adverse impact.

Human generated wastes can be controlled on or near the job site to eliminate any residual negative impacts, but the material must be removed to a sanitary landfill or treatment plant. River bottom wastes that must be removed because of contaminants will require a site for dumping. Destruction of local roads, culverts and bridges due to over-loading will also cause generation of waste. Thus the primary residual impact of waste generation will be the burden placed on the local agencies to handle the amount of material given to them. In the very rural areas, that burden will be moderate to high.

Water Quality

If appropriate mitigating measures are applied, the impact on water quality will occur during the construction phase of the project only. The primary impact will be a temporary increase in sediment loads in water courses where crossings are made. This will drive out local fish species and possibly smother benthic organisms and fish eggs downstream. These impacts will be major, but temporary. As soon as the pipe is laid and the covering returned, turbidity will decrease; the rate will depend upon the type of bottom. After a period of weeks, the fish will return and the bottom will commence being repopulated by aquatic species drifting down from upstream. The stream will be back to normal, usually, within a year of trench closing.

The only other residual impacts that might occur are those associated with accidental events such as floods and catastrophic equipment failures. These could cause debris distribution along the watercourse which would degrade the esthetic environment or cause oil and gasoline contamination. With reasonable precautions, such impacts are unlikely.

6 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

6.1 ARCTIC GAS PIPELINE PROJECT

6.1.3 Northern Border Pipeline

6.1.3.1 Assumptions and Background

Although a pipeline that proposes to transport natural gas for 50 - 100 years would appear to be a relatively long-term facility, for the purposes of this section, which compares man's use of the pipeline versus the potential productivity of the environment short-term is defined as the lifetime of the pipeline, long-term as time beyond that period of construction and operation of the pipeline.

The proposed pipeline is capable of delivering up to 1.5 billion cubic feet of natural gas per day. The proposed pipeline will cross the vast coal reserves of Montana and the Dakotas and might also transport gas produced from coal should commercial coal gasification prove feasible.

Present proven reserves of natural gas indicate a 20-year life for the proposed pipeline. Based upon the expectation of additional discoveries, the applicant believes the probable minimum life of the pipeline to be on the order of 50 years with the possibility of a maximum life of 100 years. The continued supply of energy from natural gas will support between 519,000 and 670,000 jobs annually and produce between $12 and $15.5 billion in the GNP.

In the process of bringing the benefits of an extended natural gas supply to industrial and domestic consumers, certain short-term uses will affect the environment significantly, but long-lasting adverse effects will be limited.

The construction activities during the year in which the pipeline segments are installed will divert land from agricultural, recreation and other productive rural uses. Following the installation of the pipeline most of the project area will revert back to its original use. Operations facilities such as compressor stations, communication towers, block valves, etc., will create longer term special use of the environment, possibly for 50 to 100 years.

Some of the short term impacts of the project are listed in the following section.

6.1.3.2 Environmental Values Affected by the Proposed Action

Agriculture

Approximately 20,000 acres of agricultural land will be out of production during construction with a resultant loss of crops valued at over 3 million dollars. While losses to individual farmers will be small in relation to total farm production the cumulative loss at a time of world food shortages appears to be significant. Over 640,000 bushels of major feed and grain products will be lost to the Nation. Depending upon the degree of mitigation, an equal loss might be incurred during the 2- or 3-year period following construction because of lasting impacts to the soil resource. To a lesser degree production losses will occur on the western range lands that are traversed and on the eastern forested lands where merchantable timber has required 50 years to reach its present stage.

Individual farmers and other land owners will endure nuisance-type impacts during construction. These include disruption of farming activities, interference with drainage systems, noise and air pollution and restricted access to farm and service centers.

Health and Safety

The majority of health and safety problems will be encountered during the construction period and will be mainly those associated with large numbers of people and machines working in close proximity to each other, the movement of numerous vehicles, and handling of masses of materials. Longer-term hazards will be present in the maintenance and operation of compressor stations and other features of the system. As explained in Section 4.1.3.3, there is no reason to believe that these hazards will be great.

The possibility of a rupture in the pipeline or other failure in the system must be considered. In such event a hazard to the health and safety of people in the pipeline vicinity could result. The seriousness of the hazard could range from insignificant to catastrophic (Section 3.OV.16). Although this hazard may be extremely small, it is nevertheless a long term possibility that would not exist in the absence of the pipeline.

Air and Water Quality

The air quality along most of the proposed route is relatively free of the adverse effects of industrialized activity, so the primary air pollutants are those associated with more rural activity, such as dust. Degradation of the air is less in the western part of the project than in the eastern at present. The construction phase of the project will bring large concentrations of engine-powered equipment to the right-of-way and to adjacent areas. The NO_x emitted will cause a greater fractional degradation in the western states than in the eastern, but if the Federal ambient air standards are used as a criterion, the reduction in environmental quality will be acceptable. The operational phase of the project will continually put the products of combustion from the compressor stations into the air. The burning of about 33 million cubic feet of gas per day for compressor operation will be distributed over the 1,600 miles of length, and, although large on an absolute scale, only about 2.2 percent of the pipeline capacity will ultimately be burned in the east and midwest. A considerable area of land will be disturbed by equipment during construction. This disturbed land will be more vulnerable to erosion by water and air. How long this increased vulnerability will last depends upon the degree and success of efforts at revegetation or other restoration. In summary, the degradation of air quality by the pipeline will be relatively diffuse, short term, and cause no major reduction in environmental values.

The water quality along the route is in general relatively good, except for certain areas in Pennsylvania. The construction activities, if carefully conducted, will cause only temporary and minor reductions in water quality. Sediment and siltation problems resulting from cuts across water courses may have some permanent effect on benthic organisms and the clearing of trees near water may adversely affect the thermal environment. In operation, the pipeline will not reduce water quality, since the proposed pipeline will be buried and isolated from the aquatic environment.

Any failures to the pipeline, such as rupture, will not cause any water quality problems, since the primary gas constituent, methane, is not soluble in water to any significant extent. Air quality is another matter. The release of 135 million cubic feet of flammable gas in a major break would create a significant air quality problem which is compounded by the fire danger.

Noise

Noise during the construction phase of the project will degrade the environment temporarily since the ambient sound levels along most of the route are quite low. The number of people exposed to this sound is relatively low because the route has been chosen to avoid populated areas. Construction noise, along with other aspects of the project, will cause some loss of speech transmission in humans and will cause some animals to temporarily change their habitat. Subsequent to construction, only the compressor stations will remain as noise sources, and the acoustical environment can be made acceptable beyond the property limits of the stations by appropriate design. Without noise control measures, it is predicted that the 12 proposed stations will noise impact a total of about 920 people.

Solid Waste

Solid waste from clearing, grading and construction must be properly disposed of during the construction phase of the project. Organic wastes also must be properly disposed of in the short term but will degrade with time and cause no long-term loss in environmental values. Debris left from construction, including oil, grease and gasoline spills could have long term local air and water quality impacts if improperly handled. Injudicious disposal of the large amount of soil displaced by the pipe could result in longer term degradation of water and air. Careless mining of bedding material could also leave conditions that would contribute to long term air and water pollution. Proper disposal of these materials will mitigate any degradation of environmental values.

Aesthetics

Construction activity will lower the aesthetic qualities along the route. The presence of the construction teams, the noise, dust, smoke and other activity on the project will influence the aesthetics of the corridor area. Following the restoration period, the tunnel views along the right-of-way, the visibility of microwave towers and the noise from compressor stations all will be continuing factors in lowering the aesthetic values of the corridor and adjacent areas. In some areas, such as the Badlands of North Dakota, these impacts will result in significant long term damage. Suggested mitigating measures, such as route deviations, would lower resultant impacts on many areas.

Recreation

The recreation areas that are crossed in such a way as to force the closure of a park or cause major reduction of activity will change recreation visitation and patterns of recreation use. Several hundred thousand recreation visits could either be diverted to other recreation areas or simply not occur. This will depend on whether the construction period conflicts with the high season for recreation. Most of the visitation can be expected to return to the park in the next season although restoration and new recreation habits may affect use into the second year. Except for some lingering aesthetic values that will be lost and perhaps hinder park popularity, visitation should recover to pre-construction levels. Route deviations would totally mitigate impacts on most recreational areas.

Diversity and Productivity of Biotic Systems

The wildlife habitats that lie in the path of the permanent right-of-way will be impacted as wintering, feeding, nesting, denning, roosting and cover elements for the life of the project. Older trees having cavities that are the habitats for wood-ducks, squirrels, owls, raccoons, etc., or whose branches nest larger birds such as hawks, or which produce large mast crops may take half a century or more after pipeline abandonment for reestablishment. The scattered remaining areas of natural habitat are basic to maintaining a diversity of wildlife species where for most of the route the land has been cleared and drained and is being clean farmed. Many wildlife species are found through the intensively cropped area from Iowa to Ohio only within a limited radius of the natural habitat areas. Population sizes of these species are controlled by the availability of elements of these natural habitats such as nesting, denning, wintering and cover opportunities. Each new loss of natural areas limits both the diversity of wildlife species and the potential population sizes of these species. Where such specialized needs as tree cavities for nesting and denning are not met, the former range of some species may shrink on a relatively permanent basis. While the acreage of natural habitats falling within the permanent right-of-way may be limited, it is one more encroachment on the almost vanished natural habitats along the route and will have a long term adverse impact on the opportunity to use and enjoy a diversity of plants, trees, birds and mammals in the prevailing cultured agricultural ecosystem. This will not be the last threat to these natural areas since drainage, stream alteration, urban expansion, road construction and other pipeline and powerline construction will continue to erode away remaining natural areas.

Economics and Liabilities

The major portion of the economic impact associated with construction and operation of the pipeline will be very short term. The impacts will include wages paid and spent in local areas, materials and services purchased locally, payments for right-of-way easements and other land purchases, loss of agricultural productivity for a growing season or more, temporary disruption and overloading of local services and facilities in some cases. How well individuals will fare economically as a result of the pipeline crossing their land will depend upon how aware each is of all cost implications and how carefully each contracts with the pipeline company to compensate these costs.

Taxes paid will provide a longer-term benefit to local jurisdictions. Much larger benefits will accrue from the energy supply that the pipeline will make available in the industrialized/urbanized Great Lakes/ North Atlantic regions of the Nation. Natural gas reserves now supplying these areas are being depleted and without a replacement source of energy, serious economic and social disruption would take place.

It is not expected that the existing economic environment of any area along the line will be permanently changed to a noticeable degree by the construction and operation of the pipeline, even along the sparsely settled portion of the line where the presence of operations and maintenance personnel will be most apparent. Permanent loss of productivity of land traversed should be small--possibly some portion of the area actually trenched which is less than 2,000 acres and land occupied by compressor station, access roads, etc., which might be another 1,100 acres. Improper disposal of soil displaced by the pipe could affect the future productivity of additional acreage.

Liabilities for damages imposed by construction and operation of the pipeline will be partially governed under contracts with property owners.

Liability for injury to workers and to members of the general public will be the same as in other construction projects and can be minimized by strictest adherence to safe construction practices. Longer term liabilities connected with maintenance and operation of the facility such as industrial accidents should again be similar to that of other industrial enterprises. Large-scale liability might be involved with the possibility of rupture of the line and resulting leakage of gas, fire or explosion. Such pipeline accidents have not been common but do occur.

6.1.3.3 Restrictions to Future Options and Needs

Land Use

Land in the permanent pipeline right-of-way, 10,584 acres, will have some restriction of use for the life of the project. One major restriction is that it will be kept cleared of structures. Use of an additional amount of land occupied by surface facilities of the pipeline or disturbed in a nonrecoverable way will also be limiting as mentioned in the preceding section. These would appear to be a rather small restriction to future options and needs.

Acquisition of Mineral Resources

Construction of the proposed pipeline may affect the acquisition of geologic resources in three ways: (1) direct acquisition of some associated resources by the applicant, with or without their extraction and consumption; (2) indirect acquisition of some adjacent geologic resources by others for extraction and consumption and (3) possible acquisition by others of some remote geologic resources, either in place or extracted and either raw or processed.

The geologic resources most directly affected will be those ones that are normally extracted by stripping, pitting or quarrying and which will be traversed by the proposed route. These resources mainly consist of lignite coal, sand and gravel and crushed rock. Future demands in the resource market may add sodium sulfate, clay and shale, industrial sands and perhaps peat.

The geologic resources that will be unavailable for extraction and consumption are those that directly underlie and support the right-of-way, plus those that must be left to maintain stability of the supporting materials if adjacent materials are removed.

The quantity of material that will be so lost is negligible in terms of the total of each resource that is present adjacent to the entire route. Nevertheless, in terms of some individual deposits of sand and gravel, the quantity will be large. In terms of some operators' resources, the loss may also be great. Acquisition by the applicant of the quantities lost to extraction probably will be required by present owners.

In some cases loss of geologic resources may be avoided by (1) relocation of the route; (2) temporary rerouting until the resource is extracted and (3) future transfer of the pipeline from support by in-place rock and earth materials to support by a trestle or other engineered structure.

Those geologic resources situated at depth beneath the right-of-way probably will not be affected. Much of the bituminous coal, probably all petroleum and natural gas and salt, for example, are at considerable depth. They can be extracted by wells or underground mines for which ground-surface operations need not be located in the right-of-way area.

Development of lignite coal resources is a possible side-effect of pipeline construction, depending upon continued development of a coal-gasification process to produce gas which could be transported to a market by the proposed pipeline.

Possible acquisition of some remote geologic resources, either in place or already extracted and either in raw or processed form could come about in order to provide necessary materials of various kinds required for pipeline construction. For example, nearly 1.1 million tons of steel will be required for the pipe alone.

Most of the geologic resources used in construction of the pipeline will not be available for use elsewhere. This will mean that other needs in the country may have to be met by the acquisition of new, different or additional resources for extraction and consumption.

Availability of Fuel

As explained in Section 1.1.3.1 the known and committed reserves of natural gas to be transported by the proposed pipeline are sufficient for about 20 years at design capacity. The pipeline could also reasonably be used to transport natural gas from other large known and potential reserves in Alaska and Northern Canada and synthetic gas manufactured from the vast coal deposits of Montana and the Dakotas, which would extend the life of the pipeline to 50-100 years. Therefore, the increased availability of fuel to the 29 state delivery area is long term.

The 33 mm.cf./day of natural gas consumed by the 12 compressor stations tends to limit the quantity of fuel delivered on a long term basis. The fuel (diesel and gasoline) used in construction represents a substantial short term limitation of fuel available for other uses.

Fuel used in construction has an energy equivalent equal to .98 days delivery of natural gas when the system is operating at design capacity. The natural gas consumed by the 12 compressor stations represents 2.2 percent of the gas entering the system at the Canadian border.

6.1.3.4 Benefits of Energy Supply Made Available as a Result of Proposed Action

This project would supply approximately 560 billion cubic feet of natural gas per year to the Midwestern and Eastern United States. The energy equivalent of this amount of gas could support between 519,000 and 670,000 jobs associated with the production of between $12 and $15.5 billion in GNP upon completion of the project.

7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES IF PROPOSED PROJECT IS IMPLEMENTED

7.1 ARCTIC GAS PIPELINE PROJECT

7.1.3 Northern Border Pipeline

This section describes resources that will be irretrievably lost through the implementation of the proposed project. Resources as referred to in this section include not only the materials and labor required to construct the pipeline and its related facilities but also the natural and cultural values that may be lost permanently as a result of the project implementation.

7.1.3.1 Damages From Natural Catastrophe or Man-Induced Accidents

Loss of Quantities of Natural Gas

The loss of natural gas due to pipe rupture will be orders of magnitude greater than that from small scale leaks. The rupture process and probabilities are discussed in Section 3.OV.16. In a typical Class I area, a pipe rupture is estimated to cause a loss of about 135,000,000 standard cubic feet, based on pipe volume and the time required for the automatic main line block valves to close. The heating value of this gas is approximately 135 billion Btu's.

Destruction of Wildlife and Vegetation

The effect of pipe rupture is discussed in Section 3.OV.16. Since most of the route is rural, there is potential for destruction of wildlife and vegetation. Although pipeline breaks are sufficiently rare that such destruction is unlikely, wildlife and vegetation would be destroyed for about 600 feet around a break. A forest fire resulting from a break would create more extensive damage. If an explosion of low lying gas occurs there will be an irretrievable loss of local vegetation and wildlife in about a one-half mile diameter circle. Without explosion it is unlikely that any irretrievable loss will occur.

Loss of Materials

For a pipeline rupture under outside force conditions, it is likely that only one or two pipe sections will be irretrievably lost. If a weld failure occurs, it may be necessary to replace many sections depending on the cause of the failure. If the failure occurred at a compressor station and ignition occurred, the entire station could be destroyed. Irretrievable loss of all the station materials would occur.

Possible Loss or Damage to Human Populations and Surrounding Property

There is a populated area near Penn, Pennsylvania, where some loss of homes could occur. The probability is sufficiently small that there should be little concern. (See Section 3.OV.16.)

7.1.3.2 Project Structures Unlikely to be Removed

The manner of abandonment of this project will be determined by the Federal Power Commission in accordance with Section 7(b) of the Natural Gas Act, 15 USC 717f(b) and in accordance with regulation of the Office of Pipeline Safety and will probably have to conform to regulations developed in the interim period. The applicant originally stated that all above ground structures can be removed and the pipeline could be removed if it is necessary to accommodate future construction. If and when abandonment becomes necessary, the pipeline will be removed and the pipe trench will be restored to original contour with material from the right-of-way, from borrow areas agreed upon with landowners or from commercial sources.

It appears, then, that all project features will be dismantled upon eventual abandonment and only those materials which are impractical to recover will be discarded. With the rapid reduction of world resources, it appears likely that the steel in the pipeline, compressor stations and other features will be recovered and reused. The only material to be lost is likely to be lumber, cinder block, concrete and asphalt. A loss of materials from borrow areas would occur to refill the trench since the originally removed material will not be available.

7.1.3.3 Resource Extraction

Natural Gas Resources to be Used

The Northern Border Pipeline would transport approximately two-thirds of the known and committed reserves in the Prudhoe Bay area and using present estimates this would be about 15 trillion cubic feet of gas with a heating value of about 15 quadrillion Btu. Because this pipeline will have such a large capacity one would anticipate that approximately one-half of uncommitted proven reserves on the north slope might also be transported through this system. This would amount to nearly 20 trillion cubic feet. In addition to these proven reserves, speculative recoverable reserves have been estimated by the State of Alaska in the Alaska Open File Report Fifty issued by the Division of Geological and Geophysical Surveys (DGGS) of the State of Alaska in June, 1974. The DGGS Report states that "speculative recoverable petroleum resources are here defined as those petroleum resources which are completely undiscovered, and which after discovery can reasonably be expected to be produced using present technology and economic conditions." The following figures are taken from that report for geological basins or provinces which we believe, once such reserves are drilled and proven, will be within economic range of the Alaskan system projected by the Arctic Gas group and should ultimately be delivered through that system to the United States. They are:

North Slope Onshore	41.8 trillion cf
Beaufort Province Offshore	13.5 trillion cf
Chukchi Province Offshore	33.0 trillion cf
Total	88.3 trillion cf

If it is assumed that approximately half of the speculative recoverable gas in these three areas is in fact discovered and produced to pipelines, this would be a total of recoverable reserves in addition to present proven reserves of some 44 trillion cubic feet. Following the same logic as was applied to the proven reserves (that about three-quarters of this reserve would go to that part of the United States lying east of the Rockies), one would assume that approximately 33 trillion cubic feet of what are presently speculative reserves would become available to the Northern Border pipeline from Alaska. If this is added to the estimated 19.5 trillion cubic feet which it is believed will be available to Northern Border from presently proven reserves, the total anticipated to be deliverable from Alaska through the Northern Border facilities becomes 52.5 trillion cubic feet with a heating value of about 52.5 quadrillion Btu.

Other Fossil Fuels That Would be Used

The pipeline will permit easy access to the Dunn Center, North Dakota coal fields, which could be utilized for gasification and injection into the line. No data are available on the magnitude of such a project. A newspaper report on December 14, 1974, in the Bismark Tribune (North Dakota) stated that the Natural Gas Pipeline Co. proposed to strip mine about 52 million tons of lignite coal per year to produce 365 billion cubic feet of synthetic natural gas per year. Over a 20 year period there would be an irretrievable use of about 1 billion tons of coal from the North Dakota fields.

Oil and Gasoline for Project Vehicles and Machinery

A significant amount of diesel oil, gasoline and lubricants will be required by the equipment and machinery used in construction of the projects key features: main line, river crossings, compressor stations and microwave towers.

The major items and the anticipated quantities of each to be consumed are as follows:

Item	Quantity
Gasoline	6,480 gallons
Diesel Oil	14,330,000 gallons
Lube Oil	215,150 gallons
Grease	151,130 pounds

Mineral Resources to be Used by the Project

There are several major mineral resources to be used by the project. The geologic resources impact would include the consumption of an estimated 2.5 million cubic yards of natural construction material for access roads. This would be an essentially irreversible and irretrievable commitment, as would be the terrain modification caused by the development of these sand/gravel borrow pits and rock quarry sites necessary to obtain these materials. Many of the sites exist and will not require the construction of new facilities. The locations and extent of such facilities are not available.

Concrete for use on the project which consists of cement, sand and gravel will amount to approximately 375,000 tons.

Bedding material will have to be utilized for specific sections of main line depending on the existing conditions and will amount to an estimated quantity of 2,000 cubic yards of gravel bedding material per mile.

Bituminous material will be required to provide all-weather surfaces for permanent access roads and the maintenance of the existing public system and will amount to approximately 2,000,000 gallons.

Steel pipe and other structural materials for the main line, compressor stations, microwave towers, etc., will amount to approximately 1,100,000 tons with a welding rod requirement of 4,519,200 pounds.

Water for hydrostatic test of the pipeline could amount to approximately 500,000,000 gallons, if the water was only used once. If the pipe is tested in 20 mile sections and the water is reused, 7,000,000 gallons will be required. This water will not be lost. However, it will be displaced from one drainage to another and possibly from one state to another.

Non-Renewable Resources to be Used by the Project

The construction of the pipeline will require large amounts of irretrievable and irreversible commitments in resources. The major items to be committed are as follows:

Natural Gas	13 trillion cubic feet
Diesel Fuel	14,330,000 gallons
Gasoline	6,480,000 gallons
Lube Oil	215,150 gallons
Grease	151,130 pounds
Welding Rod	4,519,200 pounds
Bituminous Material	2,000,000 gallons
Concrete	375,000 tons
Gravel	2,500,000 cubic yards
Steel	1,100,000 tons

The steel pipe could be re-usable when it is removed in the event of pipeline abandonment. The sale of the pipe for specific uses will depend on a need at the time of removal; but it is impossible to predict an after use at this time for that quantity of pipe. The condition of the pipe at the time of removal would be a factor in whether re-use is practical. Transportation cost could be prohibitive. Due to these and other unknowns, the pipe should be considered non-retrievable.

7.1.3.4 Erosion

Loss of Topsoil, Surficial Material and Organic Matter

Topsoil

Although topsoil is not usually considered an extractable resource, it should be treated as such in the Northern Border Pipeline Project. The prairie topsoil to be excavated for approximately 1,200 miles through the highest producing farmland in America is the basic resource that makes these high agricultural production levels possible.

The rich topsoils were formed over a period of many thousands of years. Their loss through excavation and return to the lower levels of the pipeline trench either with or without mixing constitute an irreversible and irretrievable loss of a valuable resource. If topsoils are excavated from an 8-foot strip to a depth of 2 feet for 1,200 miles, over 3 3/4 million cubic yards will be lost.

This loss will be partially mitigated where topsoils are replaced or mixed with other materials that are placed on the surface.

An indeterminant volume of topsoil will also be lost during the benching and leveling of the right-of-way on sloping land. Other losses of topsoil will occur from wind and water erosion on the exposed right-of-way.

Subsoils

Along the 1,600 miles of the Northern Border Project the pipe will displace approximately 3 million cubic yards of subsoils or substrata materials. It is expected that most of this material will be disposed of offsite or where practical, spread over the soil surface near the pipeline trench. In any event it will be irretrievably lost to the existing soil profile.

Effects on Aquatic Ecosystems and Water Quality

While during construction, and until disturbed surfaces have been stabilized or revegetated, there will be increased runoff bringing with it higher turbidity and siltation levels; as surface restoration takes place these factors should generally return to essentially preproject levels. In some steep, arid segments in the western portion of the pipeline, however, surface restoration will be difficult and may take many years to accomplish and water quality could be degraded for a long period. While this would not be an irreversible or irretrievable loss, it could be a long term degradation of water quality of surface restoration is not pursued very actively.

7.1.3.5 Destruction of Cultural, Archeological, Aesthetic, Scenic and Historic Sites

Loss of Sites, Mounds and Other Diggings With Archeological or Historical Value

For the purpose of discussing irreversible and irretrievable losses, archeology and history can be combined. Both deal with past generations and ages. Disturbance, damage or destruction of sites would be a permanent loss.

The pipeline construction could produce impacts that would be irretrievable to both historic and archeologic sites. The extent of these impacts is largely unknown because historical and archeological surveys have not been conducted on most of the proposed route. Section 106 of the National Historic Preservation Act of 1966 (80 Stat. 915, as amended) and Section 2b of Executive Order 11593, May 13, 1971 make the historical survey mandatory. With the exception of Fort Bouis Fur Post, which has not been precisely located, losses to historic areas are not expected to be severe. The Illinois and Michigan and Miami and Erie Canals are the only other known historical sites, and the pipeline may burrow under them rather than crossing them by open trench. Other sites of historic interest can be expected to be discovered during construction. It is likely that damage on these sites will be severe if directly crossed.

Archeological sites almost certainly would experience greater and more significant damage of irretrievable nature than will historic sites. Most of the construction corridor has not been surveyed and additional sites may be located in or near the corridor. Like the 15 known sites, losses at unknown sites have not been determined, but whatever the losses are, they would be irretrievable because the integrity of the site will be affected. At the present time, 9 of the 15 sites appear to be of special importance.

They are the North Cannonball site, North Dakota; Utica Mound Group, Barney Erikson site and Little Beaver site all at the Illinois River crossing, the two Alexander sites, Illinois and the Richardson Kame, William Alexander Kame and an unnamed village site all in Ohio.

Effects on Above Ground Structures

No buildings are expected to be moved, damaged or destroyed by the pipeline project. There is concern, however, that buildings near the route may have historical or architectural value. It is likely that such a structure may be difficult to recognize because of new siding or other modifications that would camouflage the importance of the structure. The destruction of such a building would be an irretrievable loss.

Alterations to Aesthetic and Scenic Values

Aesthetic and scenic values, while impacted by the pipeline construction and operation, will have relatively minor irreversible and irretrievable resource commitment. These will be topographic in nature with rock outcrops or other steep and/or unstable slopes the most serious areas of impact. Actions needed to protect these cuts from erosion can be expected to be rounding of the slope rather than restoration to original contours. Some river crossings, such as the Wabash, and areas of badlands, will be the areas most seriously affected topographically.

7.1.3.6 Elimination of Endangered Species Habitat

While on the basis of rather superficial surveys no prairie dog towns appear to be located within or in close proximity to the proposed route in the Dakotas. There still remains the possibility that prairie dog towns could be destroyed along the route or in connection with access road construction, at spoil or borrow sites, at storage and staging areas or at construction camps. Only with detailed study of all these areas by a technical review team can we be assured that prairie dog towns with endangered black footed ferrets in residence will not be eliminated.

There could be a serious indirect effect on the endangered Indiana bat which inhabits the Black Ball Mine near the Illinois River crossing. Increased human activity in the area and provision of additional access could result in serious losses to the Indiana bat population. A route deviation would avoid this threat.

Rare and unusual fish and mussels do occur in streams crossed by the route but with stringent efforts to control and minimize sedimentation, permanent adverse habitat changes should not take place. Sampling by technical review teams should be carried out, however, where it has been noted previously that rare mussels may occur so that specific concentrations of such mussels will not be dredged up in river crossings and brood stock eliminated.

In the event that satisfactory arrangements cannot be made with some private landowners on the reestablishment of potholes, serious irreversible and irretrievable losses of wetlands could take place in areas where agricultural drainage has already taken a heavy toll of critical waterfowl habitat.

7.1.3.7 Irrevocable Changes in Land Use

Changes in Zoning

Lands traversed by the right-of-way would not necessarily be encumbered by restrictions upon land use. However, the existence of the easement would probably inhibit the development of the land from sedentary uses (e.g., agriculture) to residential or industrial classification. In this case the permanent losses would be secondary, and a function of demographic patterns.

Increased Housing and Other Construction

The presence of the pipeline will affect the development of communities along the proposed route. Apart from the direct loss of land, the presence of the right-of-way will pose a visible interruption of the continuity of communities and the potential threat of explosion hazard will pose a secondary obstacle to development.

Conflicts With Recreational and Other Future Land Use Plans

The losses of recreational resources will be minimal. Most parks, hunting and fishing preserves, golf courses, picnic grounds, etc., will be affected only by the interdiction of permanent structures and restrictions upon vegetation along the right-of-way.

Existing parks and natural areas will suffer some permanent damage to their topographic features. The outstanding example is the region of the crossing of the Little Missouri River, in North Dakota, where a potential national wild and scenic river might be established under Section 5(d) of the Wild and Scenic Rivers Act, the proposed actions would irreparably damage the scenic qualities of the immediate local topography. The river is now part of the state river system.

Other areas similarly affected include the two crossings of the Wapsipinicon River in Iowa and the two crossings of the Wabash River in Indiana. Both rivers may be qualified for scenic or recreation river status. Impacts on these areas may be mitigated by route deviations.

7.1.3.8 Commitment of Materials and Human Resources

Construction Materials

Of the major materials and supplies to be consumed or utilized during construction, and listed in Section 1.1.3.6, only the 1.1 million tons of steel of the pipeline might be practically recoverable. The irretrievable commitments of materials will be about 375,000 tons of concrete, 14.3 million gallons of diesel fuel, 6.5 million gallons of gasoline, 215,150 gallons of lube oil, 204,000 pounds of grease directly on the job. In addition significant secondary expenditures will probably occur due to construction commuter traffic, administrative traffic, Federal and state officials flying in to inspect the project and so forth.

Use of Labor Force for Construction Period

Using the work force estimates given in Section 1.1.3.6, approximately 7,500 man-years of effort will be expended in the direct construction of the project. It is virtually impossible to estimate the number of man-years of effort involved with secondary aspects of the project such as the use of a bulldozer driver in a county sanitary landfill to cover up the project debris.

8.1.3 Northern Border Pipeline

Introduction

The preceding sections of this statement deal with the proposed pipeline route--the route selected by the applicant. In addition to the proposed route, the applicant also considered three alternative routes. These three alternative routes are referred to in this section as Lines 1, 2, and 3. Three other alternative routes are given consideration in this section by the Department of the Interior; these alternative routes are referred to as Lines 4, 5, and 6. Maps of Lines 1 through 6 are shown in figures 8.1.3-1 through -6, respectively, and are located at the end of this volume.

Environmental Findings

Differences in impacts between the proposed and alternative routes all occur west of Kankakee, Illinois. All alternative routes follow the applicant's proposal east of Kankakee.

Based on the potential impacts anticipated for the proposed route and the alternative routes, the Department of the Interior has ranked the proposed route and alternatives in terms of the most desirable environmentally (the least impacts) to the least desirable (the most impacts).

The ranking is:
- Alternative Line 5,
- Alternative Line 4,
- Alternative Line 6,
- Proposed Route,
- Alternative Line 3,
- Alternative Line 1, and
- Alternative Line 2.

Line 5, Red River

The Red River alternative route, by staying north and east of the Missouri River, avoids practically all of the native prairie, potholes, badlands, and rivers such as the Missouri, Wapsipinicon, Heart, Knife, James, etc. It stays within the 20-inch rainfall zone with the possible exception of the extreme northern end where cooler temperatures lessen the importance of more rainfall. This wetter region will enhance the success of the revegetation efforts.

Agricultural lands occur along almost all of the route. Despite this, the miles of tile system will not significantly change since the tiled areas are primarily in the Corn Belt where this route and the proposed route are the same or parallel. Because of deeper topsoils in the Red River Valley, the loss of these soils through mixing with the subsoil should not result in loss of crop productivity.

Because of the lack of habitat areas crossed, wildlife losses would be reduced greatly compared to those in the Dakotas and Montana. Once in the Corn Belt, no change would be noticed.

Generally, the terrain would be flatter in the Red River Valley.

Vegetation impacts should be less because of more rain and fewer trees and native species.

Economic and sociologic impacts should be considerably less because towns within commuting distance of the route are more numerous, larger, and therefore better able to handle a sudden and short-lived influx of workers as well as a few permanent residents.

Generally, esthetic values would be affected less because the countryside has been generally disturbed and the most sensitive areas along the proposed route are avoided.

Finally, from southern Minnesota to Kankakee, the route would parallel the Dome Corridor.

The principal disadvantages of this route are:

1) An expected greater crop production loss during year of construction, because of the greater amount and productivity of croplands crossed, and

2) The Minnesota River is a major river lying in a fairly deep valley. The valley is underlain with quartzite with quarries in the crossing area near Mankato. It will be a difficult crossing with esthetic impacts.

Line 4, Dome

The Dome alternative route is named for the corridor and right-of-way now being acquired by the Dome Corporation of Calgary, Alberta, to bring petrochemicals from the Edmonton area to Detroit, Michigan, by parallel 10- and 12-inch pipelines. Within the United States, this route is estimated to be about 233 miles shorter than the proposed route. The Dome alternative route would be followed to Kankakee from where the alternative route would be the same as the proposed route.

Construction paralleling existing right-of-way has a number of land use advantages. For example, the land use pattern will have already been altered by the initial project. The width of the right-of-way required for new construction can be reduced when an existing right-of-way is adjoined. Operational surveillance and other construction and operation costs, such as access roads, would be reduced. The joint corridor is the primary advantage of this alternative route. Several Federal agencies advocate the joint use of corridors where possible. In addition to the Dome corridor there is the opportunity in certain areas to follow the Soo Line and Burlington Northern Railroads, the only existing diagonal transportation corridor in the area.

Impacts from this alternative route, while avoiding the corridor of the proposed route, will be additive to those experienced from the Dome project. By avoiding new areas, esthetic values would probably benefit the most by not establishing a new corridor. Impacts on soils along the Dome alternative route will be less because the soils are relatively deep and on gentle slopes. More sandy areas will be encountered which will be more susceptible to wind erosion. Because of a greater percentage of the corridor being in cropland, native vegetation and wildlife losses will be minimized.

The Dome corridor avoids the two Missouri River crossings, thereby avoiding the most fragile lands and vegetation along the proposed route. These lands include the Little Missouri Badlands and segments of relict prairie vegetation. Both crossings of the Missouri River, one in the Oahe Reservoir, are avoided as well as the Little Missouri River, the Heart River, and the Killdeer Mountains. The Dome corridor also eliminates two crossings of the Wapsipinicon River in Iowa and crossing the Starved Rock area in Illinois.

The Souris River in North Dakota and the Fox River in Illinois would be crossed by following the Dome alternative route. This disadvantage is coupled with a 125-mile stretch of the James River Lowlands which contain numerous potholes and are important waterfowl areas. Overall, however, the Dome alternative route passes through about 40 miles less prairie pothole country than the proposed route. Actually, considering that the Dome route would be already disturbed, combining the two routes would result in avoiding about 165 miles of prairie potholes.

Because of crossing more cultivated land, crop losses during the year of construction could be expected to be greater than for the proposed route.

Line 6, Missouri River North

The Missouri River North alternative route differs from the Dome alternative only west of the community of Carrington in Central North Dakota. The Missouri River North alternative route would cross the International Border at Monchy Saskatchewan, and corresponds to the Northern Border proposed alignment to a point about 24 miles north and west of Wolf Point, Montana. From this point, it goes east and southeast for about 285 miles, staying north of the Missouri River, until it intersects the Dome alternative route.

The principal advantage of this route is that by staying north of the Missouri River it avoids crossing the Missouri River twice (including one in the Oahe Reservoir), the Little Missouri River, the Badlands, the Killdeer Mountains, and the Heart River. This alternative also means no change would have to be made in the southern part of the Canadian route. Advantages of the route below Carrington are discussed with the Dome alternative route.

The principal disadvantages are: (1) lengthening the route in the United States by about 32 miles, and (2) the necessity of going through a largely undisturbed area of high water table and pothole country north and northeast of Lake Sakakawea.

Lines 1, 2, and 3

The applicant in the Environmental Assessment concluded that the alternative routes (Lines 1, 2, and 3) involved impacts similar to or greater than the proposed route. The Department of the Interior concurs with the applicant's conclusions concerning these alternative routes. Therefore they have not been discussed in detail in this section.

8.1.3.1 Line 5, Red River Corridor

Project Proposal

Location

Line Number 5, Red River, shown on Figure 8.1.3-5, is proposed by the Department of the Interior to be a viable alternative to the proposed route. Line 5 would be about 343 miles shorter than the proposed route.

Line 5 begins at a point on the Canadian-United States border near St. Vincent, Minnesota, and follows the Mid-Western Gas Transmission Company pipeline to the vicinity of Ada, Minnesota. The line then proceeds southeast for about 265 miles to the vicinity of Benson, Minnesota, where it intersects Line 4. It follows Line 4 for about 550 miles to a point 15 miles west of Kankakee, Illinois, and then is identical to the proposed route to Delmont, Pennsylvania, a distance of about 440 miles.

Major River Crossings

This line would involve the crossing of eight major rivers which, in the order crossed, are: Minnesota, Mississippi, Illinois, Wabash, Muskingum, Ohio, Monongahela, and Youghiogheny.

Pipeline and Facilities

Line 5 will be approximately 1,255 miles long. The estimated facilities would be: 20 proposed and possible future compressor station sites, 13 delivery-measuring stations, 69 communication towers and 79 mainline block valves. This line would not allow for direct delivery as proposed to the city of Aberdeen, South Dakota, but an indirect tie could be made. The proposed route deliveries in Martin County, Minnesota, Hancock County, Iowa, and Buchanan County, Iowa, would be sifted north and east from the proposed locations to points where the existing company lines intersect Line 5.

Land Requirements

The estimated land requirements for right-of-way are shown below:

Summary of Estimated Land Requirements

Permanent

Feature	R.O.W. (acres)
Pipeline	9,096
Compressor Stations	400
Communication Towers	196
Mainline Block Valves	4.7
Delivery-Measuring Stations	26
Access Roads	120
Total	9,842.7

Description of the Environment

The Line 5 alternative traverses the Red River Valley of Minnesota from north to south for about 265 miles where it meets the Line 4 alternative at Benson, Minnesota.

Nearly all of that portion of the Red River Valley crossed by the route is in farms. Principal crops include spring wheat, sugar beets, corn, potatoes, and sunflower seeds.

Average annual precipitation is 19 to 22 inches, most of it occurring from late spring to early autumn. Average frost-free period is 105 to 135 days (see Section 2.1.3.1 for additional climatic data).

Elevations in the Red River Valley range from 800 feet in the north to 1,100 feet in the south. The nearly level glacial lake plain is bordered on the east by outwash, gravelly beach ridges and dunes.

Water management is a major problem of the valley. In normal years rainfall provides enough moisture for the crops commonly grown but wide year-to-year fluctuations make the supply uncertain. Even though rainfall is not high, drainage is required in the level areas. Approximately onehalf of the cropland contains open ditch drainage systems to remove excess water from the surface in the spring. Heavy soil conditions make tile drains unfeasible.

From Benson, Minnesota, to Kankakee, Illinois, Line 5 follows the route of Line 4 (see descriptions of Line 4 and of the proposed route).

The soils along the Red River Valley segment of Line 5 are extremely uniform. Only three soil associations are encountered from the Canadian-United States border to the junction with Line 4 at Benson, Minnesota. About 70 percent of the route traverses the Fargo Association with deep, fine textured soils derived from glacial lake sediments. The soils occur on level to gently undulating land. They have poor surface drainage and low permeability.

In Clay and Wilkin Counties the route crosses the Bearden-Glyndon Soil Association. Although surface soils in this association are not as fine as those in the Fargo association, the soil has the same characteristics.

In Wilkin County a small segment of the route crosses the Grimstad Association. This soil differs from others in the Red River Valley in that the surface is sandy. On drained areas wind erosion is a hazard.

From Benson, Minnesota, east, the route is the same as that segment of Line 4.

Line 5 will not encounter native plant communities through the Red River Valley. The entire area along the route is intensively farmed.

The section of Line 5 through Minnesota, before it coincides with Line 4 in Swift County, traverses flat extensively drained farmland, mostly in crops. Very little remains of natural habitats including wetlands. There are some prairie chicken booming grounds in Polk and Wilkin Counties which might be traversed, but since only a very general alignment is under consideration a more detailed survey could bypass these areas. Generally, all that would be traversed by Line 5 would be very scattered and limited uncultivated areas along fencerows, property lines, and road and railroad rights-of-way which are critical habitat for those wildlife species which still remain in this area. Foxes, skunks, badgers, cottontail rabbits, pheasants and songbirds all depend on this habitat for food, cover, and critical winter shelter. The remaining portion of Line 5 to the junction with the proposed route is in common with Line 4. The wildlife species and values are covered in the discussion of Line 4. Several State wildlife management areas could be encountered in Stevens County, Minnesota. No major streams are traversed along Line 5 which involve critical aquatic habitats or significant fishery values. The Minnesota River supports a local sport fishery and a limited commercial fishery for warm water species.

The economic and social structure of the Minnesota side of the Red River Valley is almost entirely based upon agriculture. The flat, treeless terrain is the bed of an ancient lake which left behind fertile soil and is particularly adaptable to mechanized agriculture. In addition to wheat, flax, and barley crops, potatoes and sugar beets are grown here.

Proper soil drainage is essential to the agricultural productivity of this area and extensive drainage systems have evolved. Because of the peculiarities of the drainage requirements, the drainage systems are nearly all surface drains with little or no subsurface tile drainage. This would reduce the restoration cost if disrupted by trenching.

There are no large towns on the Minnesota side of the Red River Valley, but two of North Dakota's largest cities, Fargo and Grand Forks, are located in the valley on the west side of the river. Because of the more intensive farming activity, the population density is higher along this alternative route than along the proposed route located in the grazing area of North Dakota and Montana to the west.

This alternative route would be 343 miles shorter than the proposed route. The land requirements, construction materials and labor requirements would be correspondingly smaller for this alternative route--only 75 to 80 percent of the proposed route requirements.

The nature and intensity of the economic and social impacts would not be significantly different along this alternative route than along the proposed route except that the proximity of the two larger North Dakota towns, Fargo and Grand Forks, might absorb some of the socio-economic pressure on smaller communities closer to the pipeline route.

The Red River Valley is generally unstudied for either historic or archeological sites. However, because of the rich soil, it became an important agriculture production area early in the settlement of the Dakotas and Minnesota. Many historic structures are known to occur in the vicinity of the river.

There is suspicion that the valley holds the secret to relationship between the woodland and plain associations of Indian cultures, especially of the Chippawa and Sioux.

Only one recreation area appears to be in the generalized corridor of Line 5. It is the Herman, Minnesota, Municipal Campground and Fairgrounds. The 40-acre site is owned and operated by the community.

The route follows U.S. Highway 75 south to Crookston where Minnesota Route 9 is adjacent to the corridor except for a shortcut near Breckenridge. Most of the countryside along this alternative route is the flat Red River Valley. The area is a high production farm area. Few recreation areas exist in the corridor because of lack of relief or other natural features that enhance parks and recreation areas. Most of the communities along the corridor have a community park, swimming pool, and golf course. The famous Minnesota Lake district to the east provides much of the recreation opportunity.

Esthetic values from the United States-Canadian border to Benson consist largely of the farmsteads, field patterns, and other marks of man upon the tabletop flatness of the intensive agricultural lands in the Red River Valley.

Environmental Impacts

Soil impacts from Line 5 will be considerably less than those on the proposed route. The 250-mile segment in Minnesota's Red River Valley traverses deep clayey soils on nearly level topography. The remainder of the route to its junction with the proposed route near Kankakee, Illinois, traverses the glacial till plains of the Corn Belt and is on the same course as Line 4.

Soil impacts in the Red River Valley will include contamination of topsoils with infertile subsoils as discussed in Section 3.1.3.4 for the proposed route. Surface drainage problems are common in the spring and may hinder construction activities.

A small area in Wilkin County, Minnesota, contains sandy surface soils that will present a wind erosion hazard.

Water erosion hazards will be minor because of the nearly level topography. The only significant river crossing is at the Minnesota River and is described in the Line 4 description.

Line 5 is also 343 miles shorter than the proposed route and would impact 4,157 less acres. However, the choice of this alternative route would necessitate construction of a much longer segment in Canada or possibly the choice of alternative route in Canada.

Vegetation impacts along Line 5 will be limited almost entirely to cropland. The crops impacted by the pipeline right-of-way include corn, sugar beets, potatoes, and sunflower seeds in the Red River Valley. Approximately 3,025 acres of this type of cropland would be out of production during the construction year and may be subject to decreased yields for a number of years depending upon the intensity of mitigation.

The only woodland impact would be the bottomland hardwoods removed at the Minnesota River crossing discussed for Line 4.

For the segment of Line 5 not identical with Line 4, wildlife impacts would be limited and of a short-term nature. Very scattered areas of uncultivated land and fencerows remain. Prairie chicken booming grounds could probably be avoided in laying out a final route alignment. For the segment common with Line 4 in Minnesota and Iowa, there would be an initial loss of about 120 acres of critical upland game habitat. This would require several years to recover and would result in local short-term reductions in the size and variety of wildlife populations which depend on these areas for food, cover, nesting, and wintering areas. Hunting opportunity for cottontails, jackrabbits, pheasants, and other upland game species will be reduced on a local level until brush and forbs have been reestablished. Since larger brush along the permanent right-of-way will be controlled for the life of the project overall wildlife values will be reduced on a long-term basis. Some 30 acres of upland and river bottom woodland would be cleared initially and some 12 acres kept cleared for the life of the project. There would be a long-term loss in populations of white-tailed deer, squirrels, woodland birds, etc. It would take many years for the temporary right-of-way to be reforested and many years beyond the life of the project for the permanent right-of-way to be reforested. In final alignment, the State wildlife areas in Stevens County probably could be avoided. Aquatic habitats should be back to normal at stream crossing sites within 1 or 2 years after construction if streambanks are immediately revegetated and stream substrates are restored.

The 265-mile segment from the Canadian border to Benson, Minnesota, where the line joins the alternative Line 4 route should not experience damage to designated recreation areas with a possible exception of the Herman campground and fairgrounds; neither should recreation resources along the corridor be impacted to a degree that their recreation values be lessened.

Almost all of the corridor lies in the broad, flat and rich agriculture lands of the Red River Valley. Except where the line would cross bands of trees, probably only at stream crossings, little sign of the pipeline should be observable.

Archeological and historical impacts described in Section 3.1.3.12 for the proposed route apply to Line 5.

The environment along Line 5 differs slightly from that of other routes since there is no open rangeland encountered along Line 5. Practically the entire distance is farmland. Line 5 traverses Urban Air Quality Control Region, AQCR 130, in the Fargo-Moorhead area. From the Canadian border south, measured values of suspended particulates (1974) as an annual geometric mean within the Minnesota portion of Line 5 are as follows:

East Grand Forks	97 $\mu g/m^3$
Moorhead	46 $\mu g/m^3$
Fergus Falls	64 $\mu g/m^3$

The environment along Line 5 within Iowa and Illinois has been sufficiently described in Section 2. The impact of the line through lower Minnesota, roughly from Fergus Falls to the Iowa State line, has been described under Line 4. In northern Minnesota the area around East Grand Forks is already polluted with suspended particulate matter, and is therefore sensitive to additional dust and other particulates from construction operations. This impact, however, will be decreased by the prevailing westerly winds, since the Line 5 route lies east of East Grand Forks.

Impacts in lower Minnesota are the same as for Line 4, and impacts in Iowa and Illinois are similar to those of the proposed route. In upper Minnesota there is one region that is sensitive to impact from suspended particulates.

That part of Line 5 which deviates from the proposed route parallels or adjoins highways, railroads, gas transmission lines and electrical transmission lines, each of which constitute already existing noise sources. During the construction phase of the project, nearby communities will be impacted by the noise from heavy diesel trucks as described in Section 3.1.3.15. Compressor station noise impact will be the same as described in Section 3.1.3.15 except that in certain areas, the existing ambient noise level will be higher due to traffic and other noise sources and will provide some masking of compressor station noise.

Pipeline failure hazards will be the same as described in Part I, Overview, but all damage potential could be higher because the line parallels or adjoins highways, gas transmission lines, and electrical power transmission lines.

8.1.3.2 Line 4, Dome

Project Proposal

Location

Line 4, Dome, shown on Figure 8.1.3-4, is considered, by the Department of the Interior, to be a viable alternative to the proposed route. Line 4 follows the Dome Pipeline Corporation corridor from the Canadian-United States border near Sherwood, North Dakota, to the vicinity of Kankakee, Illinois. The Dome Pipeline Corporation corridor is a new right-of-way for the construction of 10- and 12-inch diameter pipelines. The lines will extend from Ft. Saskatchewan, Alberta, cross the north-central United States, and terminate in the Detroit, Michigan-Windsor, Ontario area.

From the Canadian-United States border, the Dome route extends about 925 miles and intersects the proposed route near Kankakee, Illinois. From this point to Delmont, Pennsylvania, this alternative route is identical to the proposed route, a distance of about 440 miles. Line 4 is about 233 miles shorter than the proposed route.

Major River Crossings

This line would involve the crossing of nine major rivers which, in the order crossed, are: Bois de Sioux, Minnesota, Mississippi, Illinois, Wabash, Muskingum, Ohio, Monogahela, and Youghiogheny.

Pipeline and Facilities

Line 4 would be approximately 1,365 miles long. The estimated facilities involved will be: 22 proposed and possible future compressor station sites, 13 delivery-measuring stations, 77 communication towers, and 90 mainline block valves.

This line would not allow for direct delivery as proposed to the city of Aberdeen, South Dakota, but an indirect tie could be made. The proposed

Land Requirements

The estimated land requirements for right-of-way are shown below:

Summary of Estimated Land Requirements

Feature	Permanent R.O.W. (acres)
Pipeline	9,922
Compressor Stations	440
Communication Towers	202
Mainline Block Valves	5.5
Delivery-Measuring Stations	26
Access Roads	129
Total	10,742.5

deliveries in Martin County, Minnesota, Hancock County, Iowa and Buchanan County, Iowa, would be shifted north and east from the proposed locations to points where the existing company lines intersect Line 4.

Description of the Environment

The Line 4 alternative traverses the Black Glaciated Plains of North Dakota from Renville County to the southeast corner of the State for a distance of 325 miles.

Nearly all of this area is in farms and ranches and about three-fourths is cropland, primarily wheat. About one-fourth of the area, the steeper sites with thin soils, is native range grazed by livestock.

Annual precipitation averages 14 to 20 inches, most of it occurring from late spring to early autumn. The average frost-free period is 100 to 145 days (see Section 2.1.3.1 for additional climatic data).

Elevations range from 1,100 feet in the south to 2,000 feet in the north. The nearly level glacial plain is bordered by rolling morainic hills in the northern part of the route. Local relief is low in most of the area, but relief of 50 to 100 feet is typical of the morainic hills.

The low and erratic rainfall is the principal source of water. Livestock are watered from small reservoirs. Ground water is plentiful in glacial drift but of poor quality. Sandstones yield highly mineralized artesian water, but shales yield very little water.

From Benson, Minnesota to the junction with the proposed route near Kankakee, Illinois, Line 4 traverses the glacial till Corn Belt. Environmental conditions along this segment are similar to those described for the proposed route to the south (see Sections 2.1.3.1 through 15). Exceptions are discussed below.

While Line 4 traverses 15 soil associations in North Dakota not previously described, the differences in characteristics from the glacial till associations described for the proposed route are minor.

The entire route through North Dakota traverses the glacial till plains where topography is level to moderately sloped. Topsoils are formed from till or outwash materials and are underlain by various types of glacial till materials. Drainage over most of the area is poor and wet areas and high seasonal water tables are common.

An exception to this soil pattern occurs in McHenry, Ransom, and Richland Counties, North Dakota, where the route traverses sandhills (Valentine-Hecla-Hamer Association). These soils, composed of coarse sand blown into dunes and hummocks, developed from coarse textured outwash and lake sediments. They have low water holding capacity and high susceptibility to wind erosion.

Through Minnesota the route crosses eight soil associations. Most of the soils encountered have typical glacial till profiles on level to moderately sloping land. Textures are silty to loamy on the surface. Subsoils are deep glacial till materials with high seasonal water tables. At drainage crossings, slopes become steeper and soils thinner. The Ulen-Sioux-Grimstad Association in Stevens and Swift Counties has sand and gravel over the glacial till and is subject to wind erosion. Most of the area through Minnesota is farmland with installed tile drainage systems.

The route through Iowa and Illinois traverses the same soils described for the proposed route to the south.

The vegetation through South Dakota is typical of the mixed grass prairie. Where native rangeland is encountered the silty range site dominates the deep soil sites with shallow sites occurring at drainage breaks. Wetland sites will also be common through the poorly drained glacial till areas.

On the sandhills in McHenry, Ransom and Richland Counties, North Dakota, the range sites are sandy and sands (see Section 2.1.3.6 for description of range sites). Through Minnesota, Iowa, and Illinois, most of the land crossed is farmed. Natural plant communities occur in wetlands where farming is impractical. Flood plain hardwoods occur as narrow bands along major drainages crossed including the Souris, Sheyenne, James, Bois de Sioux, Minnesota, and the Illinois Rivers (see Section 2.1.3.6 for descriptions).

Agricultural drainage has taken a heavy toll of wetlands along this route with from one-third to two-thirds of wet areas already drained. This leaves little in the area of natural habitats and limits the wildlife species to those that can survive in close relation to agriculture. The amount and dispersion of natural habitats are a key factor in the number and diversity of wildlife species. Fence rows, uncultivated rough areas, ditch banks, road and railway rights-of-way furnish critical cover and food for many species including hawks, foxes, coyotes, skunks and badgers, cottontail rabbits, jackrabbits, pheasants, and songbirds. Within the construction right-of-way approximately 140 acres of such habitat in North Dakota, 90 acres in Minnesota, and 30 acres in Iowa would be traversed. Wooded areas of the upland and river bottoms provide habitat for the same wildlife species, but in addition provide food and cover for white-tailed deer, squirrels, ruffed grouse, woodland songbirds, and owls. Within the construction right-of-way approximately 30 acres of such habitat in North Dakota, 7 acres in Minnesota and 5 acres in Iowa would be traversed.

Line 4 crosses the prairie pothole country which contains critical breeding grounds for many waterfowl and shorebird species and which support many other species such as muskrat, mink, herons, hawks, and songbirds. The fringes of these wetlands also support many of the farm game species. Very temporary wetland areas are crossed by Line 4, but up to 300 acres of Types IV and V wetland, deep fresh marsh and deep open water lie within the construction right-of-way. These are the best waterfowl breeding habitat and are valuable as feeding and resting areas for migrating waterfowl. On many of these areas, easements have been acquired by the U.S. Fish and Wildlife Service to maintain these waterfowl values. Several State wildlife management areas in Stevens County, Minnesota, could be encountered in this routing. A large number of small streams and tributaries are crossed by Line 4 before it joins the proposed route and while they provide a variety of habitats only a few have any significant fishing. The Deep and Sheyenne Rivers in North Dakota support local sport fishing for cool water species, while the Minnesota River in Minnesota supports a local sport fishery and a limited commercial fishery for warm water species.

The economic activity along Line 4 is predominantly agricultural as it is along the corresponding segment of the proposed route. A difference exists in degree rather than type. This alternative route transects a higher value cropland area, the Black Prairie of North Dakota and Minnesota, than does the proposed route. There are more cash grain farms, fewer livestock grazing ranches, more drained land, more specialization in soybeans, barley, flax and wheat.

The area along this alternative route is more densely populated than the western segment of the proposed route.

West of the Mississippi River no registered archeological or historical sites, landmarks or proposed designations are in the immediate vicinity of the corridor. Several areas are crossed, however, that have important potential for unknown site locations. Perhaps the least known but with the greatest potential for important sites is the Souris River from Minot to the Canadian border. The closeness of the Fort Totten Indian Reservation may result in Indian related sites being discovered. In Minnesota, Ancient River Warren is a sensitive area as is the Minnesota River crossing near Mankato. Burr Oak Creek Valley and Wapsipinicon River Valley in Iowa are also areas where sites may be found.

Few recreation areas are situated along this corridor. Most of the area is cultivated land with relatively few natural features usually associated with recreation areas. Few rivers are crossed which lessens the effect on recreational activities.

Designated areas occurring along the corridor include the new and undeveloped Smoky Lake State Park on the McHenry-Pierce County line in North Dakota. The route crosses an area of North Dakota with numerous lakes that could affect fishing and hunting if the route is not carefully located.

In Minnesota, lakes occur occasionally along the route with the largest number in Nicollet County. Line 4 is also near the urban area of Mankato which has the only park directly in line with the corridor. This is the 300-acre Seven Mile Creek Park. Hiking and snowmobiling are popular activities. The nearby Minnesota River also provides recreation activity in the form of trails and fishing.

Four county recreation areas are along the route in Iowa. Three are in Mitchell County not far from the Minnesota border. They are Pioneer Park southwest of Riceville, Koon's Forest (7 acres and undeveloped), and the New Haven Pothole area consisting of 165 acres with fishing and hunting as principal activities. The fourth area in Chickasaw County is the Goodale Conservation area consisting of a picnic area and fishing opportunities.

This segment of alternative Line 4 does not appear to cross major areas where esthetic values are especially critical. The sand dune area in southeastern North Dakota is probably the most sensitive, with Smoky Lake State Park, the Nicollet County lakes, and the Minnesota River crossing being the next most sensitive areas.

Environmental Impacts

Soil impacts along Line 4 would be considerably less significant than along the proposed route. This is primarily because: (1) the entire route remains in the glacial till area where soils are relatively deep and slopes are level to moderate, and (2) the route is shorter than the proposed route by about 233 miles and affects 2,824 less acres.

Because the route traverses the till plains it will cross proportionately more cropland and less rangeland than the proposed route. Throughout most of the route, seasonal water tables will be encountered; tile drains and wetland areas will be common.

In North Dakota the route traverses sandhills soils in McHenry County and again in Ransom and Richland Counties. Another sandy area is crossed in Stevens and Swift Counties, Minnesota. These areas will present severe wind erosion hazards not encountered on the proposed route (see Section 3.1.3.4 wind erosion impacts).

Critical areas subject to erosion will occur at the following stream crossings: the Souris River in McHenry County, the Sheyenne River in Benson, Barnes, and Ransom Counties, the James River in Foster County, and the Bois de Sioux in Richland County, all in North Dakota. In Minnesota the route crosses the Minnesota River in Nicollet County. At these sites sheet and rill erosion hazards will occur in addition to streambank erosion hazards.

Along Line 4 vegetation impacts will relate more to cropland than to natural vegetation. Only about one-fourth of the land traversed in North Dakota is native range; the remainder is cropland in spring wheat. Adverse impacts to crops will occur along 295 miles (3,570 acres) and to native range for 90 miles (1,090 acres). The impacts will be the same as those described for the proposed route.

Through the sandhills in North Dakota and the sandy areas in Minnesota, special revegetation efforts will be required because of wind erosion hazards and the difficulties associated with revegetating sandy lands. Since detailed surveys are not available the extent of sandhills crossed is not known.

There will be impacts to riparian vegetation at the stream crossings (see Section 3.1.3.6 for description of flood plain and woodland impacts).

Across Minnesota, Iowa, and Illinois, the route will cross cropland in corn, soybeans, and some pasture. Impacts will be almost entirely on annual crops (see Sections 3.1.3.6 and .11 for similar proposed route impacts).

Construction through fence rows, rough areas and road and railroad rights-of-way will result in an initial loss of some 260 acres of critical upland habitat. This will require several years to recover and will result in local short-term reductions in the size and variety of those wildlife populations which depend on this habitat for food, cover, nesting, and wintering areas. Hunting opportunity for cottontails, jackrabbits, pheasants and other upland game species will be reduced on a local level until brush and forbs have become reestablished. Since larger brush will be controlled, there will be some loss of value for the life of the project. Some 42 acres of upland wooded and river bottom wooded areas will be cleared within the construction right-of-way and some 17 acres will be kept cleared for the life of the project. There would be a long-term loss in the size and variety of those wildlife populations using this wooded habitat. Populations of white-tailed deer, squirrels, woodland birds, etc., would be reduced far beyond the life of the project since even after brush and tree control ceased, it would take many years for trees to move back into the permanent right-of-way. If careful construction techniques and immediate and intensive restoration procedures are used in those wetland areas traversed by the pipeline, losses of waterfowl and shorebird reproduction should be limited to 1 or 2 years after construction. Aquatic habitats should be back to normal at stream crossing sites within 1 or 2 years after construction if streambanks are immediately revegetated and the original streambed substrate is restored. With further on-the-ground planning cooperation between design engineers and State and Federal wildlife agencies, many of the natural habitat areas traversed by first alignment of Line 4 could be avoided such as the State wildlife areas in Stevens County, Minnesota.

Along Line 4 it is likely that right-of-way costs would be higher and the per acre value of crops lost through right-of-way land being held out of production for a season or longer would also be higher. On the other hand, alternative Line 4 would be 233 miles shorter from the Canadian border to Delmont, Pennsylvania. This difference in distance is 15 percent. The amounts of right-of-way, gasoline, and diesel fuel, tons of steel in pipe, welding rod, etc., and construction manpower requirements would all be reduced by a similar percentage. While the per unit (miles or spread) economic and social impacts would remain about the same as in the proposed route, the total impact of construction expenditures would be reduced. Balanced against this is the fact that the Canadian portion of the line would be about 241 miles longer with this alternative.

This alternative route is nearly 100 miles away from the present area of coal gasification development in southwest North Dakota. What effect this might have on development of a coal gasification industry is an unknown quantity, but is a possible impact of this alternative location of the pipeline.

This alternative route avoids passing through any Indian reservations and most large towns, although it would lie within a 2 to 8 mile proximity of Valley City, North Dakota (1970 population 7,843), Willmar, Minnesota (12,869), Mankato, Minnesota (30,895), Albert Lea, Minnesota (19,419) and Austin, Minnesota (25,074).

The economic and social impact on areas along this route would not be significantly different from that along the proposed route. Only the names of the individuals and communities impacted would be different.

The Lake Souris region has the highest potential of any area along this alternative west of Waterloo, Iowa, for potential archeological sites. As a result, the potential for damage to unknown sites is high.

From the point east of Waterloo to the North Dakota-Canadian border this route crosses few areas where recreation and esthetic resources are likely to be severely impacted. In Iowa and Nicollet County, Minnesota, wooded areas will likely be fragmented by the corridor. Where this occurs within a park the esthetic value of the area will decline. Park related activities probably will not occur during the construction period. The Minnesota River crossing northeast of Mankato will cause damage to the topography and vegetation. This may be a severe problem. Elsewhere, the sandy soils in the vicinity of the Sheyenne National Grassland and Sheyenne State Forest appear to be very sensitive.

Air quality conditions along Line 4 are similar to those of the proposed route with the exception that Line 4 passes near the industrial city of Mankato, Minnesota. In addition, Line 4 passes through a corner of Air Quality Control Region 132 about 35 miles southwest of Fergus Falls, Minnesota. Suspended particulate values have been measured (as annual geometric mean) along Line 4 in the relatively well populated regions of Minnesota as follows:

Mankato	1974	83 $\mu g/m^3$
Willmar	1974	80 $\mu g/m^3$
Fergus Falls	1974	64 $\mu g/m^3$

These values approach or exceed the National Air Quality Standards for particulate matter. Each value was measured in a town or city environment. The environment in the other states that Line 4 traverses has been sufficiently described in Section 2. Dust and other particulate matter from construction operations may impair the air quality in regions that are already relatively polluted. There is negligible danger of impact from other species as described in Section 3.1.3.14. It is possible that the crossing of the Minnesota River north of Mankato will qualify as an environmentally sensitive site, since the river follows a relatively narrow but not deep gorge. In general, the impact of Line 4 on air quality will be similar to that of the proposed route which is described in Section 3.1.3.14, but certain areas of Minnesota may be more sensitive to impact.

Line 4 passes many communities and presents these communities with the same noise impacts as presented to communities located along the proposed route. The communities located along the route will be exposed to compressor station noise and the noise of heavy diesel trucks hauling construction equipment and pipe as described in Section 3.1.3.15.

8.1.3.3 Line 6, Missouri River North

Project Proposal

Location

Line 6, Missouri River North shown on Figure 8.1.3-6, is considered by the Department of the Interior, to be a viable alternative to the proposed route. Line 6 is identical to the proposed route for about 145 miles from the starting point near Morgan, Montana. The line leaves the proposed route at a point about 24 miles north and west of Wolf Point, Montana, and proceeds north of the Missouri River for about 285 miles until it intersects Line 4 near Carrington, North Dakota. From this point it is identical to Line 4 for some 760 miles and identical to the proposed route for about 440 miles.

Major River Crossings

This line would involve the crossing of nine major rivers and they are listed here in the order crossed: Bois de Sioux, Minnesota, Mississippi, Illinois, Wabash, Muskingum, Ohio, Monongahela, and Youghiogheny.

Land Requirements

The estimated land requirements for right-of-way are shown below:

Summary of Estimated Land Requirements

Feature	Permanent R.O.W. (acres)
Pipeline	11,851
Compressor Stations	520
Communication Towers	252
Mainline Block Valves	6
Delivery-Measuring Stations	26
Access Roads	155
Total	12,810

Pipeline and Facilities

Line 6 will be approximately 1,630 miles long or about 32 miles longer than the proposed route. The estimated facilities are: 26 proposed and possible future compressor station sites, 13 delivery-measuring stations, 89 communication towers, and 102 mainline block valves.

This line would not allow for direct delivery as proposed to the city of Aberdeen, South Dakota, but an indirect connection could be made. The proposed route deliveries discussed for Line 4 in Minnesota and Iowa, would be shifted north and east from the proposed locations.

Description of the Environment

Alternative Line 6 leaves the proposed route 145 miles from the Canadian-United States border, remains north of the Missouri River and meets alternative Line 4 near Carrington, North Dakota. The route traverses the glaciated plain where nearly all of the land is in farms and ranches. One-half to three-fourths of the land is devoted to crop production, primarily spring wheat. The remaining land is native range used for livestock grazing.

Annual average precipitation varies from 10 inches at the western portion of the route to 20 inches at the eastern end. Average frost-free period is 100 to 135 days, increasing from west to east (see Section 2.1.3.1 for more detailed climatic data).

Elevations range from 1,500 to 3,000 feet. The topography varies from rolling hills along the eastern portion to nearly level glacial plains in the east. Steep slopes and badlands are common on the valley slopes and will be encountered at the White Earth and Little Knife Rivers and Shell Creek.

The low and erratic rainfall is the principal source of water. Water for livestock is stored in small upland reservoirs. Small to moderate amounts of ground water are available but may be hard (see Section 2.1.3.5 for additional data on water).

For descriptions of the route from Carrington, North Dakota, east, see description of the Line 4 alternative route.

All of the soils occurring along Line 6 have been described for the proposed route through Roosevelt County, Montana. The two routes traverse the same soil series. In North Dakota the same soils are crossed but in a different pattern. The dominant soil crossed, about 90 percent of the route, is the Williams series. This is a deep loamy soil occurring on side-slopes and ridges. Slopes range from nearly level to 6 percent (see detailed description in Section 2.1.3.4).

At the crossing of the White Earth River drainage in Mountrail County, the route will cross the Barnsville series for about 5 miles. This is a very shallow soil, 24 inches to soft shale, on slopes up to 50 percent (see detailed description in Section 2.1.3.4).

Most of the land along this route is devoted to spring wheat production. Where native vegetation is encountered, it will be on silty range sites. On the steep slopes of the White Earth River crossing shallow range sites are common. Brush species occur along the flood plain of the White Earth River.

Significant wildlife habitat areas along Line 6 are primarily brushy gullies, breaks, and riparian areas. These are not numerous in this heavily cropped area of rolling plains. Riparian habitat is sparse along the stream courses. Deer, antelope, sharp-tail grouse, Hungarian partridge and cottontails are the major game species in the area. No significant fishing resources occur in the streams traversed. While pothole country is crossed in McLean, Sheridan and Wells Counties, North Dakota, few wetland areas would actually have to be crossed since a final route could be selected to avoid most of the widely scattered potholes.

The socio-economic structure of this alternative would not differ significantly from that of the proposed route. The basic economic activity is agriculture. There is, perhaps, a somewhat greater density of cash grain farms along the alternative than along the proposed route. Wheat, flax and rye are the most important crops, which along with livestock raising are the basis of the agricultural activity.

This total alternative route is 32 miles longer than the proposed route which would require only an insignificant increase in expenditures for land, labor, and materials--about 2 percent.

The only population center within a 10-mile radius of this alternative route is Williston, North Dakota (population 11,280 in 1970).

The Fort Peck Indian Reservation is likely to provide unknown sites of value to both historians and archeologists. Also, the route parallels the valley of the Missouri River close enough that sites are likely to be discovered there.

The background material presented in Section 2.1.2.12, Archeology and History, applies to this alternative.

Line 6 generally parallels Lake Sakakawea which is within 15 to 25 miles south of the route. As a result, the Sakakawea oriented recreation areas are avoided. Much of the area crossed is either cropland or grazing land. McCloud Lake, on the southwest edge of the community of Ray is the only recreation area near the route.

Most esthetic values involve grazing land and croplands. Line 6 is north of most of the sharp breaks close to the reservoir to the south. Most of the physical relief occurs in the vicinity of stream crossings where valleys are deeply cut. The Little Muddy River, White Earth River, and Shell Creek are the best examples of deeply cut valleys having significant scenic values.

At the eastern end of Fort Peck Indian Reservation a sensitive area exists along Big Muddy Creek and associated sandy area and marsh. The route passes south of Medicine Lake National Wildlife Refuge, however, the area crossed acts as a buffer to the refuge.

In the eastern part of McLean County and through Sheridan County numerous lakes dot the countryside. Some of them have fish and most are primary waterfowl nesting areas.

Environmental Impacts

Soil impacts on Line 6 will be relatively moderate. The route includes 285 miles not previously described, about 90 percent of which crosses the deep loamy Williams Soil series with nearly level to moderately rolling topography. Impacts on this soil include the topsoil contamination described for the proposed route, potential wind erosion soil losses, and moderate losses from water erosion.

The 5 miles through the White Earth River drainage will encounter shallow to shale soils on steep slopes. In this area erosion hazards will be high.

The route is approximately 32 miles longer than the proposed route and will impact about 387 acres more land surface.

Vegetation impacts on Line 6 will include the loss of spring wheat on approximately 1,200 acres and grazing from about 865 acres. About 1,200 acres of fallow cropland will also be crossed. This would mean a loss of 30,000 bushels of wheat and about 216 animal unit months of grazing. These losses are comparable to those incurred along the proposed route to the south. The grazing lands are typical of the mixed grass prairie and are dominated by the silty range site (see Section 2.1.3.6). Because of the deep silty soils and moderate topography revegetation will not be difficult.

At the White Earth River drainage shallow and shale range sites will be crossed for about 5 miles. Revegetation will be difficult in this area.

Along Line 6 through North Dakota, impacts on wildlife would be limited since the route would cross primarily cropland and open rolling range and would not significantly impact aquatic habitat. There would be temporary wildlife losses until brush and forbs were reestablished on the infrequent gullies crossed. There could be some temporary disruption of waterfowl and shorebird use of the few potholes which might be impacted.

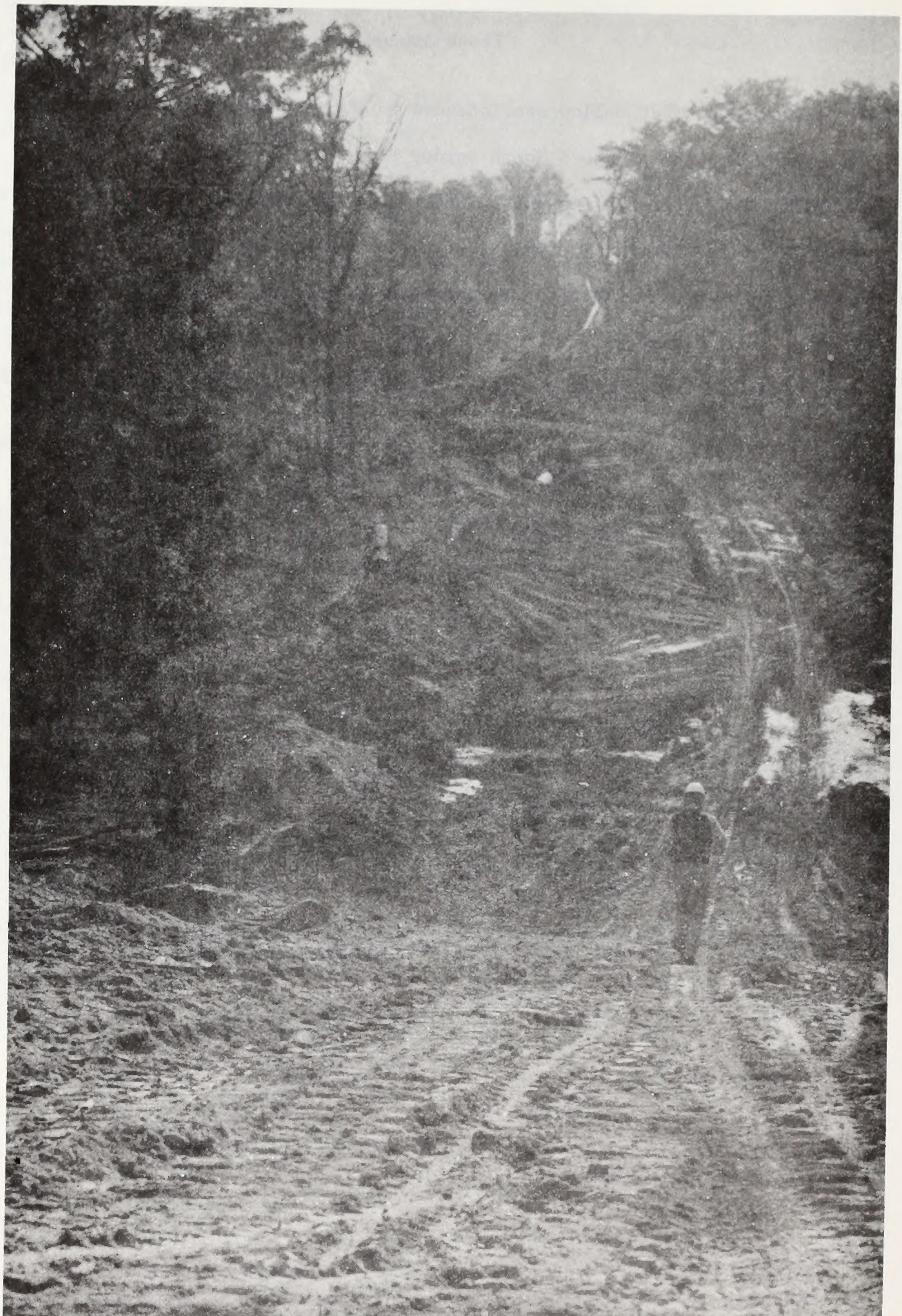
Along the 285-mile stretch from the proposed route to the junction with alternative Line 4 impacts on recreation or upon designated recreation areas should be negligible. No parks are crossed and McCloud Lake near Ray, North Dakota, should not be disturbed. It is primarily a fishing area.

Esthetic values should not experience serious damage because of the pipeline along this 285-mile segment of the route. The most sensitive areas are the streams and valleys of Big Muddy Creek, Little Muddy River, White Earth River and Shell Creek. The breaks country can be expected to have unstable soils making restoration of the topography and vegetation difficult. Also, a cleared corridor will be maintained in wooded areas that occur along the stream. Overall these impacts should not detract significantly from the esthetic values of the area.

All other environmental impacts will be essentially the same as those described for the proposed route to the south.

Photo Appendix

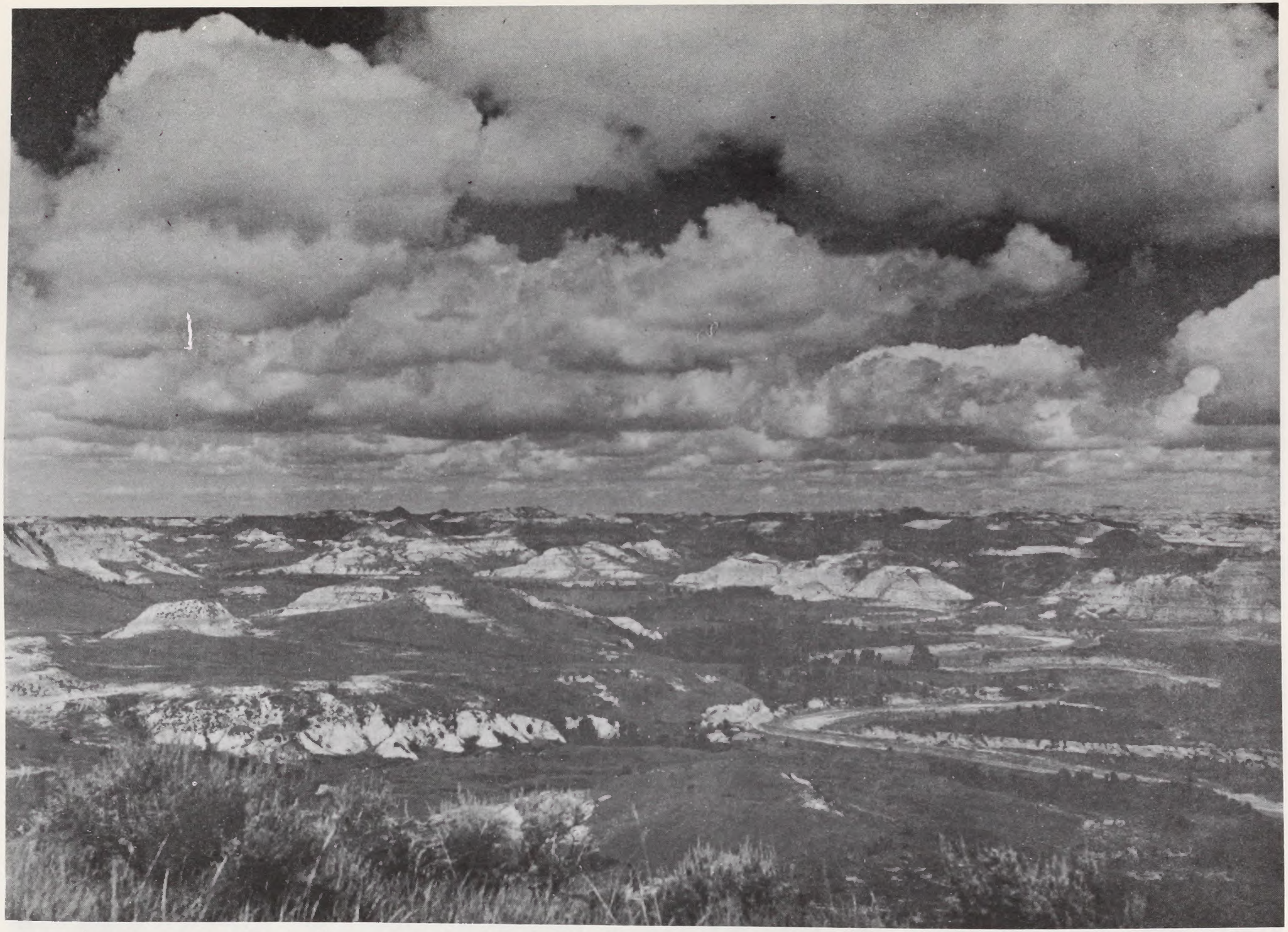
The photos that follow are intended to portray typical scenes of landscape that the proposed North Border Route would pass through as well as few of the specific areas where environmental impacts are expected to be severe. Typical scenes include, for example, a photo of the mix grass prairie found in the western Dakotas and eastern Montana. Similar countryside photos are from Grant County, South Dakota and east central Ohio. Environmental critical areas shown include the Little Missouri Badlands of North Dakota and the Illinois River near Ottawa, Illinois. In addition other photos are intended to illustrate typical environmental conflicts. In this group a midwestern stream is shown with its woodline banks, a South Dakota wetland, and a tiled field in Ohio.



Pipeline route through an eastern
deciduous-coniferous forest after
trench has been backfilled over pipe.

Pipeline route revegetated with grasses and legumes
and maintained clear of trees and brush.

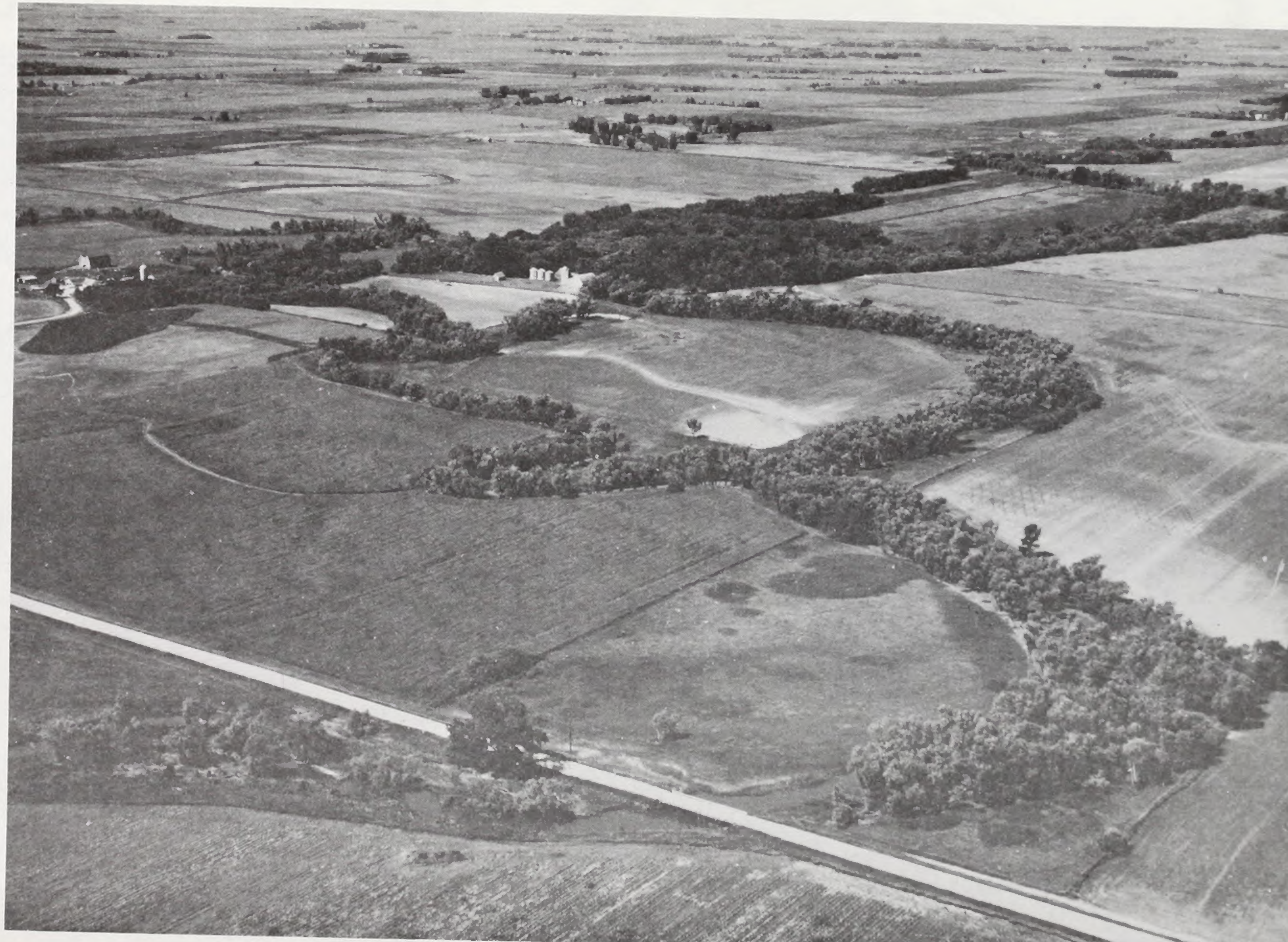
Grazing land in the mixed-grass prairie typical of the western portion of the proposed route.



Panoramic view of the Little Missouri Badlands, North Dakota.
The steep slopes and shallow soils are highly susceptible to erosion
when disturbed and revegetation is difficult.

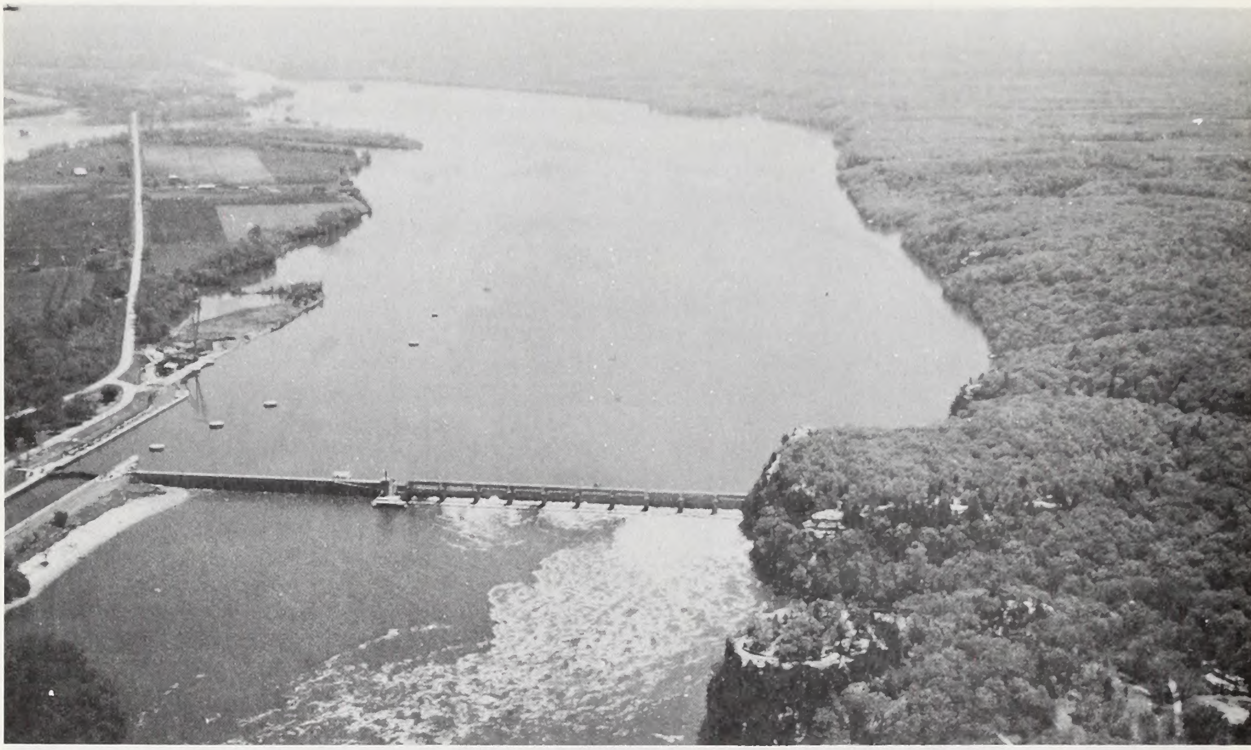
Hardwood bluffs along the Heart River, North Dakota.

Rolling prairie country, Dunn County, North Dakota.



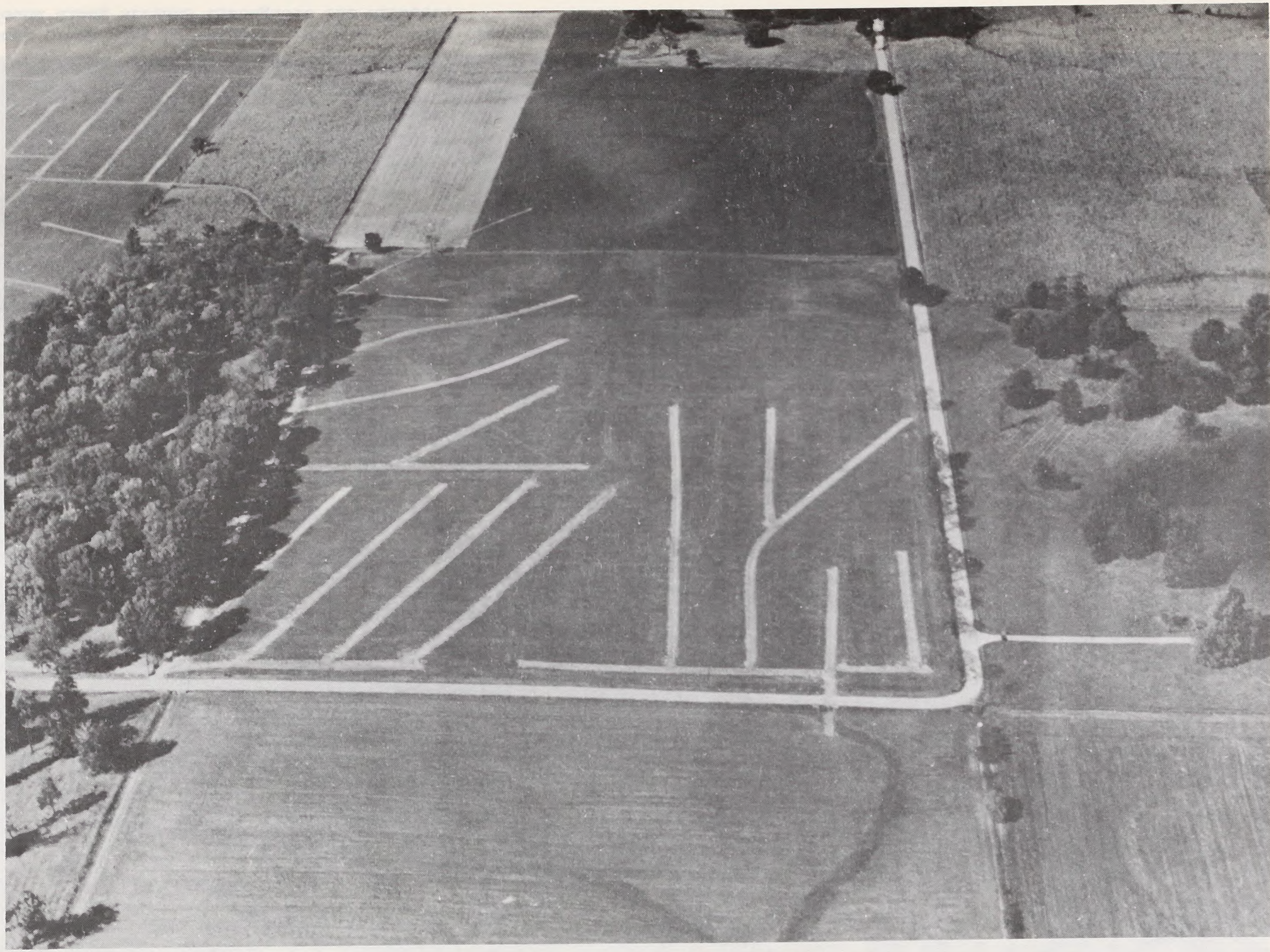
View from Grant County, South Dakota illustrates the cultivated field - scattered woodlot - wooded drainage pattern of the rural midwest. This is the area once occupied by the Tall Grass Prairie which has almost completely been converted to intensive agriculture.

Highly productive waterfowl habitat in the prairie pot-
hole country of South Dakota.



Illinois River showing locks and dam. Starved Rock is in lower center with Starved Rock State Park occupying right bank.

Typical farm country in east-central Ohio.



Newly installed tile drain system on Ohio farm. Drains are 100 feet apart. This system is typical of those found throughout the Midwest.

Rock Creek near Logansport, Indiana showing riparian vegetation typical of that found along streams throughout the Midwest.

Foldouts

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NORTHERN BORDER PIPELINE COMPANY
DOCKET NO. CP74-290
EXHIBIT G (AMENDED)
HEARING EXHIBIT NO.
PAGE 2 OF 2

* THE TOTAL QUANTITY OF GAS RECEIVED BY COLUMBIA AND NORTHERN AT PRUDHOE BAY FROM THE SOHIO-BP PRUDHOE BAY RESERVES IS PRESENTLY ESTIMATED AT 666 MMcfd. THE DIVISION OF THIS QUANTITY BETWEEN COLUMBIA AND NORTHERN IS DEPENDENT ON SEVERAL FACTORS, INCLUDING THE TIME WHEN OIL FLOWS THROUGH THE ALYESKA PIPELINE AND THE QUANTITY OF THE FLOW. SINCE THE PRECISE DIVISION OF THIS QUANTITY IS NOT PREDICTABLE AT THIS TIME, FOR FLOW STUDY PURPOSES THE TOTAL QUANTITY (666 MMcfd) OF GAS IS SHOWN AS BEING DELIVERED TO COLUMBIA AS THIS RESULTS IN THE MAXIMUM FACILITIES ON THE PIPELINE. FOR INFORMATIONAL PURPOSES, TWO VOLUMES (100 MMcfd AND 450 MMcfd) ARE ALSO SHOWN BEING DELIVERED TO NORTHERN NATURAL AND REPRESENTS THEIR ESTIMATE OF THE RANGE OF SOHIO-BP GAS WHICH THEY EXPECT TO RECEIVE.

ITEM NO	ITEM	MONTANA		NORTH DAKOTA					SOUTH DAKOTA			MINNESOTA			IOWA				ILLINOIS			INDIANA		OHIO		
1	STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2	APPROXIMATE STATION MILEPOST	61	127	185	238	299	355	414	469	529	581	634	691	747	801	858	915	971	1027	1084	1138	1201	1262	1324	1384	1443
3	COMPRESSION RATIO		1.33		1.32		1.30		1.31		1.30		1.27		1.26		1.20		1.19		1.16		1.29		1.22	
4	COMPRESSOR SUCTION/DISCHARGE PRESSURE (PSIG)		1076/1440		1089/1440		1103/1440		1096/1440		1108/1440		1127/1440		1141/1440		1194/1440		1206/1440		1241/1440		1109/1439		1182/1440	
5	HORSEPOWER REQUIRED		21,473		20,796		19,866		20,294		19,323		18,100		16,221		12,005		11,246		6846		12,086		7632	
6	HORSEPOWER INSTALLED		27,241		26,882		27,314		27,224		27,366		27,720		27,994		28,056		28,014		12,020		12,086		11,946	
7	NUMBER OF UNITS - COMPRESSOR/COOLER		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0	
8	STATION FUEL CONSUMPTION (MMCFD)		4.0		3.9		3.7		3.8		3.6		3.4		3.0		2.3		2.1		1.3		2.3		1.5	
9	VOLUME COMPRESSED (MMCFD)		1651.0		1647.1		1643.4		1639.6		1608.7		1605.3		1521.1		1419.2		1417.1		1041.0		1038.7		870.1	

SYSTEM GAS DISTRIBUTION SUMMARY

DELIVERY POINTS	NNG I	NNG II	NNG III	MW	NGPL	PAN	CG I	CG II	CG III	TET	TOTAL
SECTION NUMBER	1	2	3	4	5	6	7	8	9	10	
VOLUME INTO SECTION - MMCFD	1655.0	1612.4	1524.1	1421.4	1210.0	1042.3	871.6	308.6	199.5	166.8	1655.0
FUEL USAGE - MMCFD	15.4	7.0	3.1	4.4	0.0	3.6	1.5	0.0	0.0	0.0	35.0
CO. USE & UNAC. FOR LOSS - MMCFD	0.1	0.5	0.5	1.0	0.8	0.8	2.8	0.5	0.1	0.9	8.0
DELIVERY VOLUME - MMCFD	27.1	80.8	99.1	206.0	166.9	166.3	558.7	108.6	32.6	165.9	1612.0
VOLUME OUT OF SECTION - MMCFD	1612.4	1524.1	1421.4	1210.0	1042.3	871.6	308.6	199.5	166.8		
ALTERNATE DELIVERY VOLUME - MMCFD	27.1	80.8	206.4								
ALTERNATE DELIVERY VOLUME - MMCFD	27.1	80.8	565.9								

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Figure 1.1.3.7-1 Flow diagram. Daily design capacity. Summer conditions

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* THE TOTAL QUANTITY OF GAS RECEIVED BY COLUMBIA AND NORTHERN AT PRUDHOE BAY FROM THE SOHIO-BP PRUDHOE BAY RESERVES IS PRESENTLY ESTIMATED AT 666 MMcfd. THE DIVISION OF THIS QUANTITY BETWEEN COLUMBIA AND NORTHERN IS DEPENDENT ON SEVERAL FACTORS, INCLUDING THE TIME WHEN OIL FLOWS THROUGH THE ALYESKA PIPELINE AND THE QUANTITY OF THE FLOW. SINCE THE PRECISE DIVISION OF THIS QUANTITY IS NOT PREDICTABLE AT THIS TIME, FOR FLOW STUDY PURPOSES THE TOTAL QUANTITY (666 MMcfd) OF GAS IS SHOWN AS BEING DELIVERED TO COLUMBIA AS THIS RESULTS IN THE MAXIMUM FACILITIES ON THE PIPELINE. FOR INFORMATIONAL PURPOSES, TWO VOLUMES (100 MMcfd AND 450 MMcfd) ARE ALSO SHOWN BEING DELIVERED TO NORTHERN NATURAL AND REPRESENTS THEIR ESTIMATE OF THE RANGE OF SOHIO-BP GAS WHICH THEY EXPECT TO RECEIVE.

ITEM NO	ITEM	MONTANA		NORTH DAKOTA					SOUTH DAKOTA			MINNESOTA			IOWA				ILLINOIS			INDIANA		OHIO		
1	STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2	APPROXIMATE STATION MILEPOST	61	127	185	238	299	355	414	469	529	581	634	691	747	801	858	915	971	1027	1084	1138	1201	1262	1324	1384	1443
3	COMPRESSION RATIO		1.45		1.44		1.44		1.45		1.43		1.40		1.38		1.29		1.27		1.21		1.34		1.40	
4	COMPRESSOR SUCTION/DISCHARGE PRESSURE (PSIG)		987/1440		996/1440		998/1440		991/1440		1002/1440		1021/1440		1040/1440		1115/1440		1135/1440		1188/1440		1017/1364		1017/1427	
5	HORSEPOWER REQUIRED		29,807		29,959		30,032		30,836		29,963		28,682		25,590		18,327		16,789		9778		14,953		14,691	
6	HORSEPOWER INSTALLED		32,917		32,518		33,008		32,931		32,825		33,043		33,135		33,339		33,503		15,144		14,953		14,691	
7	NUMBER OF UNITS - COMPRESSOR/COOLER		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0		1/0	
8	STATION FUEL CONSUMPTION (MMCFD)		5.3		5.3		5.3		5.5		5.3		5.1		4.5		3.3		3.0		1.7		2.6		2.5	
9	VOLUME COMPRESSED (MMCFD)		1880.0		1874.7		1869.4		1863.9		1827.7		1822.6		1725.8		1609.5		1606.6		1180.0		1177.4		985.4	

SYSTEM GAS DISTRIBUTION SUMMARY

DELIVERY POINTS	NNG I	NNG II	NNG III	MW	NGPL	PAN	CG I	CG II	CG III	TET	TOTAL
SECTION NUMBER	1	2	3	4	5	6	7	8	9	10	
VOLUME INTO SECTION - MMCFD	1885.3	1833.0	1730.3	1612.8	1371.8	1181.7	988.0	345.5	225.9	188.8	1885.3
FUEL USAGE - MMCFD	21.3	10.4	4.5	6.3	0.0	4.3	2.5	0.0	0.0	0.0	49.3
CO. USE & UNAC. FOR LOSS - MMCFD	0.2	0.5	0.5	1.2	0.9	0.9	3.3	0.6	0.2	0.9	9.2
DELIVERY VOLUME - MMCFD	30.8	91.8	112.5	233.5	189.2	188.5	632.7	123.0	36.9	187.9	1826.8
VOLUME OUT OF SECTION - MMCFD	1833.0	1730.3	1612.8	1371.8	1181.7	988.0	349.5	225.9	188.8		
ALTERNATE DELIVERY VOLUME - MMCFD	30.8	91.8	233.8								
ALTERNATE DELIVERY VOLUME - MMCFD	30.8	91.8	658.3								

NORTHERN BORDER PIPELINE COMPANY

Figure 1.1.3.7-2 Flow diagram, Daily design capacity, Winter conditions

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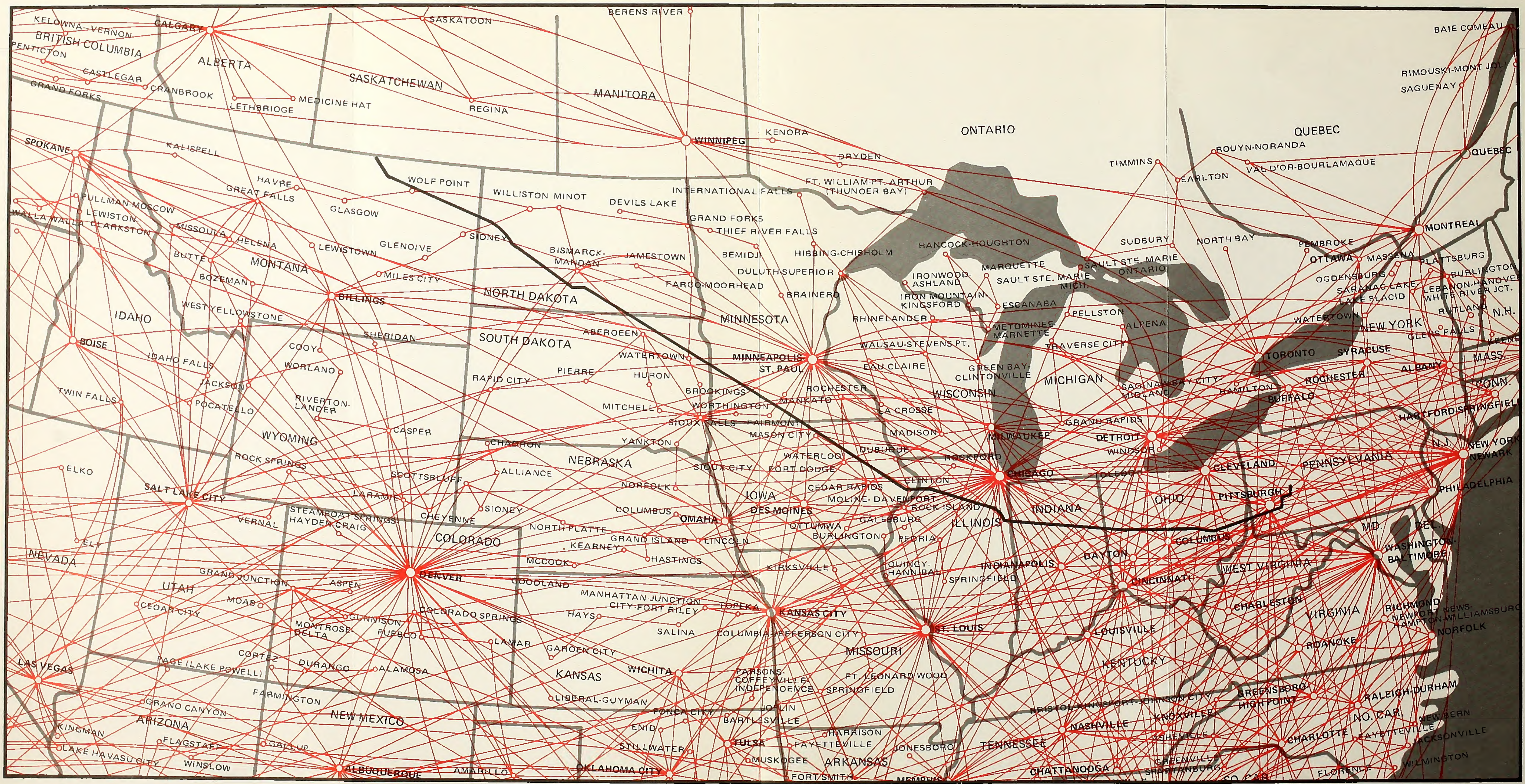

Figure 2.1.3.11-5 Commercial air service in proximity to the proposed route.

Figure 8.1.3-1 Line 1 Alternative Route Map.

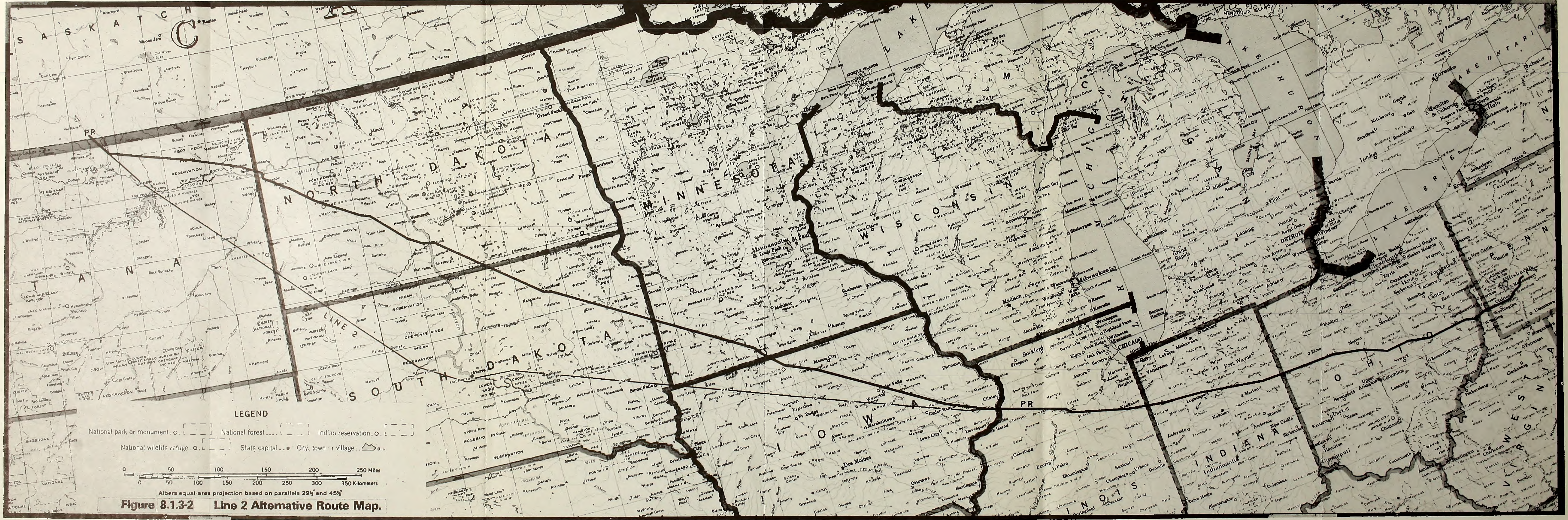

Figure 8.1.3-2 Line 2 Alternative Route Map.

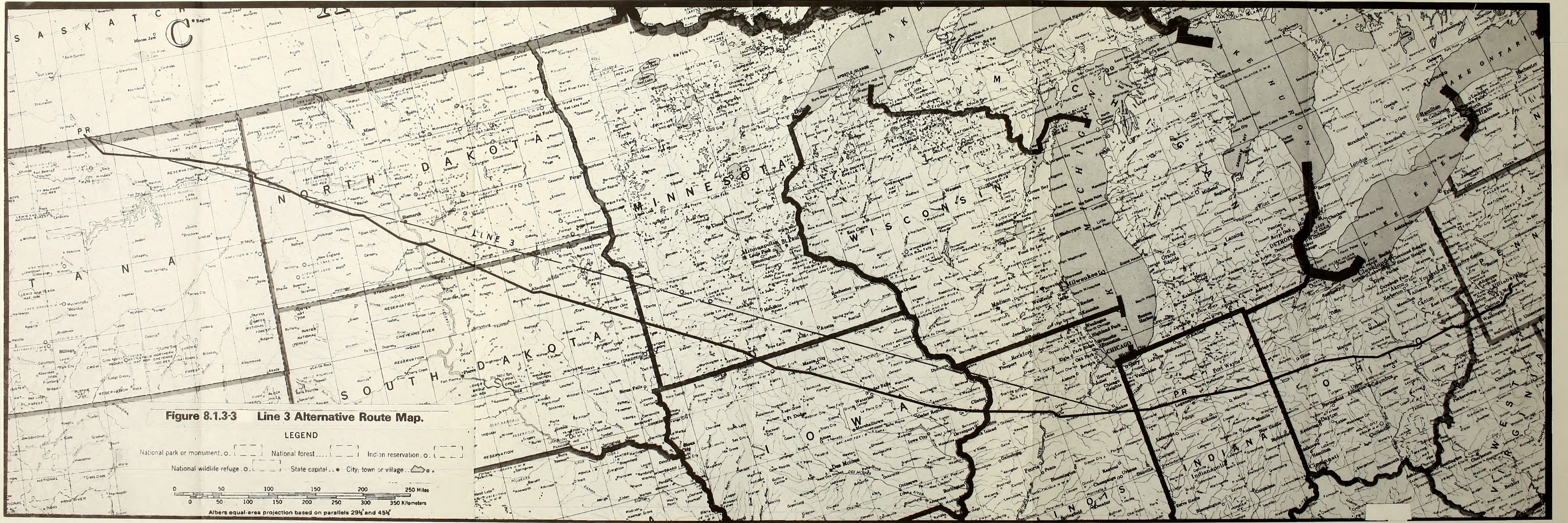

Figure 8.1.3-3 Line 3 Alternative Route Map.

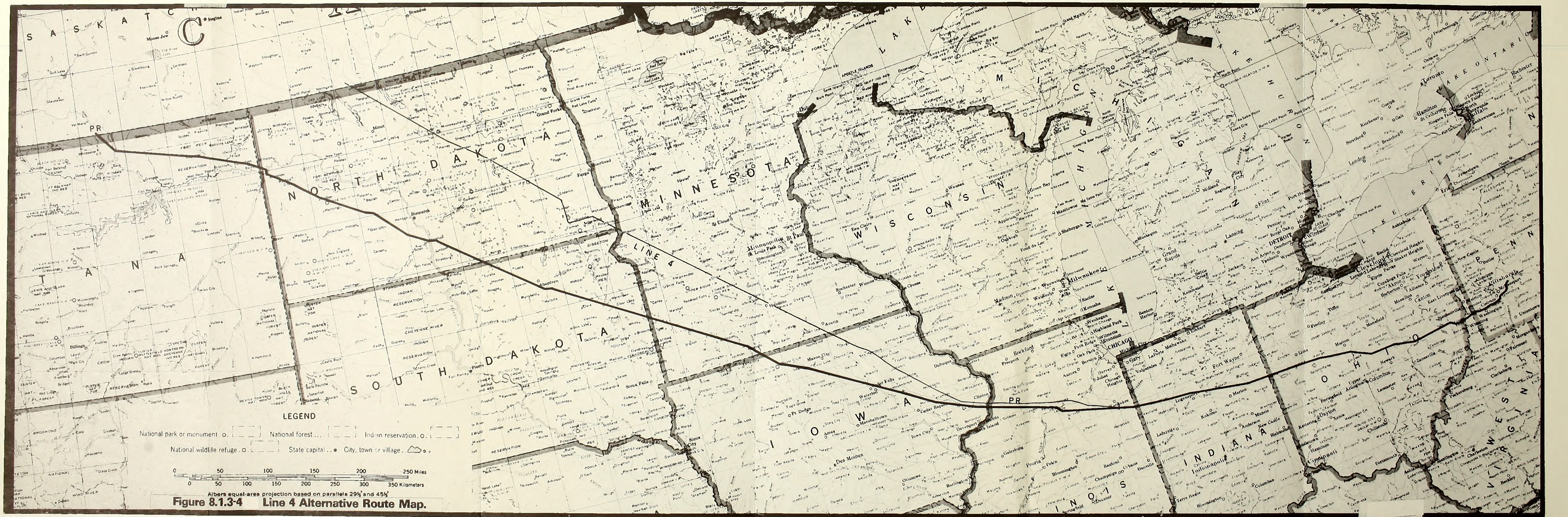

Figure 8.1.3-4 Line 4 Alternative Route Map.

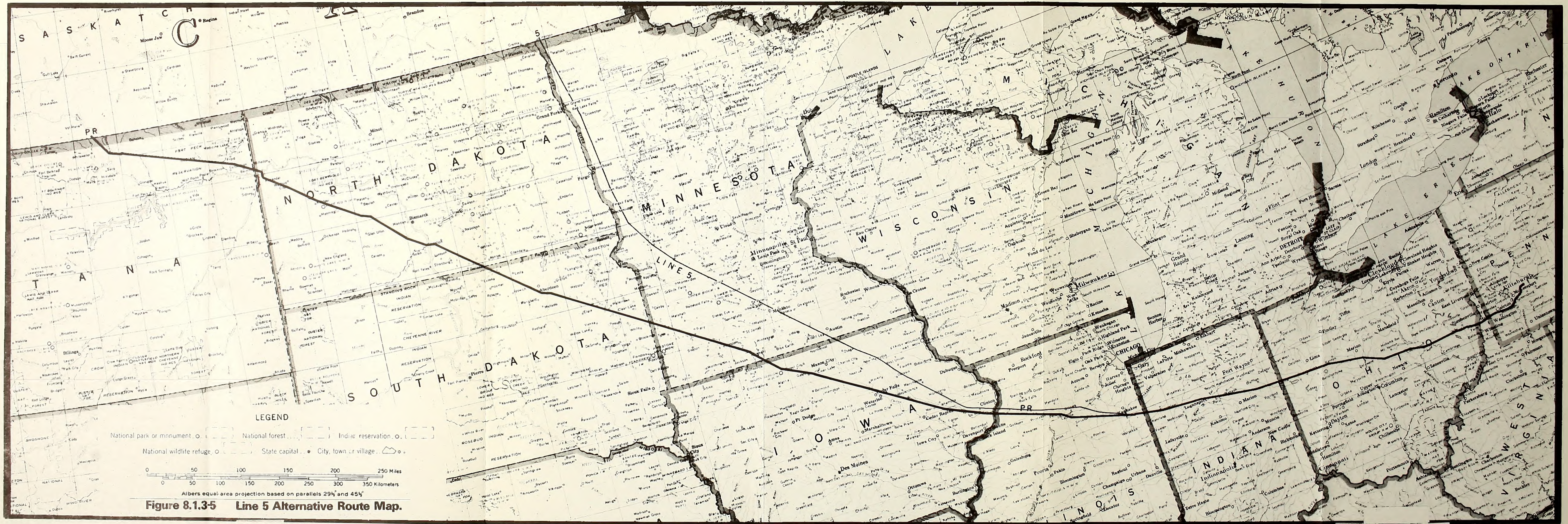

Figure 8.1.3-5 Line 5 Alternative Route Map.

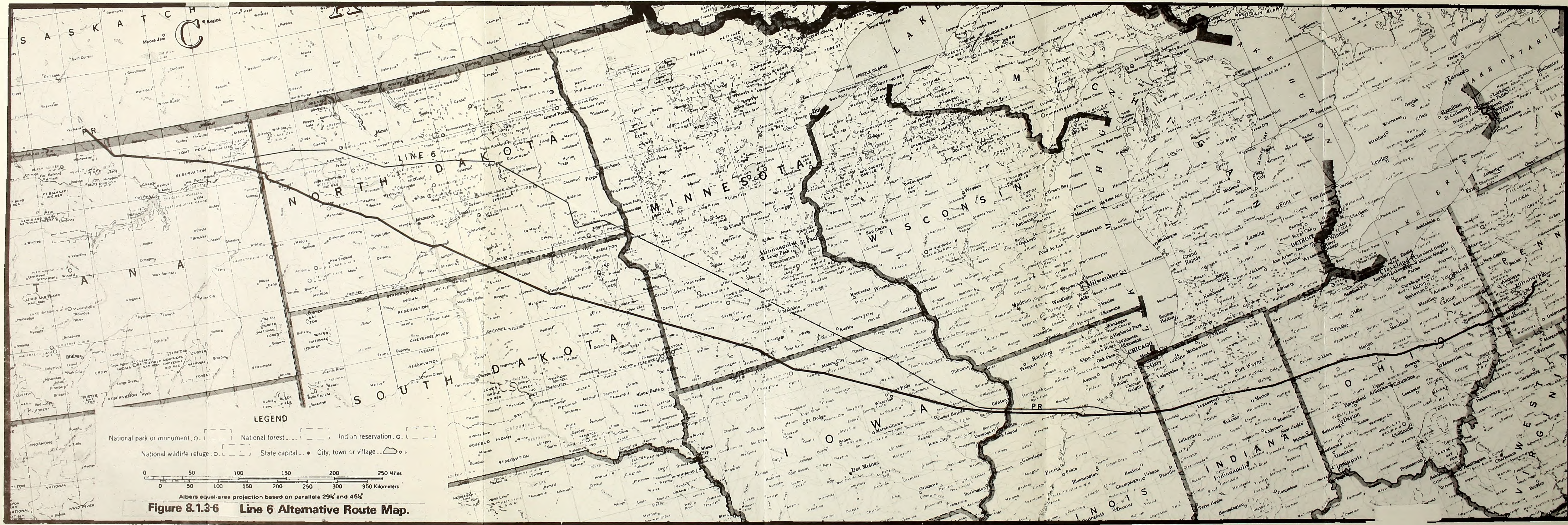

Figure 8.1.3-6 Line 6 Alternative Route Map.