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CROW TRIBE
OF
INDIANS

SYNFUELS FEASIBILITY STUDY

VOLUME II

PROCESS DESIGN AND COST ESTIMATE
BOOK I: SECTIONS 1.0 THROUGH 6.2

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VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

BOOK II

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

VOLUME II

PRELIMINARY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

1.0 FEASIBILITY STUDY OVERVIEW

Volume I is the Executive Summary, which summarizes the work completed for the Feasibility Study. It describes the objectives of the study, the findings, and the conclusions. It also provides a status of the overall program, including process technology, cost estimates, legal and financial information, environmental impact, and socioeconomic factors. The volume also summarizes the special studies conducted to determine certain specifics for the basis of design. A Phase II management plan is presented in Volume I which encompasses preliminary engineering to support permitting and financing activity.

Volume II covers the Engineering and Cost Analysis. The Engineering portion describes in detail the process units within the Base Case. Also covered are three alternate cases where they deviate from the Base Case and the three special process studies. The screening studies that defined the parameters of the Base Case are examined. Economic criteria, primarily for the Base Case, are established and evaluated. Then cost estimates (capital and operational) are presented. Because of the amount of material presented, Volume II is divided into three separate books.

Volume III covers the Financial and Legal Analysis for the SNG plant. The financial portion of this volume examines all economic aspects of the project. Balance sheets are presented along with special sensitivity studies (debt/equity ratio, interest rates, coal prices, and effect on SNG cost for varying capitol requirements). Capital requirements, return on investment, and risk analysis are discussed. The legal portion assesses the federal, state, local, and tribal regulations that impact the implementation of the Crow Synfuels Project, examines jurisdictional issues and addresses Water Law and Indian Law.

1.0 (Continued)

Volume IV covers Environmental, Health, Safety, and Socioeconomic issues. Federal, state, and tribal permitting (environmental: air, water, and solid waste) with jurisdictional definition is discussed. The effects of nature (flora, fauna, climatology, air quality, water, physiography, and seismology) as an impact on the plant site and transportation corridors are presented in detail for the Crow Reservation.

Health and Safety deal with the hazards associated with the synfuels plant and with the handling of raw materials and products. The control measures and practices to ensure safe plant operation are analyzed.

Volume V covers Special Studies. Part I of this volume discusses the special studies conducted on resources and site analyses. This part reports the studies on the coal supply, on transportation of the coal, on solid waste disposal, on sources and movement of raw water, and on the analyses of 11 candidate sites for the SNG plant. The resource requirements (coal and water), their cost, and their handling have greatest impact on the Crow project.

Part II of Volume V covers the marketing and transportation analyses for both SNG and byproducts. This part identifies the best disposition of SNG and the byproducts. The market for natural gas and the impact of this substitute natural gas on the market plus the means and costs of moving the SNG into the market are considered. Byproducts, including methanol and power, as saleable products are examined in detail.

Part III of Volume V covers planning and communication. It developes a strategy to gain acceptance for the feasibility study. The communication of information about the synfuels plant to all affected parties becomes important in Phase II (permitting and financing activities) by developing support for the plant.

2.0 INTRODUCTION

The Crow Tribe of Indians has initiated a synfuels plant study to determine the feasibility of developing their energy resources in response to a U.S. Department of Energy solicitation. The Crow Reservation (2.3 million acres) in Montana has large quantities of surface minable coal and access to sufficient raw process water for a projected 25-year life coal conversion plant(s). Coal resources are estimated in excess of 16 billion tons. Two major sources of water are available to the Crow Tribe.

The objective of this feasibility study is to determine the financial, environmental, socioeconomic, and technical viability of the proposed synfuels plant. The study includes such areas as plant siting and design, special technical substudies, capital and operating cost, and marketing.

The Crow Synfuels Project is a coal-to-SNG gasification plant in which subbituminous coal on the Crow Reservation is gasified in a Lurgi process to produce pipeline quality gas for sale to a predetermined market. The work performed to date on this project is presented in this feasibility study final report.

Four different process configurations are evaluated in the feasibility study, a Base Case and three alternate cases. The Base Case uses Westmoreland coal (40% fines maximum) from the Absoloka mine to produce substitute natural gas (SNG) and power for sale. The fines are used in the boilers for power generation and the coarse coal is gasified in the Lurgi reactors. The plant is sized for 125 MM SCF/CD of SNG. The plant is located remotely from the mine (Site 1) because of environmental restrictions imposed by the nearby Northern Cheyenne Indian Reservation which has a Class I PSD designation. Coal is transported by rail. During the coal mining and preparation, it is estimated that as much as 40 percent

of the coal could be in a size range of less than 1/4 inch. These fines are consumed in a boiler to generate steam which is used in the process and for power generation. Excess power produced is exported for sale.

Alternatives to the Base Case, namely a Self-sufficiency, a Coproduction, and a Shell Coal Case, were also studied and are reported herein. These alternate cases use essentially the same processing procedure and process units as the Base Case and most of the information for the Base Case applies to the other cases.

The Self-sufficiency Case examines the use of only the portion of coal fines necessary to generate the power required by the SNG plant. The balance of coal fines will need to be disposed of elsewhere. Discussion in the study of this case is limited to differences from the Base Case.

The Coproduction Case involves producing less SNG to coproduce methanol as part of the primary product line. The objective is to assess the economics of liquid production along with SNG. Coproducing SNG and methanol is more efficient than producing all methanol because of the high methane content in the raw gas leaving the gasifier. However, a premium is required to produce a liquid. This study attempts to quantity the economics of this alternative.

The Shell Coal Case uses a coal from a different mine on the Crow Reservation and assumes the SNG plant is a minemouth plant (Site 23). This coal from a Shell operated mine has slightly different characteristics than the Base Case coal (Westmoreland mine). The cost of Shell coal is an important factor in the economics of this case. Although the plant can be located at the mine, the location is remote requiring a longer water pipeline and longer access roads to service the site. The study analyzes these parameters.

2.0 (Continued)

Volume II presents the technical and economic criteria necessary to evaluate not only the Base Case but also the other study cases.

The technical criteria are the overall design basis for the study and include the two coal analyses, site data for the two sites, raw water analysis, utility design information and product and byproduct specifications. The economic criteria section describes the study basis for the capital and the operating and maintenance costs. The overall cost basis is the same for all four cases.

In the contents and results section, the overall plant description, feed and product summary, thermal efficiency, design basis, plant unit list, train philosophy, plot plan, overall block flow diagrams for overall material balance, water balance, sulfur balance, air emissions and solid effluents, steam balance, utilities summary, catalysts and chemicals summary, operating and maintenance manpower and process unit designs are presented for each of the four cases. For cases other than the Base Case, only the data that differs from the Base Case is presented.

The process unit design includes the unit design basis, process description, process sketch, material balance, equipment list, and plot plan for each unit in the synfuels facility. Control systems and electrical designs are included for the Base Case. Civil/Structural designs are included for Sites 1 and 23, the only two sites considered in the four cases.

In addition to the technical data, the capital and operating cost results are presented. The economic criteria establish the estimate base and the results are tabulated in the capital cost estimate section. Total field, office and other capital costs are included and represent the total capital requirements for the project. Operating costs are based on operating

labor, maintenance labor, maintenance materials, catalysts and chemicals, coal costs, taxes and insurance, and byproduct credit developed for the plant. These capital and operating costs become the bases for the economic and financial analysis presented in Volume III of this report.

This feasibility study final report provides sufficient information to make the decision to proceed to the next phase with preliminary engineering, permitting and financing activities being the major objective.

3.0 SUMMARY

The primary objective of the Crow Tribe of Indians Synfuels Feasibility Study is to determine the cost of service for producing SNG from coal on the Crow Reservation. In this volume, the capital and operating costs for the synfuels facility are developed. These values become the basis for the cost of service development in Volume III, Financial and Legal Analysis.

To determine the optimum location, coal supply, and process design required the investigation of various special studies and process configurations. This part of the study describes the results of the four process design cases which were considered in evaluating the capital and operating costs for the synfuels facility. The special studies presented in Volume V analyze the impact of the coal supply and the site.

The synfuels feasibility study evaluates four process design cases: a Base Case and three alternate cases.

The Base Case is a coal-to-SNG plant, based on Westmoreland Resources, Inc. coal generating export power and located at Site 1. The Self-sufficiency Case assumes that electric power is generated only for in-plant use (no export power). The site, coal source, and SNG product are identical to the Base Case. The Coproduction Case varies the process design to coproduce SNG and methanol. Other parameters are identical to the Base Case. The Shell Coal Case is based on producing the same amount of SNG as the Base Case, but uses Shell coal and Site 23 as the basis for the design. Export power is also generated.

3.1 DESIGN CONSIDERATIONS

Several design considerations apply to all of the cases.

3.1 (Continued)

In each case the plant uses the best available control technology to protect the local environment. Particulate matter and sulfur oxides are removed from flue gases; coal dust is contained within closed conveying and storage systems.

The facility is designed to produce 125 MM SCF/CD of SNG in the Base Case. Additionally, the facility is designed to be expandable to twice this size at a later date. Coal reserves, water supply, plot area and location are adequate to accommodate a 250 MM SCF/CD facility with power generation.

Environmental constraints imposed by the nearby Northern Cheyenne Indian Reservation, which has an EPA designated Class I air emissions control requirement, necessitates the location of the synfuels plant away from the Westmoreland mine for the coal supply producing 250 MM SCF/CD and export power. Air emissions modeling indicates that a single 125 MM SCF/CD plant without generating export power could be located at the minemouth. This would result in considerable capital savings and should be evaluated during the next project phase.

The plant is designed to achieve zero water discharge. Only in wetting of the solid wastes to aid in their handling and through evaporation does any water leave the plant. No deep disposal wells are required to inject waste water. All ponds are lined to eliminate percolation loss.

Solid wastes, depending on the case, are disposed of either in the mine or adjacent to the plant on a virgin site. The wastes are disposed in a clay lined subsurface containment. The encapsulation prevents the wastes from being subject to leaching by surface water runoff. Monitoring wells assure that subsurface contamination of aquifers does not take place.

3.2 BASE CASE

The process technology is described in detail for the Base Case, but much is common to all of the cases.

The process design is based on Lurgi coal gasification technology which has been proven in commercial installations. The largest Lurgi type operating plants are in South Africa. The Great Plains Project in North Dakota, which is very similar in design to the proposed Crow Synfuels plant, is being constructed at the present time.

In addition to coal gasification, Lurgi technology is used for gas cleanup, liquid byproduct processing, methanol synthesis, and methanation. The selective Rectisol process removes carbon dioxide and sulfur compounds from the cooled gasifier product gas and condenses naphtha. Rectisol produces an H_2S rich gas stream which is suitable for Claus sulfur recovery. Air emissions modeling show that the Rectisol CO_2-rich gas stream can not be directly vented to the atmosphere because of the hydrocarbon content. Instead, the gas makes up a portion of the fuel used in the process steam superheater. Lurgi liquid byproduct processing consists of: gas liquor separation, tar distillation, naphtha hydrotreating, and phenosolvan. The methanol used in the Rectisol unit is produced by the Lurgi methanol synthesis process which has been used in commercial installations to produce methanol from natural gas. The Great Plains Project will demonstrate the Lurgi methanation process on a commercial scale.

Other licenser technologies are used in the plant. Ammonia is recovered from the gas liquor by the U.S. Steel Phosam-W process. The Sulfur Recovery Unit incorporates the Shell Adip and Scot processes, the Claus process and the Peabody-Holmes Stretford process. The Texaco Partial Oxidation process produces additional "raw" synthesis gas from phenols, oils and tars. Hydrogen production uses the Union Carbide Pressure Swing Absorption process, and oxygen production uses proven technology. Davy-McKee provided a package with preliminary technical information for their Saarberg-Hoelter flue gas desulfurization process.

3.2 (Continued)

The utility and offsite units are similar to conventional refinery systems designed by Fluor.

3.3 COMPARISONS

The following sections depict the various parameters that were evaluated and the resulting comparisons.

3.3.1 Coal Feed Comparison

Coal Analyses for the four cases are presented in Table 3.3.1-1, and coal feeds for the four cases are presented in Table 3.3.1-2. The first three cases are based on coal from Westmoreland's operating Absaloka mine and the fourth case is based on coal from Shell's proposed Young's Creek mine.

The price per ton of delivered coal for the Power Self-sufficiency Case does not allow for disposal of the excess fines. A substantial cost could be incurred if no market is available for the excess fines.

The coal analyses data reflect three items which favor the Shell coal -- lower ash content, lower sulfur content and higher calorific value. The latter is the most significant because it results in 4 percent less coal required for the Shell coal to produce the same gas product. This is depicted in Table 3.3.1-2. The lower ash quantity reduces solid waste disposal costs, and the lower sulfur percentage reduces overall sulfur emissions, however, the latter two do not significantly impact the overall economics.

Even though less coal is required for the Shell Coal Case, the Shell coal is more expensive at the mine. The higher cost at the mine more than offsets the transportation costs associated with the other cases which use Westmoreland coal.

TABLE 3.3.1-1
COAL ANALYSIS
(As Received)

	Base Case @ Site 1	Self-Sufficiency Case @ Site 1	Coproduction Case @ Site 1	Shell Coal Case @ Site 23
Moisture, wt.%	26.0	26.0	26.0	26.3
Ash, wt.%	7.4	7.4	7.4	4.1
Volatile Matter, wt.%	26.5	26.5	26.5	32.5
Fixed Carbon, wt.%	40.1	40.1	40.1	37.1
TOTAL	100%	100%	100%	100%
HHV, Btu/lb	8612	8612	8612	9090
Sulfur, wt.%	0.82	0.82	0.82	0.38

TABLE 3.3.1-2
COAL FEED COMPARISON

	Base Case @ Site 1	Self-Sufficiency Case @ Site 1	Coproduction Case @ Site 1	Shell Coal Case @ Site 23
Coal Quantity, MM Tons/yr	5.976	4.380	5.976	5.843
Coal Cost at Mine, $/Ton	10.70	10.70	10.70	-
Coal Cost at Plant, $/Ton	14.75	14.75	14.75	15.85
Annual Coal Cost, $ Million	88.1	64.6	88.1	92.6

3.3.1 (Continued)

Water for the project is supplied from the Bighorn River. Although water requirements vary between winter and summer conditions, approximately 10,000 acre - feet are required per year for the 125 MM SCF/CD facility. The pipeline for transporting the water to the facility is sized for the expanded case (250 MM SCF/CD).

3.3.2 Product and Byproduct Summary

The products and byproducts for the four cases are presented in Table 3.3.2-1. They reflect the methanol production in the Coproduction Case versus only SNG as in the three other cases. The quantity of products and byp ·ducts from the Coproduction Case indicate a reduction in power export of 41 MW. The energy equivalent of the coproduced SNG and methanol versus the SNG in the Base Case is 5815 million Btu per hour versus 5615 million Btu per hour respectively. Naphtha production is considerably less for the Coproduction Case. The reduction in naphtha results because less tar oil is upgraded with the elimination of the CO shift unit in the Coproduction Case. The increase in naphtha production in the Shell Coal Case is a characteristic of the coal.

The efficiency for the Coproduction Case is lower than for the Base Case. The efficiencies are comparable for the Base Case and the Shell Coal Case. The reduction in power production raises the efficiency considerably for the Self-sufficiency Case.

3.3.3 Capital Cost Summary

The capital costs are based on a combination of capacity factoring, machinery and equipment factoring, and detailed estimating techniques. Each unit is priced on a Direct Field Cost basis for each case. Overall costs are summarized in Table 3.3.3-1.

TABLE 3.3.2-1

PRODUCT AND BYPRODUCT COMPARISON

	Base Case @ Site 1	Self-Sufficiency Case @ Site 1	Coproduction Case @ Site 1	Shell Coal Case @ Site 23
SNG, MM SCF/SD	137.5	137.5	67.35	137.5
Naphtha, ST/D	196.2	196.2	116.8	352.6
Ammonia, ST/D	76.8	76.8	76.7	90.3
Sulfur, ST/D	87.2	87.2	86.7	39.9
Methanol, ST/D	0	0	3752	0
Electricity, MW	283.2	0	212.3	301.7
Overall Efficiency, %	54.2	63.9	52.8	55.0

TABLE 3.3.3-1
CAPITAL COST SUMMARY

	Base Case @ Site 1 ($ Million)	Self-Sufficiency Case @ Site 1 ($ Million)	Coproduction Case @ Site 1 ($ Million)	Shell Coal Case @ Site 23 ($ Million)
Direct Field Costs	884.4	711.2	888.2	921.3
Material Transport Costs	70.0	56.0	70.6	74.0
Indirect Field Costs	351.6	289.1	348.2	352.7
Home Office Costs	160.0	132.2	170.0	165.0
Total Field and Office Costs	1 466.0	1 188.5	1 477.0	1 513.0
Other Capital Costs	570.4	483.0	570.7	580.9
Total Capital Costs[1]	2 036.4	1 671.5	2 047.7	2 093.9

(1) Does not include financing costs and interest during construction (IDC).

3.3.3 (Continued)

This table summarizes the capital costs for each case exclusive of financing costs and interest during construction (IDC). The Base Case reflects a 3 percent lower capital cost than the Shell Coal Case. The increased Shell Coal Case capital costs reflect the additional water pipeline, access roads and site preparation costs required for Site 23. Also, increased capital costs result because of additional power generating facilities for the Shell Coal Case. Because the Shell Coal has a higher heating value, less coal is required to supply the inplant energy consumption, therefore a corresponding greater power export results.

Comparing the Base Case and the Power Self-sufficiency Case, the capital cost difference is $364.9 million to produce an additional 283.2 MW of power. This is $1288/kW which is comparable to the installed cost for new coal fired power generating facilities.

For the Coproduction Case, the capital costs are very similar to those of the Base Case.

In summarizing the capital cost analysis, the Self-sufficiency Case represents a significantly lower capital requirement than the other three cases. However, it does not result in any export power, and it does not consume all of the coal fines that are generated in the coal preparation. The Coproduction Case is only slightly more costly than the Base Case and produces slightly more product on a Btu basis but produces less byproduct in the form of power and naphtha. The Shell Coal Case has a higher capital cost than the Base Case because of the longer water pipeline and access roads and the higher site preparation costs due to the rougher topography at Site 23.

3.3.4 Operation Cost Summary

The operating costs for the four cases are presented in Table 3.3.4-1. Review of the operating costs shows the highest operating costs for the Shell Coal Case primarily because of the higher coal costs and higher electrical costs associated with the longer water pipeline for Site 23. The Self-sufficiency Case is a simpler plant requiring fewer operating personnel and less overall maintenance labor and materials. The Base Case and Coproduction Case are very similar in operating costs.

To evaluate the net operating costs for the four cases, a comparison of the byproduct revenues is analyzed. Table 3.3.4-2 summarizes the expected annual revenues for each case. Examining the byproduct credits, the Shell Coal Case has the highest value because of the greater quantity of naphtha and export power produced. The Self-sufficiency Case byproduct value is much less than the other cases because there is no export power credit. The Coproduction Case is lower than the Base Case reflecting the reduction of naphtha and power export.

The results of combining the annual operating costs with the byproduct credits for the four cases studied are summarized in Table 3.3.4-1. The lowest net annual operating costs are reflected in the Shell Coal Case. A discounted cash flow analysis is necessary for each of the four cases studied to determine which case has the lowest cost of service. The discounted cash flow analyses along with various sensitivity analyses are presented in Volume III, Financial and Legal Analysis.

Additional information required to perform the economic evaluations as well as to provide a portion of the basis of design is presented in Table 3.3.4-3. It presents the production schedule and onstream factor for each of the cases. Also required are the cash disbursement schedules. These are presented in Table 3.3.4-4. The cash flow corresponds to the project master schedule included in the Management Plan of Volume I, Executive Summary.

TABLE 3.3.4-1

OPERATING COST SUMMARY

	Base Case @ Site 1 ($ Million)	Self-Sufficiency Case @ Site 1 ($ Million)	Coproduction Case @ Site 1 ($ Million)	Shell Coal Case @ Site 23 ($ Million)
Coal Cost	88.1	64.6	88.1	92.6
Catalysts and Chemicals	13.6	11.0	11.0	12.8
Plant Management Staff	1.6	1.6	1.6	1.6
Operating Labor and Materials	16.0	15.1	16.4	16.0
Maintenance Labor and Materials	36.1	28.8	36.3	36.4
Electricity	0.5	0.3	0.5	2.5
Ash Disposal	2.2	1.5	2.2	2.1
Taxes and Insurance	37.0	29.7	37.2	38.5
Annual Operating Costs	195.1	152.6	193.3	202.5
Byproduct Credits	(115.2)	(25.1)	(83.5)	(135.3)
Net Annual Operating Costs	79.9	127.5	109.8	67.2

Note: Operating costs for 1989 are assumed to be 67 percent of the above values.

TABLE 3.3.4-2
ANNUAL BYPRODUCT REVENUES

	Base Case @ Site 1 ($ Million)	Self-Sufficiency Case @ Site 1 ($ Million)	Coproduction Case @ Site 1 ($ Million)	Shell Coal Case @ Site 23 ($ Million)
Naphtha, $268/ST	17.4	17.4	10.4	31.4
Ammonia, $235/ST	6.0	6.0	6.0	7.0
Sulfur, $60/ST	1.7	1.7	1.6	0.8
Electricity, 4¢/kWh	90.1	0	65.5	96.1
Total	115.2	25.1	83.5	135.3

TABLE 3.3.4-3

PRODUCT PRODUCTION SCHEDULE

	Base Case Self-Sufficiency Case Shell Coal Case	Coproduction Case
First Gas into Pipeline	1/1/89	1/1/89
First Methanol to Sales	-	1/1/89
Full Production	7/1/89	7/1/89
1989 SNG Production (1)	30,688	14,973
1989 Methanol Production (3), (4)	-	834,000
1990 - 2013 SNG Production Per year	45,625	22,348
1990 - 2013 Methanol Production (3), (4) per year	-	1,250,000
2014 SNG Production (1)	22,813	11,174
2014 Methanol Production (3), (4)	-	622,000
SNG Heating Value (2)	980	980
Onstream Factor	332	332
Plant Production, per stream day (1)	137.5	67.3
per calendar day (1)	125	61.2

NOTE:

1. Gas Production in MM SCF (Million Standard Cubic Feet)
2. SNG Heating Value in Btu/SCF (British thermal units per standard cubic foot)
3. Methanol production in short tons (short ton is 2000 lb.)
4. Methanol heating value - 9740 Btu/lb

TABLE 3.3.4-4
CASH FLOW SCHEDULE

	Base Case @ Site 1 ($ Million)	Self-Sufficiency Case @ Site 1 ($ Million)	Coproduction Case @ Site 1 ($ Million)	Shell Coal Case @ Site 23 ($ Million)
4th Quarter 1982	1.7	1.5	1.8	1.8
1st Quarter 1983	2.6	2.3	2.7	2.7
2nd Quarter 1983	3.1	2.7	3.2	3.1
3rd Quarter 1983	5.0	4.3	5.2	5.1
4th Quarter 1983	6.8	5.9	7.1	6.9
1st Quarter 1984	8.3	7.2	8.7	8.5
2nd Quarter 1984	9.0	7.7	9.4	9.2
3rd Quarter 1984	9.5	8.0	9.9	9.7
4th Quarter 1984	9.7	8.2	10.0	9.9
1st Quarter 1985	10.8	9.5	11.4	11.0
2nd Quarter 1985	12.4	11.0	13.1	12.6
3rd Quarter 1985	12.9	11.4	13.6	13.1
4th Quarter 1985	39.3	33.1	40.3	40.2
1st Quarter 1986	66.9	55.7	68.3	69.2
2nd Quarter 1986	99.8	82.3	101.2	103.4
3rd Quarter 1986	131.1	107.1	132.5	135.7
4th Quarter 1986	156.0	128.0	157.4	161.2
1st Quarter 1987	182.3	149.2	183.4	188.2
2nd Quarter 1987	200.4	164.0	201.1	206.5
3rd Quarter 1987	204.8	167.7	205.2	210.8
4th Quarter 1987	191.8	157.2	191.8	197.0
1st Quarter 1988	184.1	151.2	183.7	188.6
2nd Quarter 1988	171.1	139.8	170.7	175.3
3rd Quarter 1988	136.5	110.7	136.1	139.5
4th Quarter 1988	106.4	85.8	106.0	108.7
1st Quarter 1989	68.7	55.2	68.5	70.4
2nd Quarter 1989	5.4	4.2	5.4	5.6
Total	2,036.4	1,671.5	2,047.7	2,093.9

4.0 SCOPE OF WORK

The scope of work for the Preliminary Design and Cost Estimate of the Crow Tribe of Indians Synfuels Plant is presented in this section. Primary tasks include developing the technical and economic criteria which are the basis for the subsequent preliminary plant design and capital cost estimate; the process development; utility and offsites design; special process studies and capital and operating cost determination. The following describes the major tasks performed in each of these specific areas. The information addresses the Base Case which is a coal conversion facility producing 125 MM SCF/CD of SNG using Westmoreland Resources, Inc. coal. Where criteria differs for the other three cases (i.e., coal analysis for the Shell Coal Case), these differences are presented.

4.1 PROCESS DEVELOPMENT

A process design package is developed for each major unit in the gas production, purification, and byproduct processing portion of the plant. These design packages include the following items:

(1) Process flow diagrams which contain simplified graphic representations of the equipment and piping, necessary to define the basic process. Equipment names, item numbers and significant design parameters are shown.

(2) Mass balances which contain composition and mass flows of each major stream entering or leaving the unit. These data are presented on a separate tabulation. Components are shown in moles/hour and/or pounds/hour, along with stream flowing conditions.

4.1 (Continued)

(3) Process and mechanical specifications to the extent necessary to obtain cost estimates for equipment. Detail data sheets of the equipment, containing dimensions or duty requirements, design temperature and pressure, metallurgy and any auxiliary equipment requirements were developed where individual pieces of equipment were priced. These priced data sheets are not included in the report.

(4) Major equipment requirements to facilitate preparation of plot plans, cost estimates, and the equipment procurement schedule.

(5) Plot plans or layout sketches showing the location of major equipment items within the area allocated to each process unit are developed. These plot plans indicate the required area for all mechanical equipment, buildings, structures, and electrical substations required for the process plant. Locations are based on equipment functions in the process, maintenance and safety requirements. Detailed piping, structural, and architectural drawings are not included in the feasibility study.

(6) Utility and offsite requirements for each process unit. The consumption of steam, boiler feed water, condensate, cooling water, electric power, fuel and inert gas are determined for each unit. Offsite requirements for receiving chemicals, treating effluents, product storage and shipping are presented.

The process units are based on Lurgi technology. Design data for the gasification section were obtained from samples of the two potential coal feed stocks submitted to Lurgi for testing at their laboratory. These laboratory tests provided the design basis for the commercial facility. Licensor secrecy arrangements determined the amount of detail which is presented in the study report.

4.2 UTILITY SYSTEMS DEVELOPMENT

Utility systems for the facility are designed to meet the requirements of the process units. The design of the utility systems includes the following items:

(1) Utility system flow diagrams which show the major equipment in each utility system and the distribution network to the various process unit consumers. Utility equipment names, item numbers and significant design parameters are shown.

(2) Mass balances which contain flow for major streams in the utility distribution system. These data are presented on the system flow diagram or in a separate tabulation.

(3) Major equipment or packaged utility systems specified in sufficient detail to obtain cost estimates for the mechanical equipment. Specification data sheets containing dimensions or duty requirements and auxiliary equipment requirements are prepared. These data are not included in the study report.

(4) Major equipment requirements to facilitate preparation of plot plans, cost estimates and the equipment procurement schedule.

(5) Plot plans or layout sketches showing the location of major equipment items within the area allocated to the utility system.

(6) Utility and offsite requirements for each system to facilitate the design of other utility systems and the offsite support facilities.

4.2 (Continued)

The remoteness of the plant location requires the facility to be self-sufficient in all utility requirements. A study regarding power self-sufficiency vs. power generation is presented. This addresses the issue of how to consume excess coal fines that are generated with a Lurgi based synfuels plant. Results of optimization studies balancing the process cooling water requirements to the process waste water available are presented.

4.3 OFFSITES DEVELOPMENT

The major offsite sections include storage and loading facilities for byproducts, buildings, roads, ash disposal, and water supply.

The offsite requirements for the facility are designed to meet the requirement of the process and utility section of the plant. The design of the offsite facilities includes the following items:

(1) Block flow diagrams which show the flow of materials between the offsite facilities and the process units and utility systems. Major flow streams are identified on the diagram and where necessary a separate tabulation details the mass and energy balance for the system.

(2) Major equipment or packaged systems specified in sufficient detail to obtain cost estimates for the mechanical equipment.

(3) Land requirements for the offsite facilities determined from the development of the overall plant plot plan. Allowances for interconnecting pipeways, roads and buildings are included in the plot plan. Storage areas for coal, raw water ponds, effluent treatment and product tankage are based on estimated process requirements.

4.3 (Continued)

(4) Utility summaries for the offsite areas tabulated for inclusion in the overall plant requirements.

4.4 SPECIAL PROCESS STUDIES

The special studies include the analysis of flue gas desulfurization processes, steam pressure level, and expanded plant capabilities (250 MM SCF/CD). In addition to the studies indicated, complete designs and cost estimates were prepared for three other cases: an alternate coal supply, power self-sufficiency, and methanol/SNG coal production.

4.5 CAPITAL AND OPERATING COSTS

Using process definitions. specifications, plot plans, layouts, information from Fluor's data base and vendor quotes, capital cost estimates are presented for onsite process units, utilities, and offsites. To these total field and office costs are added other capital costs, some normally provided by the client, to obtain total capital requirements. Other capital costs include land, spare parts, paidup royalties, shop, machinery and lab equipment, owners costs, startup costs, management reserve, working capital financing costs, and interest during construction. The total capital requirements serve as the basis for the economic analysis performed in Volume III, "Financial and Legal Analysis".

SECTION 5.0
CRITERIA, RATIONALE, AND ASSUMPTIONS

5.1 COAL ANALYSES

Tables 5-1 and 5-2 give the coal analyses as developed by Lurgi for the Westmoreland Resources, Inc. Absaloka mine coal and the Shell reserve coal respectively. The former is the coal resource for the first three process cases, and the latter is the coal resource for the fourth process case.

TABLE 5-1

COAL ANALYSIS

WESTMORELAND RESOURCES - ABSALOKA MINE

Proximate Analysis, wt%	As Received	Dry Ash Free
Moisture	26.0	-
Ash	7.4	-
Volatile Matter	26.5	39.8
Fixed Carbon	40.1	60.2
	100.0	100.0
Ultimate Analysis, wt%		
Carbon		75.98
Hydrogen		4.59
Nitrogen		1.09
Sulfur		1.23
Chlorine		0.03
Oxygen		17.08
		100.00
Sulfur Distribution, wt%		
Pyritic		0.80
Organic		0.38
Sulphate		0.05
Total		1.23
Calorific Value, Btu/lb		
HHV	8,612 (calc)	12,931.4
LHV	8,392 (calc)	12,493 (calc)

Ash Fusion Properties, °F	Atmosphere	
	Reducing	Oxidizing
Softening Point (H=W)	2084	2174
Melting Point (H=1/2 W)	2093	2237
Flow Point	2120	2306
Flow Point minus Melting Point	27	69

Hardgrove Grindability Index 50 @ 23.34% moisture

calc = calculated value

TABLE 5-2

COAL ANALYSIS

SHELL OIL COMPANY - YOUNGS CREEK COAL

Proximate Analysis, wt%	As Received	Dry Ash Free
Moisture	26.3	-
Ash	4.1	-
Volatile Matter	32.5	46.7
Fixed Carbon	37.1	53.3
	100.0	100.0

Ultimate Analysis, wt %	
Carbon	75.51
Hydrogen	5.19
Nitrogen	1.26
Sulfur	0.55
Chlorine	0.03
Oxygen	17.46
	100.00

Sulfur Distribution, wt %	
Pyritic	0.23
Organic	0.28
Sulfate	0.04
Total	0.55

TABLE 5-2 (Continued)

Calorific Value, Btu/lb	As Received	Dry Ash Free
HHV	9090	13,061[1]
LHV	8752 (calc)	12,570 (calc)

Ash Fusion Properties, °F	Atmosphere	
	Reducing	Oxidizing
Softening Point (H=W)	2201	2273
Melting Point (H=1/2 W)	2210	2282
Flow Point	2219	2291
Flow Point minus Melting Point	9	9

Hardgrove Grindability Index 45.4 @ 23.8% moisture

calc = calculated

(1) 12,869 calc by DuLong formula

5.2 SITE DATA

5.2.1 AREA DESCRIPTION

The Crow Tribe of Indians Synfuels Plant will be located in southern Montana southeast of Billings upon the Crow Indian Reservation. The reservation abuts the southern border of Montana as shown in Drawing 835704-00-5-060, Site Location Map. Major communities located around the reservation include Hardin, Montana to the north; Billings, Montana to the northwest; and Sheridan, Wyoming to the southeast. Major Indian communities within the reservation boundaries include Crow Agency, Lodge Grass, and Wyola. The Bighorn and Little Bighorn Rivers flow in a northerly direction through the reservation. The Little Bighorn River flows into the Bighorn River near Hardin. Yellowtail Dam is located on the Bighorn River with Bighorn Lake behind the dam.

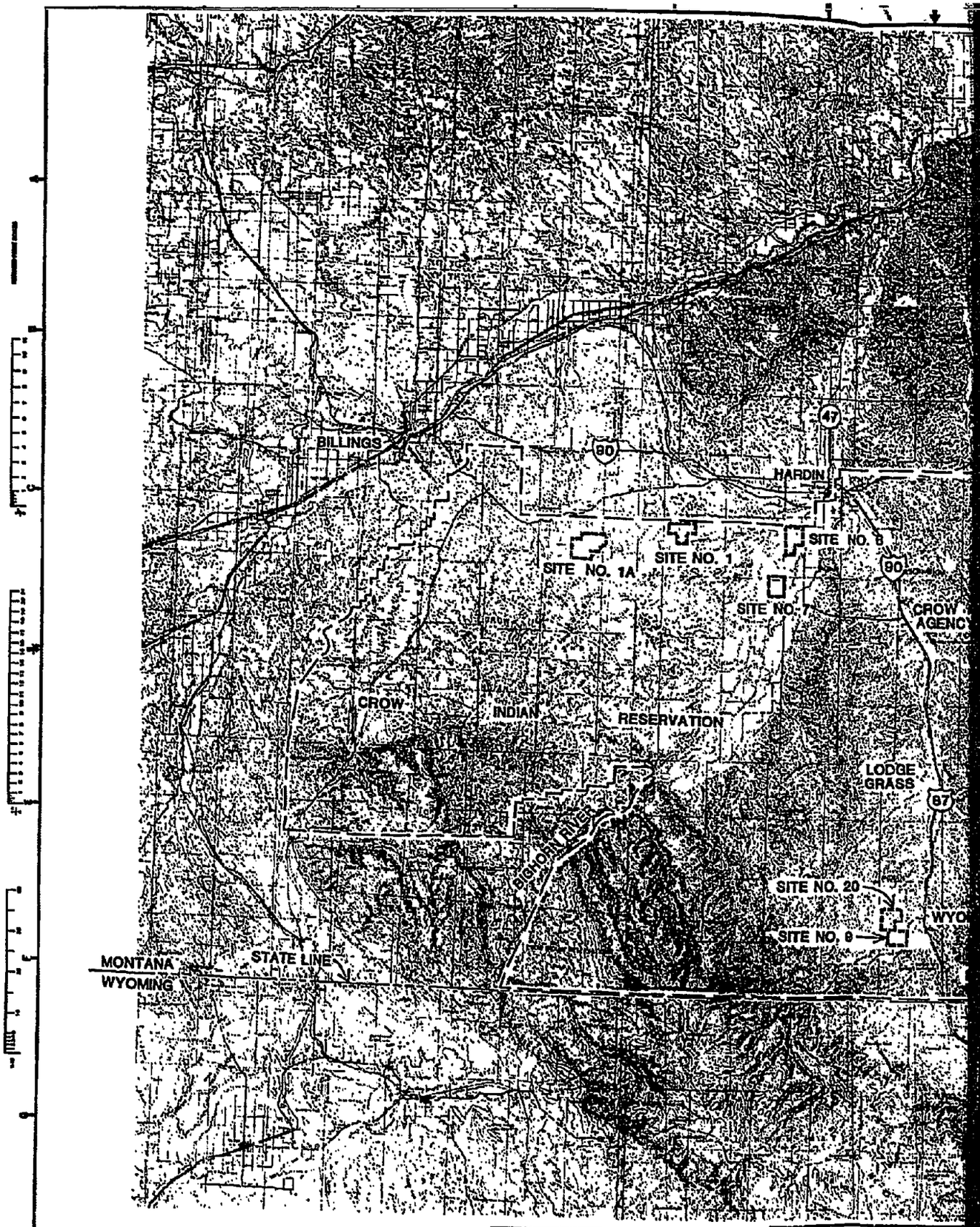
The Shell Oil Company mine is located in the southeast corner of the reservation. The Westmoreland Resources, Inc. mine is located in the Ceded Area bordering on the northerly line of the Crow Reservation corner.

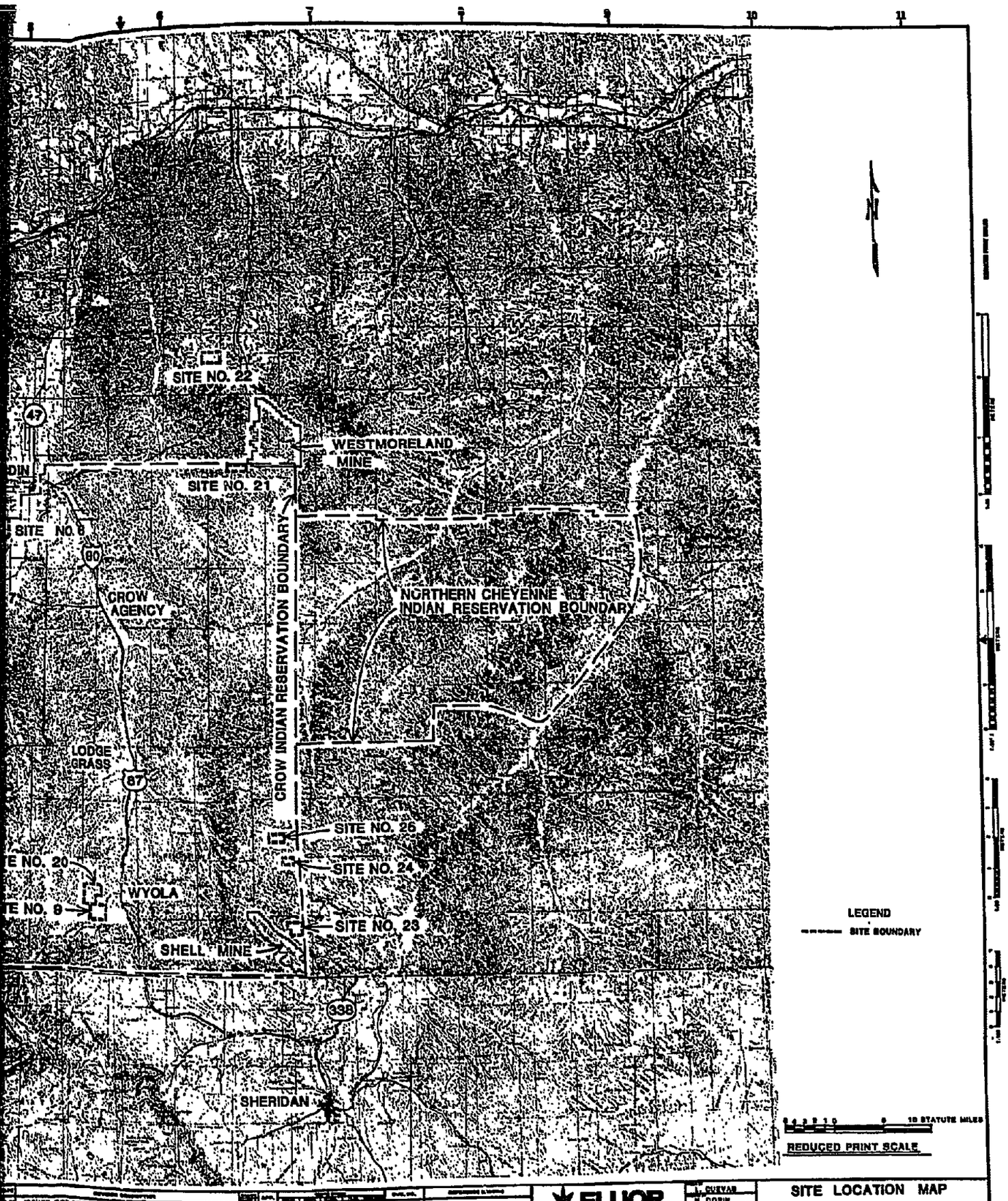
The Northern Cheyenne Indian Reservation is located near the northeast corner and along the eastern boundary of the Crow Indian Reservation.

The Northern Cheyenne Indian Reservation is classified as a Class 1 air quality area as designated by the Environmental Protection Agency (EPA).

5.2.2 SITES STUDIED

Eleven different site locations for the synfuels plant were studied during the plant site selection process as described in the Resource and Site


BILLINGS
90
47
HARDIN
SITE NO. 8
SITE NO. 1A
SITE NO. 1
SITE NO. 7
90
CROW AGENCY
CROW
INDIAN
RESERVATION
LODGE GRASS
87
BIGHORN RIVER
SITE NO. 20
SITE NO. 9
WYO
MONTANA
WYOMING
STATE LINE
USE OR DISCLOSURE OF REPORT DATA
IS SUBJECT TO THE RESTRICTION ON THE
NOTICE PAGE AT THE FRONT OF THIS REPORT
ISSUED FOR SITE EVALUATION REPO



ISSUED FOR SITE EVALUATION REPORT									

FLUOR

L. CUEVAS		
M. DORN		
A. GRECHKO	6-1-81	
M. DORN	6-1-81	
B. LANG	6-1-81	

SITE LOCATION MAP

CROW TRIBE OF INDIANS SYNFUEL FEASIBILITY STUDY

1:250000	835704-00-5-060	A

Analysis Section (Volume V) of this report. From this special study, two plant sites were selected for the feasibility study. These sites are referred to in this report as follows:

Site 1 - This plant site is located between the cities of Billings and Hardin near the northernly boundary of the Crow Reservation. Site 1 is used in the Base Case for the feasibility study economic analysis. In addition to the Base Case, Self-sufficiency Case, and Coproduction Case are associated with Site 1.

Site 23- This plant site is located in the southeast corner of the reservation north of and adjacent to the proposed Shell mine. Site 23 is used for the Shell Coal Case economic analysis.

A description of the different process cases mentioned above is contained in Section 6.4 and 6.5 of this Volume II.

5.2.3 TOPOGRAPHIC MAPS AND AERIAL PHOTOGRAPHS

Topographic information of the area was obtained using various U.S. Geological Survey maps. The maps used in the study are listed in Table 5.2-1.

Aerial photo indexes of Bighorn County were obtained from:

Aerial Photography Field Office
USDA-ASCS

TABLE 5.2-1

SOURCE OF TOPOGRAPHIC INFORMATION

SITE	MAP NO.	SCALE	DATE
Billings, Montana	Map NL 12-9	Scale 1:250,000	1979
Forsyth, Montana	Map NL 13-4	Scale 1:250,000	1976
Hardin, Montana	Map NL 13-7	Scale 1:250,000	1963
Roundup, Montana	Map NL 12-6	Scale 1:250,000	1977
Cody, Wyoming	Map NL 12-12	Scale 1:250,000	1979
Sheridan, Wyoming	Map NL 13-10	Scale 1:250,000	1962
Bar V Ranch, Montana	7.5 minute series	Scale 1:24,000	1978
Bar V Ranch NE, Montana	7.5 minute series	Scale 1:24,000	1978
Benteen, Montana	7.5 minute series	Scale: 1:24,000	1967
Bentonite Flats, Montana	7.5 minute series	Scale: 1:24,000	1969
Camp Four, Montana	7.5 minute series	Scale: 1:24,000	1969
Chimney Creek, Montana	7.5 minute series	Scale: 1:24,000	1960
Corinth, Montana	7.5 minute series	Scale: 1:24,000	1969
Crow Agency, Montana	7.5 minute series	Scale: 1:24,000	1967
Good Luck Creek, Montana	7.5 minute series	Scale: 1:24,000	1967
Hardin, Montana	7.5 minute series	Scale: 1:24,000	1960
Hardin SW, Montana	7.5 minute series	Scale: 1:24,000	1960
Iron Spring SW, Montana	7.5 minute series	Scale: 1:24,000	1972
Kid Creek, Montana	7.5 minute series	Scale: 1:24,000	1967
Little Bear Creek, Montana	7.5 minute series	Scale: 1:24,000	1967
Lodge Grass, Montana	7.5 minute series	Scale: 1:24,000	1967
Mission Coulee, Montana	7.5 minute series	Scale: 1:24,000	1960
Mountain Pocket Creek, Montana	7.5 minute series	Scale: 1:24,000	1964
Ninemile Point, Montana	7.5 minute series	Scale: 1:24,000	1960
Padlock Ranch, Montana	7.5 minute series	Scale: 1:24,000	1972
Pass Creek East, Montana	7.5 minute series	Scale: 1:24,000	1967
Pearl School, Montana	7.5 minute series	Scale: 1:24,000	1976

TABLE 5.2-1 (Continued)

SOURCE OF TOPOGRAPHIC INFORMATION

SITE	MAP NO.	SCALE	DATE
Prante Ranch, Montana	7.5 minute series	Scale: 1:24,000	1960
Rowley, Montana	7.5 minute series	Scale: 1:24,000	1969
Rowley, NW	7.5 minute series	Scale: 1:24,000	1969
Shick Ranch, Montana	7.5 minute series	Scale: 1:24,000	1960
The Dugout, Montana	7.5 minute series	Scale: 1:24,000	1972
Walkerhill, Montana	7.5 minute series	Scale: 1:24,000	1960
Wolf School, Montana	7.5 minute series	Scale: 1:24,000	1972
Wyola, Montana	7.5 minute series	Scale: 1:24,000	1967
Wyola NE, Montana	7.5 minute series	Scale: 1:24,000	1967
Yellowtail Dam, Montana	7.5 minute series	Scale: 1:24,000	1964
Acme, Wyoming	7.5 minute series	Scale: 1:24,000	1968
Monarch, Wyoming	7.5 minute series	Scale: 1:24,000	1964

5.2.4 SITE RECONNAISSANCE

During the week of October 19 through 23, 1981, representatives from the Bureau of Indian Affairs (BIA), Council of Energy Resource Tribes (CERT), Pacific Coal Gasification Company (Pacific), and Fluor Engineers and Constructors, Inc. (Fluor) participated in a site reconnaissance trip. The purpose of the trip was to investigate and evaluate potential plant sites and resources of coal for the synfuels facility. Details of the site reconnaissance and the evaluations of the potential sites are described in the Resource and Site Analysis Section (Volume V).

Information and data were gathered regarding civil/structural, environmental and transportation concerns. In addition to prospective plant sites, potential water and coal sources were visited and evaluated. Basic information pertaining to climate, maps, land ownership, railroad, roads, building regulations and mining operations was obtained.

In addition to Site 1 and Site 23, nine other potential sites were considered. Criteria for the evaluation of the sites included.

(1) Usable Area
(2) Topography and Drainage
(3) Impact Upon Class 1 Air Quality Area (Northern Cheyenne Indian Reservation)
(4) Road Access
(5) Railroad Access
(6) Proximity to Raw Water Supply

5.2.5 METEOROLOGICAL AND DESIGN DATA

The following meteorological and design data are used as the basis for the feasibility study. The source of the regional climatological information was

5.2.5 (Continued)

the National Climatic Center's Climatological Summaries, issued by the National Oceanic and Atmospheric Administration (NOAA). The summaries include information for Billings, Montana; Colstrip, Montana; Wyola, Montana; and Sheridan, Wyoming.

Temperature

Temperatures for site design are:

(1)	Design Dry Bulb	88°F
(2)	Corresponding Wet Bulb	64°F
(3)	Design Wet Bulb	65°F
(4)	Corresponding Dry Bulb	85°F
(5)	Maximum Dry Bulb	100°F
(6)	Minimum Dry Bulb	-30°F

NOTE: The design dry bulb and wet bulb are the temperatures which are not exceeded more than 5 percent of the time during the hottest three months of the year.

Source: "Cooling Tower Fundamentals and Application Principles," The Marley Co., 1969.

5.2.5 (Continued)

Rainfall

(1) Annual Mean 15 in.

(2) Design Storms:

Frequency	Duration	Rainfall
25	60 min.	2.1 in.
50	60 min.	2.6 in.

Figure 5-1 shows the rainfall intensity vs duration curves for the Billings, Montana area.

Sources: Engineering Department, City of Billings. "Climatological Summary," National Climatic Center.

Snow Load

Design Snow Load 30 psf live load

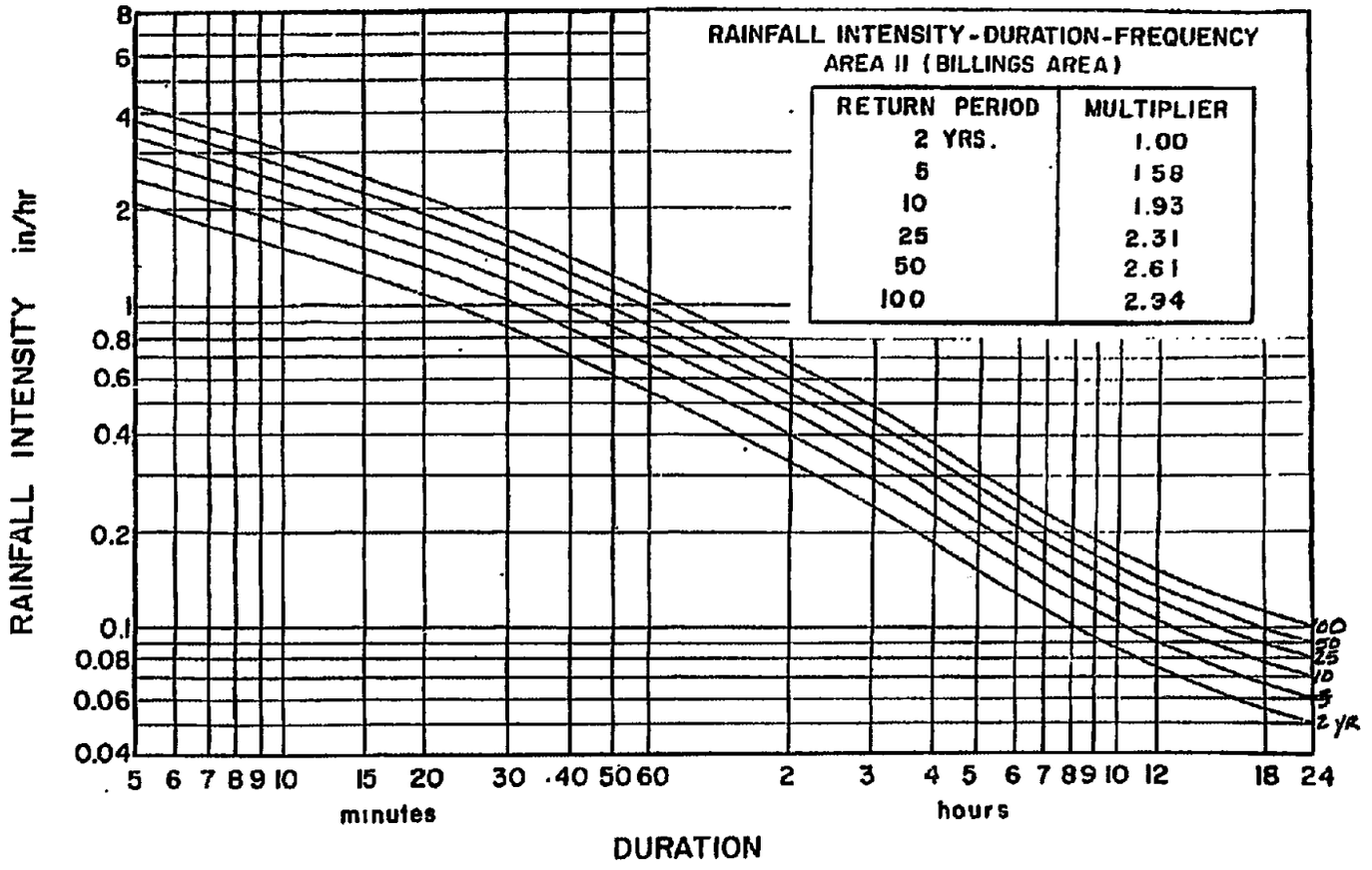
Sources: Engineering Department, City of Billings. "Recommended Snow Loads for Montana Structures," Department of Civil Engineering, Montana State University, Bozeman, Montana, March 1978.

Wind

Prevailing Direction	from West
Extreme Wind (Fastest Mile)	79 mph

FIGURE 5-1

RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



SOURCE: ENGINEERING DEPARTMENT, CITY OF BILLINGS, MONTANA

5.2.5 (Continued)

The wind roses for the following areas are as shown on Figure 5-2.

(1) Westmoreland Mine Area
(2) Colstrip Area
(3) Billings Area
(4) Shell Mine Area

Design Wind Pressure: 30 psf @ 30 ft.

Sources: "Climatological Summary," National Climatic Center, 1980.
"Environmental Impact Study on Coal Development on the Crow Indian Reservation," Bureau of Indian Affairs, Department of the Interior, Report No. 273.
Uniform Building Code, 1979.

Frost Depth

Frost Depth for Foundations 4 ft.

Sources: Engineering Department, City of Billings, Montana.
Engineering Department, City of Hardin, Montana.

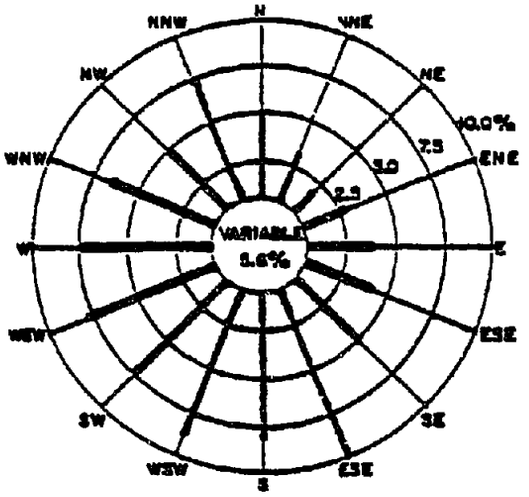
Evaporation

Average Annual Gross Evaporation 40 in.

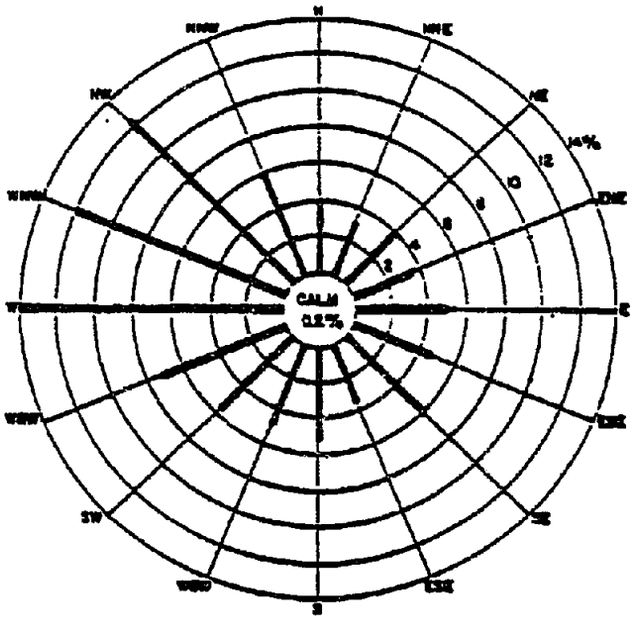
Sources: "Climatological Summary," National Climatic Center, 1980.
"Environmental Impact Study on Coal Development on the Crow Indian Reservation." Bureau of Indian Affairs, Department of the Interior, Report No. 273.

FIGURE 5-2

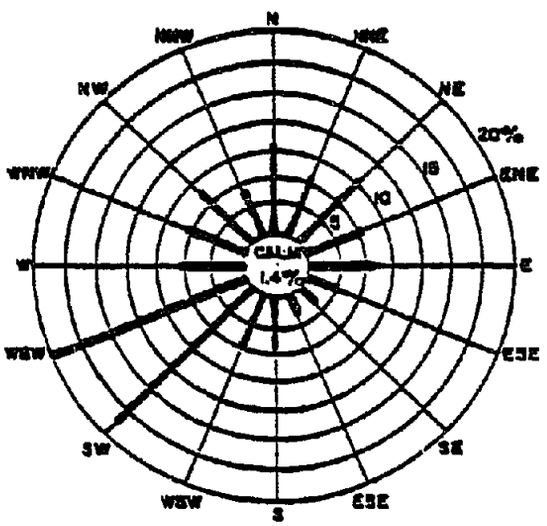
SELECTED WIND ROSES



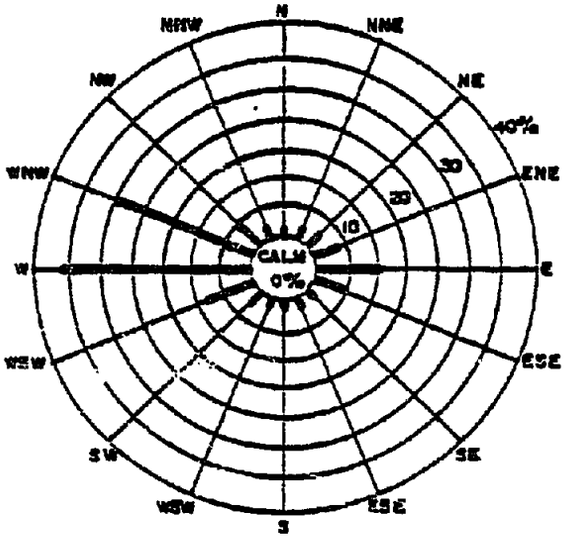
WESTMORELAND MINE AREA



COLSTRIP AREA



BILLINGS AREA



SHELL MINE AREA

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NOTICE PAGE AT THE FRONT OF THIS REPORT

5.2.5 (Continued)

Seismic

Seismic Zone: UBC Zone 1

Source: Uniform Building Code, 1979.

5.2.6 BUILDING CODES AND REGULATIONS

Among the building codes and regulations that the design and construction of the plant facility will comply with are the following:

ORGANIZATION

AASHO - American Association of State Highway Officials
ACI - American Concrete Institute
AISS - Asphalt Institute
AITC - American Institute for Timber Construction
AMCA - Air Moving and Conditioning Association
ANSI - American National Standards Institute
ASHRAE- American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME - American Society of Mechanical Engineers
ASTM - American Society of Testing Materials
AWPA - American Wood Preservers' Association
AWS - American Welding Society
AWWA - American Water Works Association
IAPMO - International Association of Plumbing and Mechanical Officials
NEC - National Electrical Code
NFPA - National Fire Protection Association
SSPC - Steel Structures Painting Council
TEMA - Tubular Exchangers Manufacturers Association

5.2.6 (Continued)

UBC - Uniform Building Code
UFC - Uniform Fire Code
UL - Underwriters Laboratory
UPC - Uniform Plumbing Code

In addition, the project will comply with all Crow Tribe of Indians Codes and Regulations.

5.2.7 DESCRIPTION OF SITE 1

5.2.7.1 Site Location and Description

Site 1 is located between the cities of Billings and Hardin as shown on the Area Map, Drawing 835704-00-4-079 and the Vicinity Map, Drawing 835704-00-5-080. The site is approximately 45 miles by road from Billings and 15 miles from Hardin. The land is presently cultivated for dryland wheat farming. Main plant buildings and structures would barely be seen from Interstate 90 and probably not seen from Hardin.

The plant site is composed of the following Sections located in Township 2 South, Range 31 East:

Section 16: SW¼
Section 17: S½
Section 20: N½
Section 21: NW¼

	DATE	REVISION DESCRIPTION	CHECKED	APP.
1	1/94	ISSUED FOR STUDY	[illegible]	

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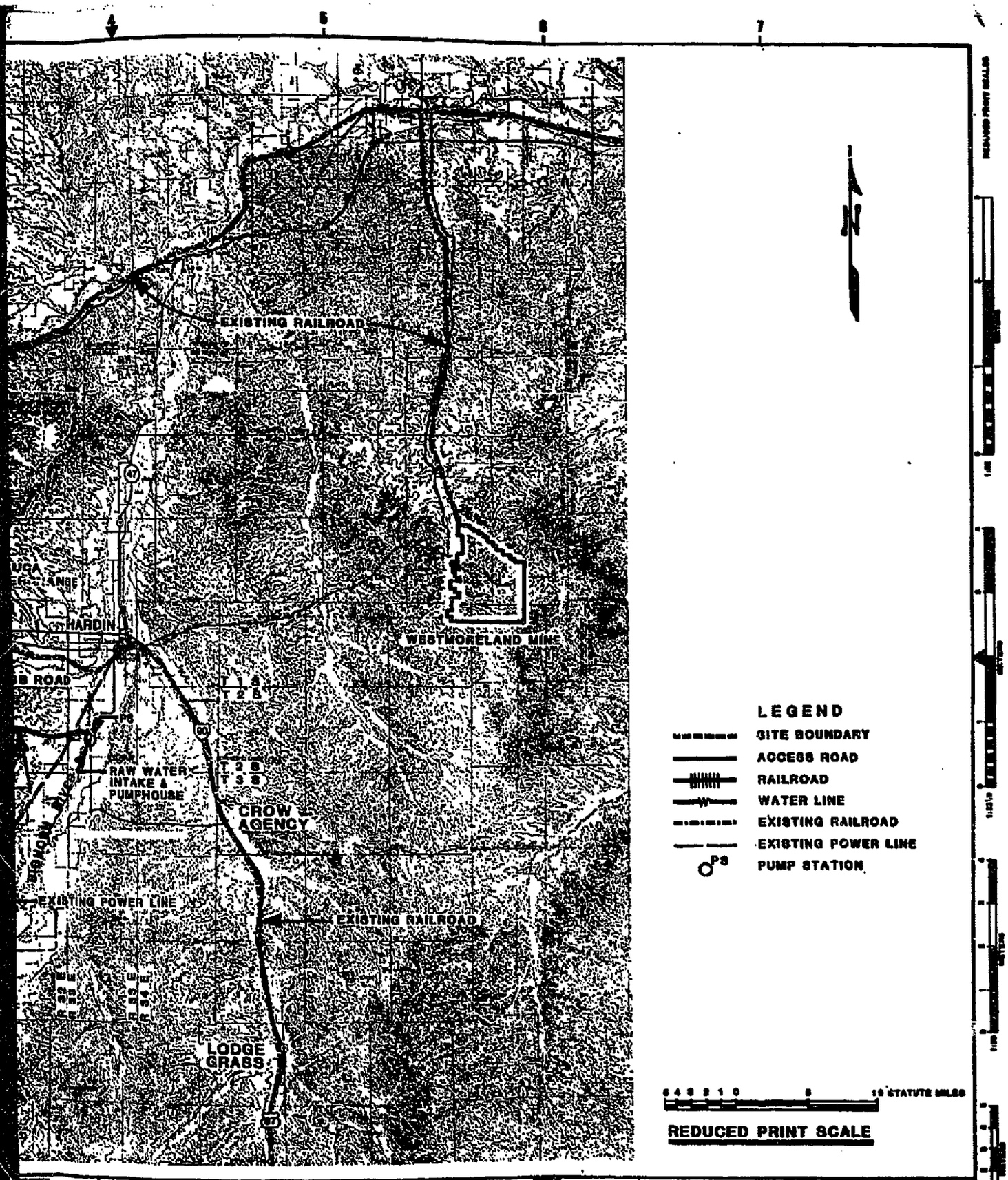

DWG. NO.	REFERENCE DRAWING
00-6-080	VICINITY MAP

FLUOR

J. GRAU
M. DORIN
M. DORIN
R. LANG

SITE # 1 AREA MAP

SYNFUELS FEASIBILITY STUDY

CROW TRIBE OF INDIANS MONTANA

SCALE	DRAWING NUMBER	REV.
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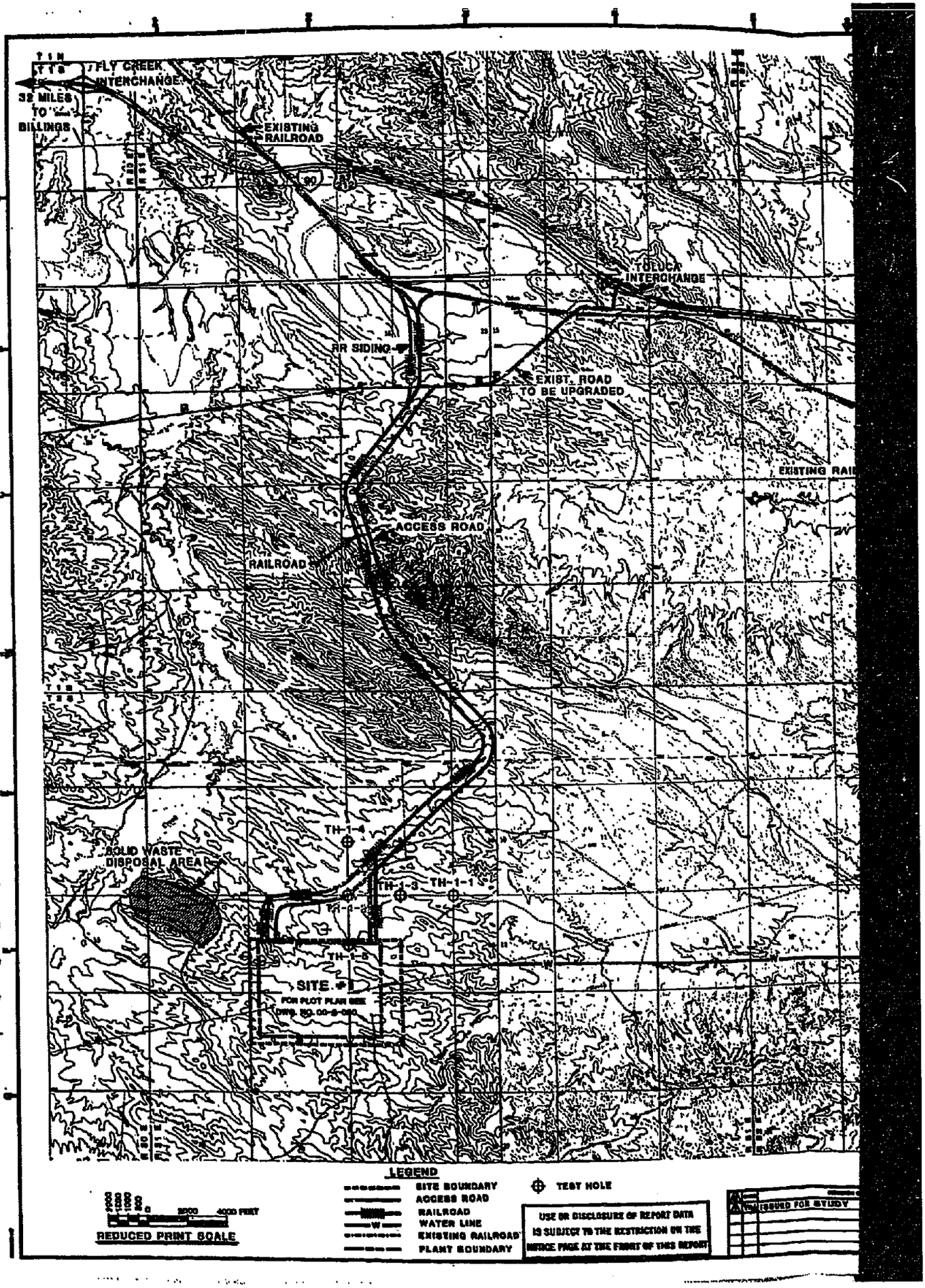
FLY CREEK INTERCHANGE
32 MILES TO BILLINGS
EXISTING RAILROAD
TOLUCA INTERCHANGE
RR SIDING
EXIST. ROAD TO BE UPGRADED
EXISTING RAI
ACCESS ROAD
RAILROAD
TH-1-4
SOLID WASTE DISPOSAL AREA
TH-1-3
TH-1-1
TH-1-2
TH-1-5
SITE
FOR PLOT PLAN SEE DWG. 80-00-S-000
LEGEND
SITE BOUNDARY
ACCESS ROAD
RAILROAD
WATER LINE
EXISTING RAILROAD
PLANT BOUNDARY
TEST HOLE
0 2000 4000 FEET
REDUCED PRINT SCALE
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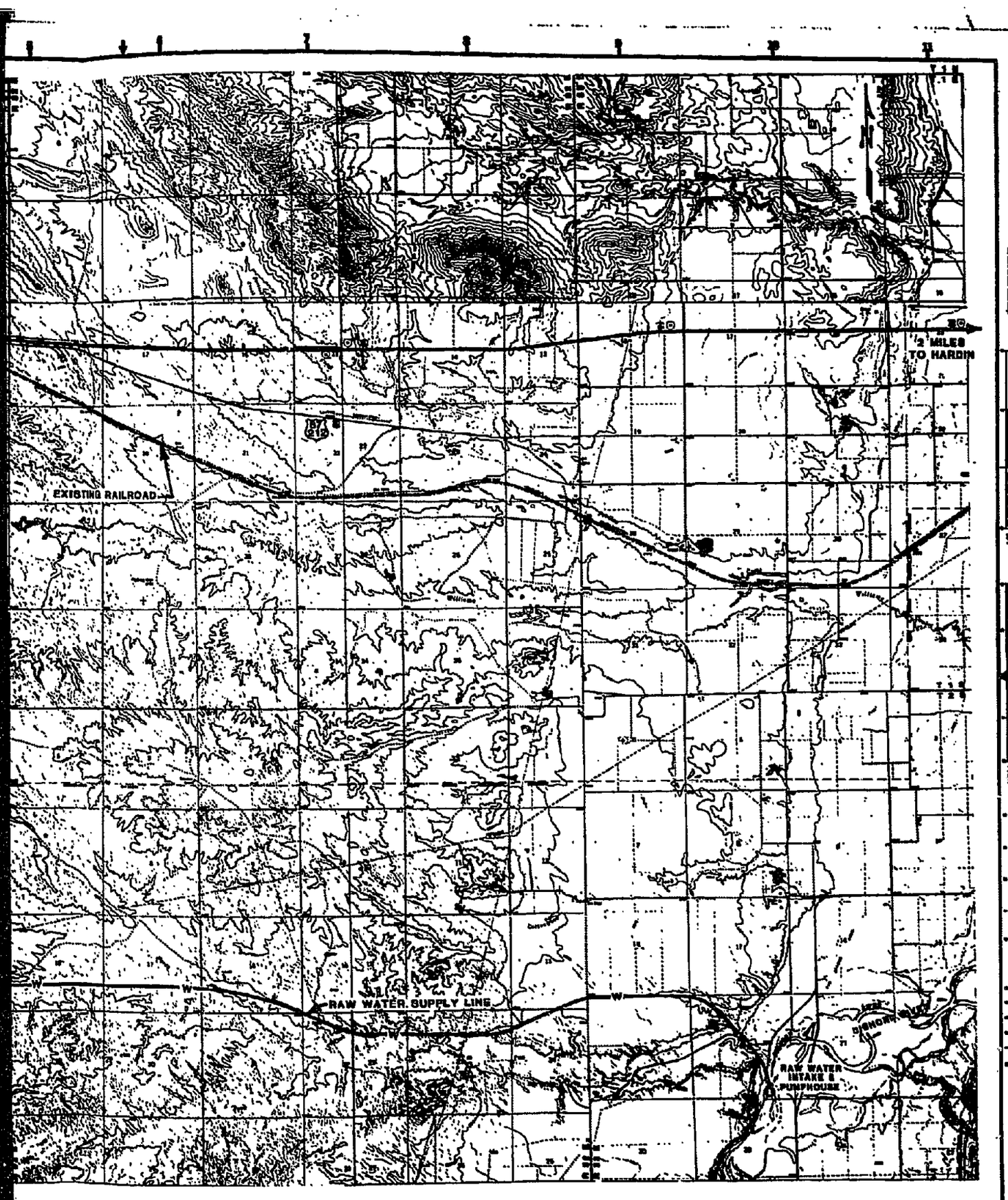
ISSUED FOR STUDY



ISSUED FOR STUDY

00-0-C70	AREA MAP
00-0-C80	PLOT PLAN

FLUOR

SITE #1 VICINITY MAP

SYNFUELS FEASIBILITY STUDY

CROW TRIBE OF INDIANS MONTANA

1"=2000' 835704-00-5-080 1

5.2.7.2 Physiography and Natural Drainage

Most of the plant site is generally flat at an elevation of about 3340 feet. The peak elevation of 3400 feet occurs near the northwesterly corner of the site. The minimum elevation is approximately 3300 feet occurring at the easterly boundary of the site. The direction of the natural drainage in the area is generally away from the site in a northwesterly direction.

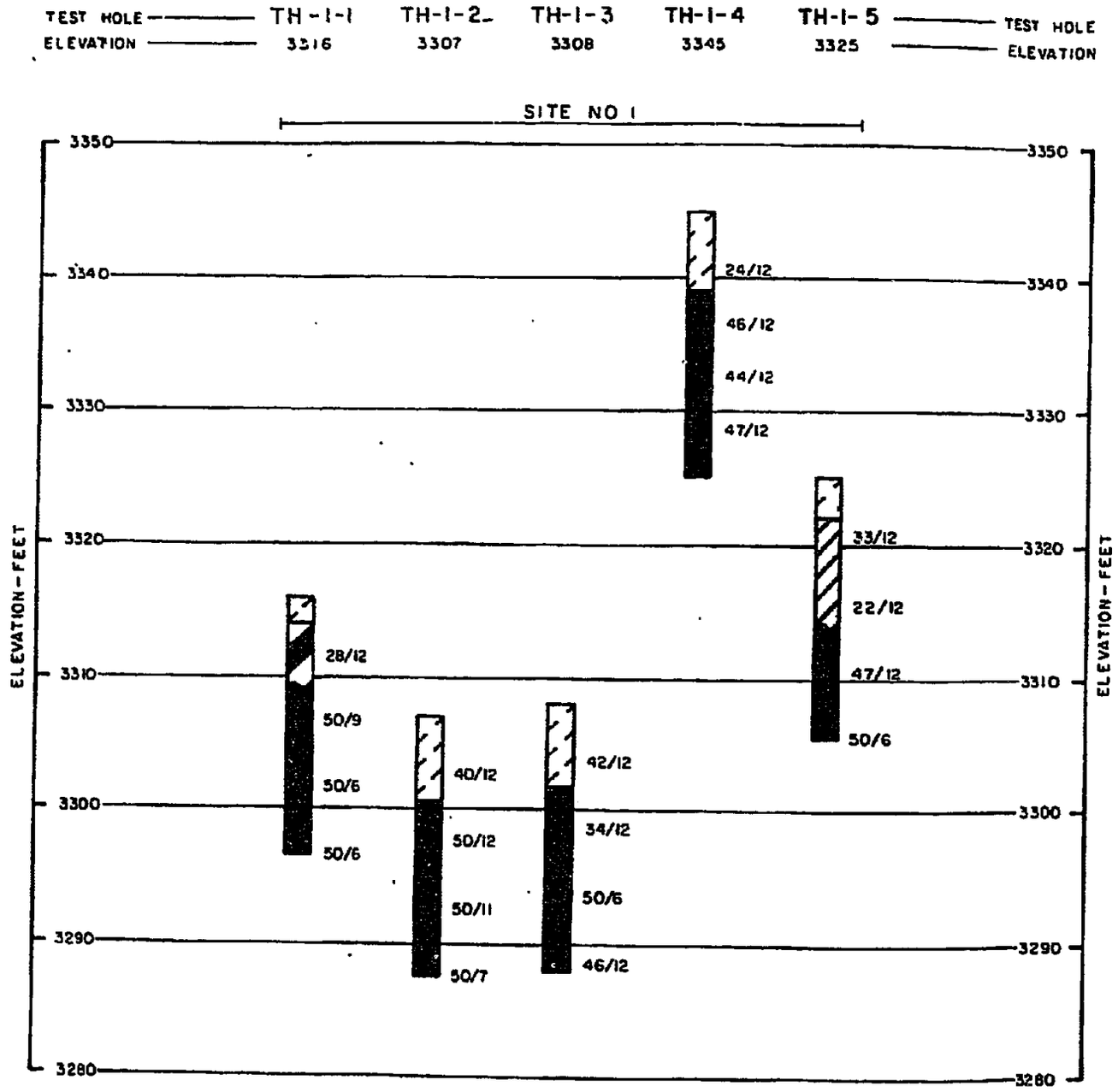
The site area is drained by two different drainage courses: Fly Creek and North Fork Two Leggins Creek. Essentially, the westerly half of the site is drained to Fly Creek while the easterly half is drained to North Fork Two Leggins Creek. Fly Creek flows northerly into the Yellowstone River. North Fork Two Leggins Creek flows easterly and drains into the Bighorn River, then into the Yellowstone River. The Yellowstone River flows into the Missouri River.

5.2.7.3 Geotechnical Data

During April 27th through May 1, 1981, a preliminary geotechnical investigation was performed by Woodward-Clyde Consultants. This investigation was done as part of the Feasibility Study for the Crow Electric Power Generation Project.

This preliminary geotechnical investigation included a limited soil reconnaissance in the vicinity of Site 1. The investigation consisted of five test holes in this area, each to a depth of 20 feet. The locations of the test holes are shown on the Vicinity Map, Drawing 835704-00-5-080. Drawing 835704-00-2-107 shows the summary logs of the test holes.

The test holes indicate that the upper 3 to 7 feet layer of the soils consist of stiff to very stiff clays. The remaining depth of the test hole shows hard claystone bedrock underlying the upper layer.



SOURCE: GEOTECHNICAL REPORT BY WOODWARD-CLYDE CONSULTANTS
FOR CROW ELECTRIC POWER GENERATION PROJECT FEASIBILITY STUDY, OCTOBER 1981

REV. NO.	DATE	REVISION DESCRIPTION	DRAWN / CHECK	DATE
1	5/24/82	ISSUED FOR STUDY	L.C. / M.D.	6/3/82

FLUOR

TEST HOLE ELEVATION

LEGEND

CLAY, STIFF TO VERY STIFF, SILTY, SANDY, CALCAREOUS, OCCASIONALLY POROUS, SLIGHTLY MOIST TO MOIST, BROWN (CL, CL-CH, CH).

CLAY, VERY STIFF, SANDY, MOIST, BROWN, OLIVE, GRAY (CL, CL-CH, CH). (WEATHERED BEDROCK).

CLAYSTONE, MEDIUM HARD, SANDY, SCATTERED BENTONITIC CLAY LENSES GRAY, BLACK (BEDROCK).

CLAYSTONE, HARD TO VERY HARD, SANDY, SCATTERED BENTONITIC CLAY LENSES, MOIST, GRAY, BROWN, BLACK (BEDROCK).

44/12 INDICATES 40 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2-INCH DIAMETER SAMPLER 12 INCHES.

INDICATES GRADUAL CHANGE IN MATERIALS. EXACT STRATA CHANGE NOT LOCATED.

NOTES:

1. TEST HOLES WERE DRILLED BETWEEN APRIL 27, 1981 AND MAY 1, 1981 WITH A 4-INCH HELICAL AUGER POWERED BY A CENTRAL MINE EQUIPMENT (CME-45) DRILLING RIG.
2. TEST HOLE LOCATIONS AND ELEVATIONS ARE APPROXIMATE. TEST HOLE ELVATIONS WERE OBTAINED FROM U.S.G.S. TOPOGRAPHIC MAPS.

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FORM E-305 REV. 9/78
PRINTED IN U.S.A.

OBER 1981

FLUOR

DRAWN BY: L. CUEVAS			
CHECKED BY: M. DORIN			
SUPERVISOR: A. QUINONES	RELEASED DATE: 6/3/82		
SUPERVISING ENGR.: M. DORIN	INITIALS: M. Dorin		
PROJECT ENGR.: R. LANG	APP. DATE: R.H. Lang 6/4/82	SCALE: NONE	DRAWING NUMBER: 835704-00-2-107
CLIENT	APP. DATE		REVISION: 1

SITE #1 SUMMARY LOGS OF TEST HOLES

SYNFUELS FEASIBILITY STUDY

CROW TRIBE OF INDIANS — MONTANA

5.2.7.3 (Continued)

Laboratory tests indicate that the clays and claystone bedrock expand when wetted. No ground water was encountered in any test holes which indicates that groundwater will present no excavation or foundation problems.

Excavation of the soil and rock is expected to be generally accomplished with scrapers bulldozers and ripping equipment. Very little blasting, if any, is anticipated.

All onsite soils are assumed to be suitable for recompaction.

A site soil investigation will be performed prior to the detailed engineering phase.

5.2.7.4 Existing Onsite Structures

A buried 12 inch diameter high pressure gas pipeline runs diagonally across the site as indicated on the Vicinity Map, Drawing 835704-00-5-080. This pipeline is relocated as described in Section 6.8.1.1 of this Volume.

5.2.7.5 Existing Roads

Two existing highways are located near the site as shown on the Vicinity Map, Drawing 835704-00-5-080. Interstate 90, which also is designated as State Route 87/212, is a divided expressway running in an east-west direction. This route is located approximately 8 miles north of the site. Old State Route 87/212 is a 2-lane undivided road also running in an east-west direction. This road is located about 6 miles north of the site. This road is in current use as an alternate route to Interstate 90. The two roads provide independent transportation routes between Billings and Hardin.

5.2.7.5 (Continued)

The plant access road will connect Site 1 with old State Route 87/212 and also Interstate 90 at Toluca Interchange as shown on Drawing 835704-00-5-080.

During the reconnaissance trip of October 19 through 23, 1981, road maps for the state of Montana and Bighorn County were obtained from Montana Department of Highways.

Road maps for the Crow Indian Reservation were obtained from Bureau of Indian Affairs, Crow Agency, Montana.

Standard Specifications for Road and Bridge Construction and Standard Drawings Supplement were obtained from Montana Department of Highways, Contract Plans Division.

5.2.7.6 Existing Railroad

The existing Burlington Northern rail lines in the region are shown on the Area Map, Drawing 835704-00-4-079. The existing rail lines serve Westmoreland mine; Billings, Montana; Hardin, Montana; and Sheridan, Wyoming. The existing rail lines in conjunction with a new railroad are used for the import of coal from Westmoreland mine, the import of equipment, supplies and catalysts, and the export of byproducts and spent catalysts. The nearest rail line passes approximately 7 miles north of the site running in a northwest-southeast direction.

A railroad map for the state of Montana plus a map of the United States showing locations of coal resources were obtained from Burlington Northern Railroad Co., Billings Office.

"Standard Plans for Unit Coal Train Spur and Loop Tracks" was obtained from Burlington Northern Railroad Co., Engineering Division, 176 East 5th Street, St. Paul, Minnesota 55101.

5.2.7.6 (Continued)

The coal supply for Site 1 is transported by rail from the Westmoreland mine. The mine is located about 42 miles east of the plant site as shown on Drawing 835704-00-4-079. The coal is transported north from the mine along an existing spur for a length of about 32 miles to an existing Burlington Northern mainline. The coal is then transported in a southwesterly direction on the existing mainline for a distance of about 66 miles to Huntley. Here the train changes to another existing mainline going easterly toward Hardin. Twenty-nine miles from Huntley the train meets the new plant rail line running south to the plant site. A description of the new railroad is contained in Section 6.8.1.3. The coal travels a total distance of about 136 miles from the Westmoreland mine to the plant site.

5.2.7.7 Existing Utilities

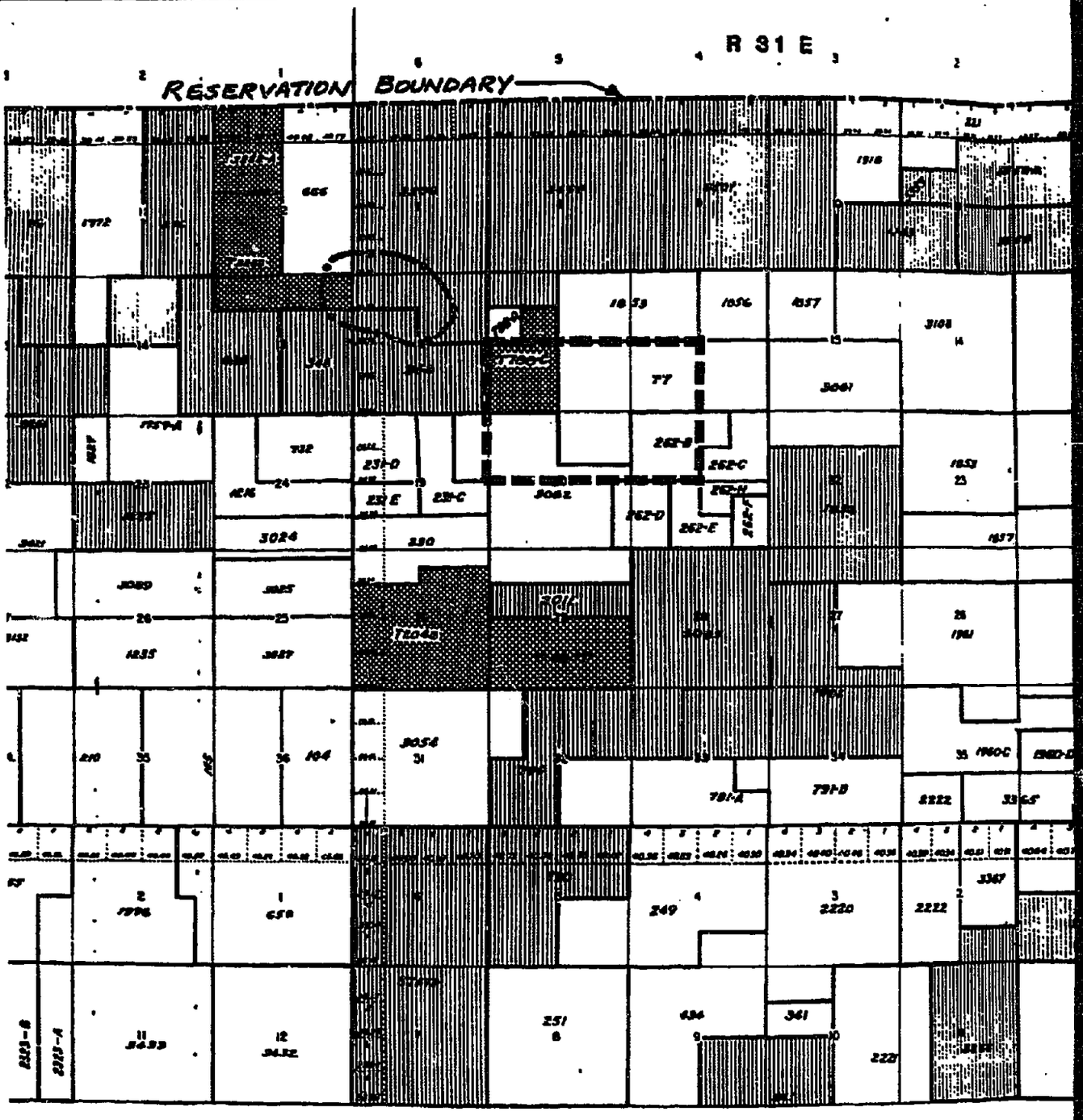
An existing 230 kV powerline is located approximately 9 miles east of the site. The powerline runs in a northeasterly direction from Yellowtail Dam toward Hardin as shown on Drawing 835704-00-4-079. This could supply temporary power to the site during plant construction and startup operations.

5.2.7.8 Land Ownership Status

The land ownership status of Site 1 and the solid waste disposal area is shown on Drawing 835704-00-2-108.

The northwesterly corner of the site is Trust Land - tribally owned. The rest of the site is Trust Land - Individually owned Indian allotment or tract.

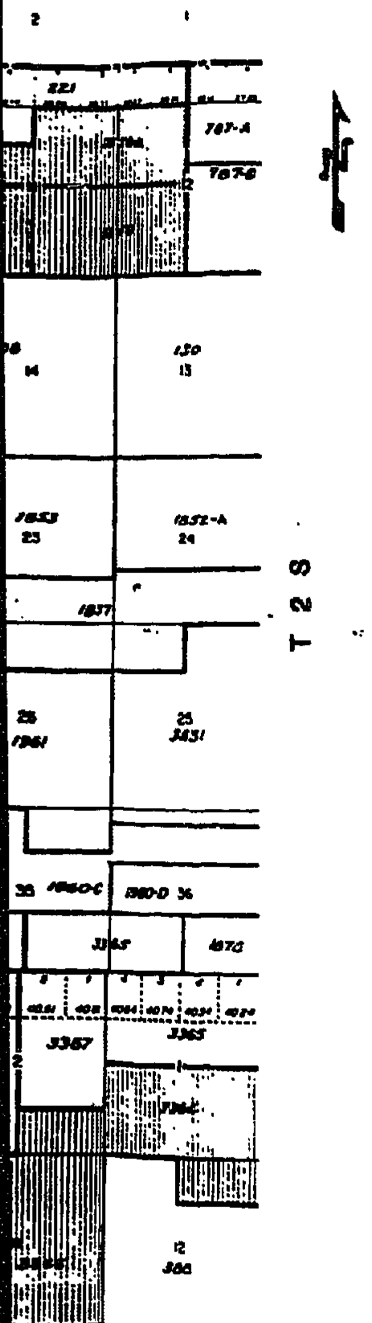
The solid waste disposal area lies primarily on Fee Lands. This land is not owned by either the tribe or individual Indians.



SOURCE: U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS

REV. NO.	DATE	REVISION DESCRIPTION	DRAWN	DATE
1	5-21-82	ISSUED FOR STUDY	MD.	6/2/82
			CHECK	

FLUOR



LEGEND

- OO — TRUST—Individually Owned Indian Allotment or Tract
- TRUST—Tribally Owned by The (NO. DENOTES AN ACQUIRED ALLOTMENT/TRACT)
- TR — TRUST—Tribally Owned in Reserve Status
- G — GOVERNMENT OWNED—B I A Submarginal Lands
- G — GOVERNMENT OWNED—B I A
- GOVERNMENT OWNED—OTHER FEDERAL AGENCY
- FEE LANDS
- Paved Road
- Graveled Road
- Improved Dirt Road
- Unimproved Dirt Road or Trails
- Dashed township or section lines indicate unsurveyed area.
- BOUNDARY OF SITE #1
- SOLID WASTE DISPOSAL AREA

DRAWN BY: J. GRAU		**SITE #1 LAND OWNERSHIP STATUS**	
CHECKED BY: M. DORIN		SYNFUELS FEASIBILITY STUDY	
SUPERVISOR: A. QUINONES	RELEASE DATE: 5-21-82	CROW TRIBE OF INDIANS	MONTANA
SUPERVISING ENGR.: M. DORIN	INITIALS: M. Dorin		
PROJECT ENGR.: R. LANG	APP. DATE: RDL 6/82	SCALE: 1"=1 Mile	DRAWING NUMBER: 835704-00-2-108 — REVISION: 1
CLIENT:	APP. DATE:		

UOR

5.2.8 DESCRIPTION OF SITE 23

5.2.8.1 Site Location and Description

Site 23 is located northerly of and adjacent to the proposed Shell mine along the easterly boundary of the Crow Indian Reservation as shown on the Area Map, Drawings 835704-00-4-081 and 835704-00-5-082. The plant site is located about 115 miles by road from Billings, 70 miles from Hardin, and 20 miles from Sheridan, Wyoming. The land is presently being used for grazing. The plant would not be visible from any major highway or population center.

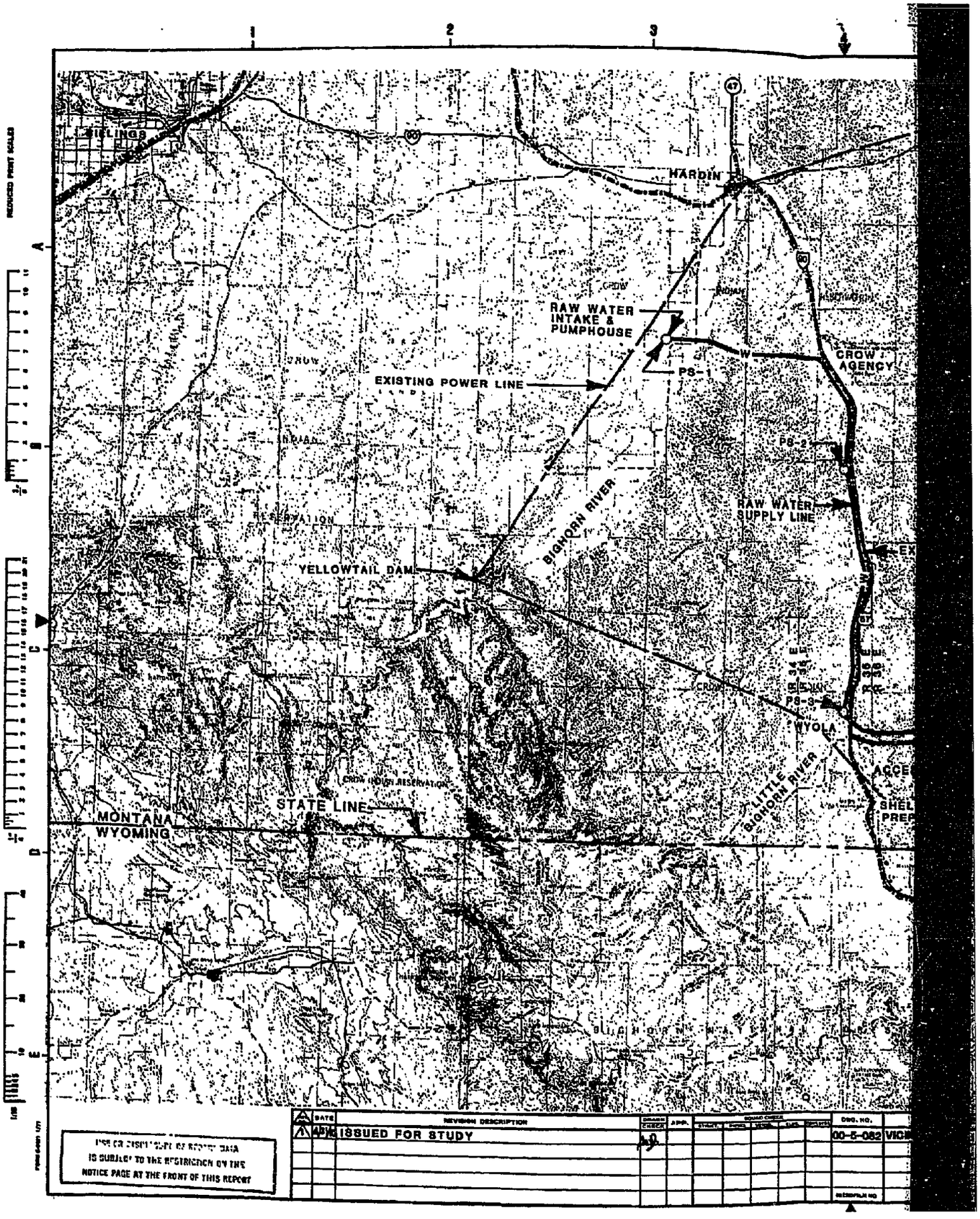
The site is composed of the following Sections:

Township 9 South, Range 38 East
Section 2: S½
Section 3: SE¼ SE¼
Section 10: NE¼ NE¼
Section 11: All

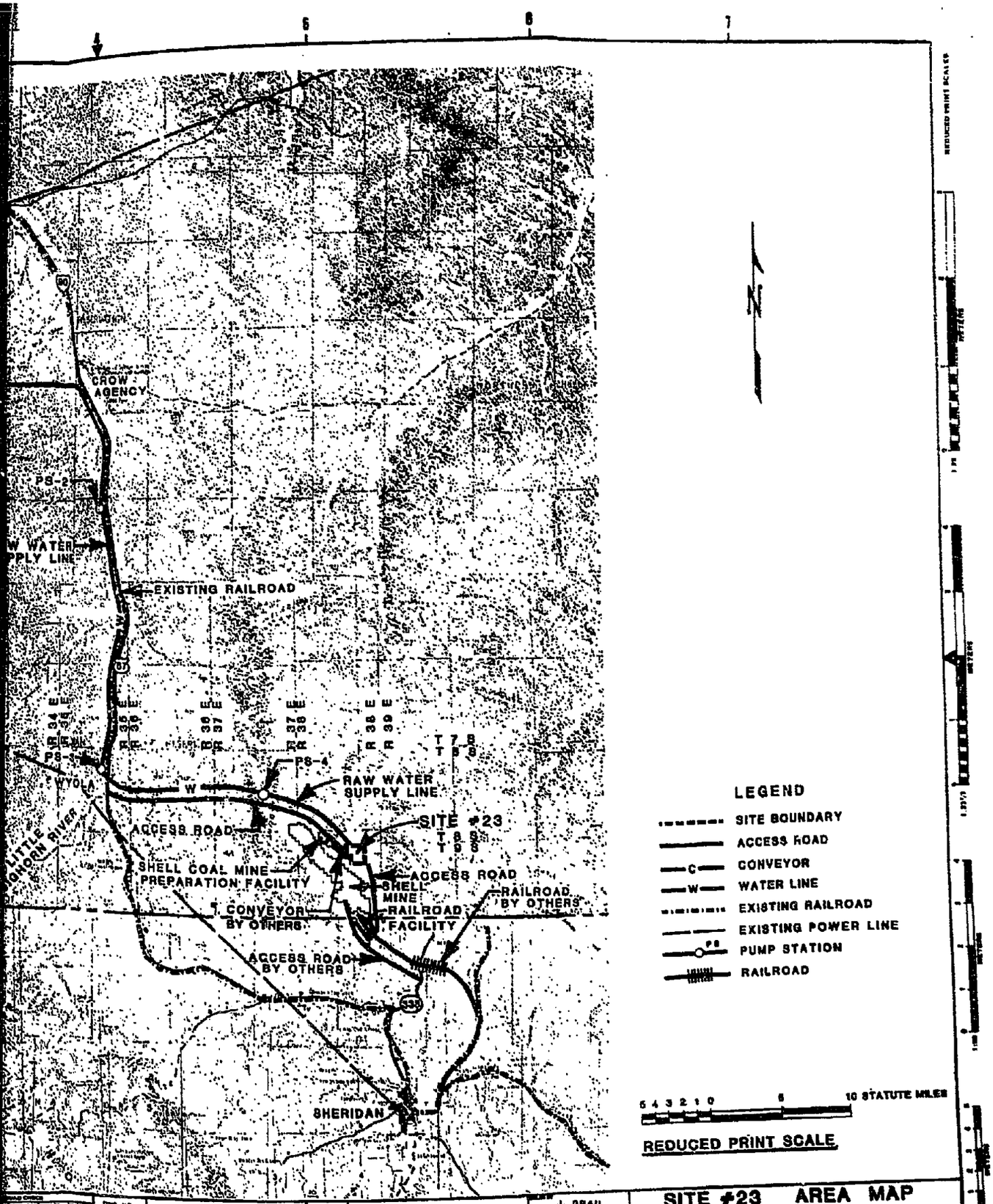
5.2.8.2 Physiography and Natural Drainage

The site is situated on a high plateau with a mild grade over the site of about 2-1/2 percent sloping to the east. The average elevation over the site is approximately 4380 feet. The maximum elevation of 4400 feet occurs in the westerly portion of the site while the minimum elevation of 4300 feet occurs along the easterly plant boundary.

The site is bounded on the north, south and west by very steep slopes which limit the available area of the plant. East of the Crow Indian Reservation boundary, the plateau continues at a gradual slope. A prominent ravine projects about 1800 feet into the northerly portion of the site.



USE OR DISCLOSURE OF ABOVE DATA IS SUBJECT TO THE RESTRICTION ON THE NOTICE PAGE AT THE FRONT OF THIS REPORT



DWG. NO.	REFERENCE DRAWING
00-5-082	VICINITY MAP

FLUOR

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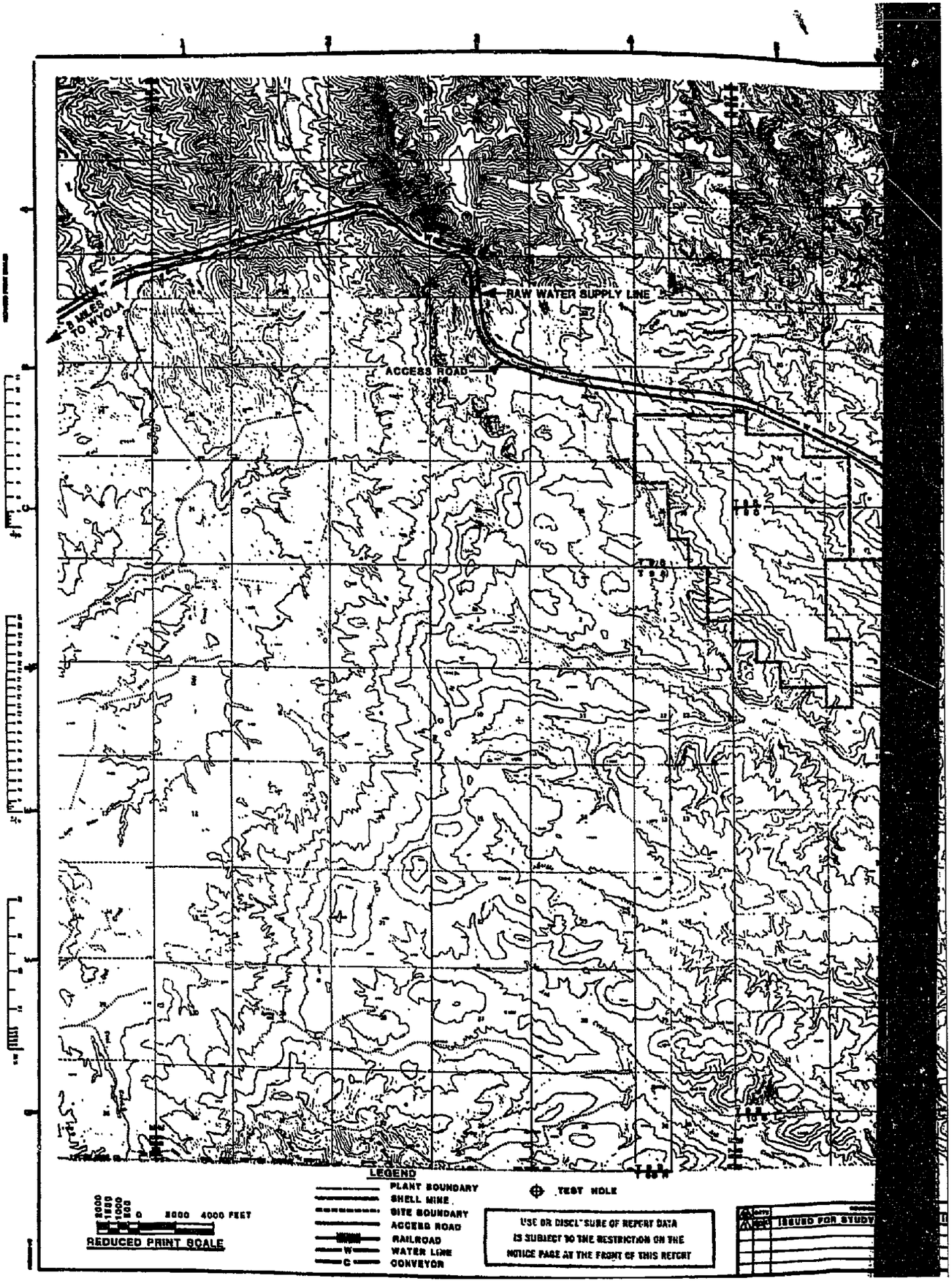
J. GRAU	
M. DORIN	
S. QUINONES	7/31/82
M. DORIN	
R. LANG	

SITE #23 AREA MAP

SYNFUELS FEASIBILITY STUDY

CROW TRIBE OF INDIANS MONTANA

SCALE	DRAWING NUMBER	REVISION
1:250000	835704-00-4-081	1


RAW WATER SUPPLY LINE
8 MILES TO WYOLA
ACCESS ROAD
LEGEND
PLANT BOUNDARY
SHELL MINE
SITE BOUNDARY
ACCESS ROAD
RAILROAD
W WATER LINE
C CONVEYOR
TEST HOLE
0 2000 4000 FEET
REDUCED PRINT SCALE
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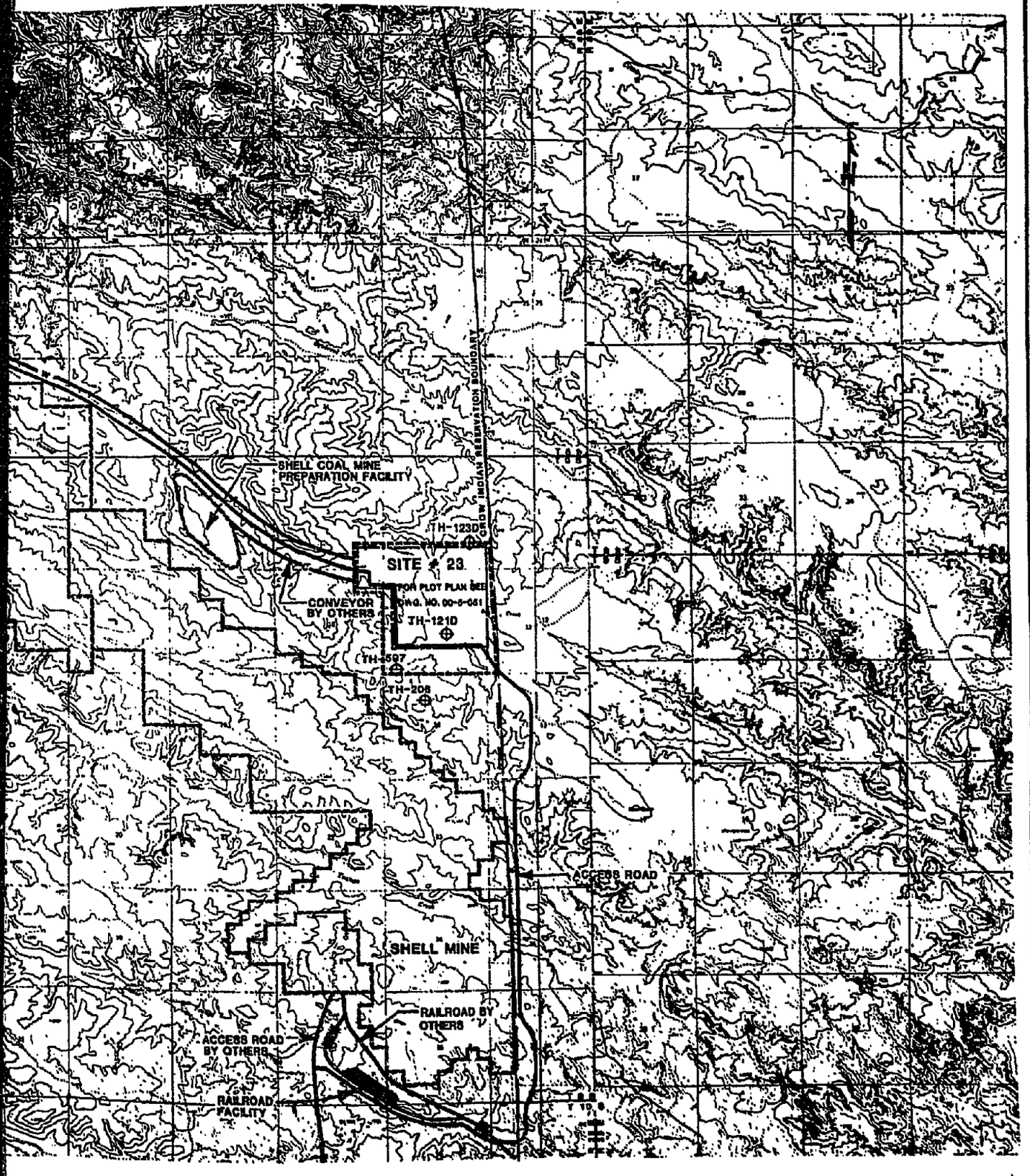


ISSUED FOR STUDY

00-A-001 AREA MAP
00-5-001 PLOT PLAN

FLUOR

SITE # 23 VICINITY MAP
SYNFUELS FEASIBILITY STUDY
CROW TRIBE OF INDIANS MONTANA
1" = 2000' 836704-00-5-002 1

5.2.8.2 (Continued)

The predominant direction of runoff across the plant site is from west to east. The natural drainage around the site is generally in a direction away from the site. The drainage is intercepted by Squirrel Creek located to the north, Tanner Creek located to the south, and Dry Creek located to the east. These creeks flow in an easterly direction and drain into the Yellowstone River, which flows into the Missouri River.

5.2.8.3 Geotechnical Data

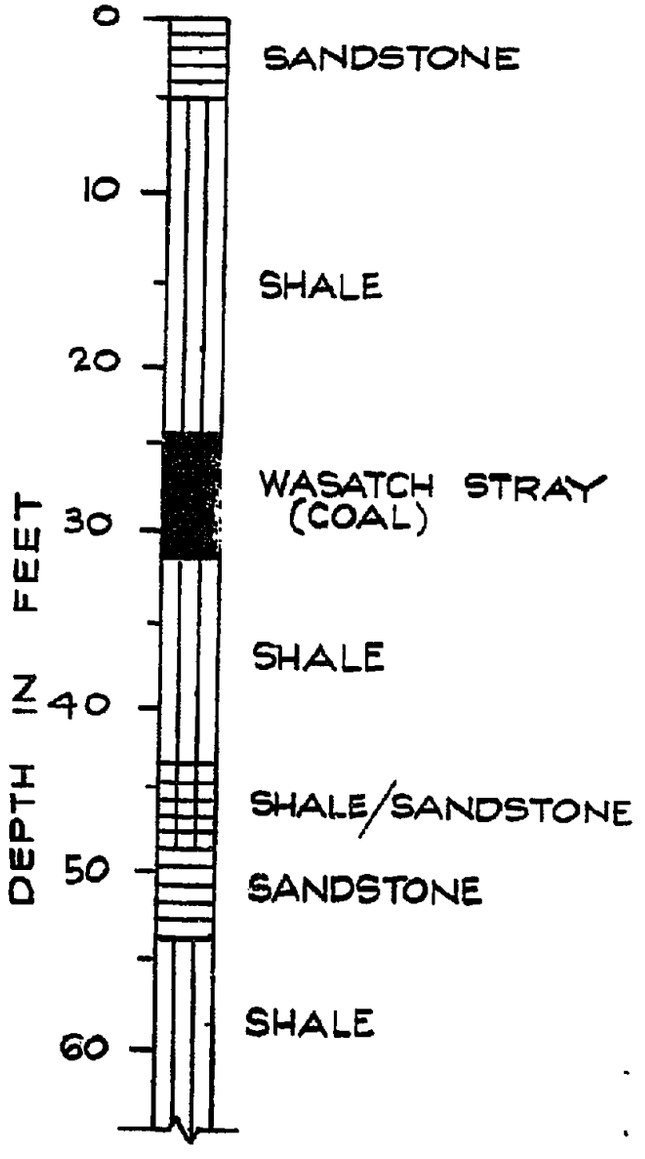
During 1975 and 1981 test holes were drilled in the area of the Shell mine for the purpose of mine evaluation and planning. This was performed for the Shell Oil Company. The test holes were deep drillings of up to 600 feet in depth. No other soils data from any other test borings is known to exist.

The locations of the test holes within and near Site 23 are shown on the Vicinity Map, Drawing 835704-00-5-082. Summary logs of the test holes are shown on Drawing 835704-00-2-109.

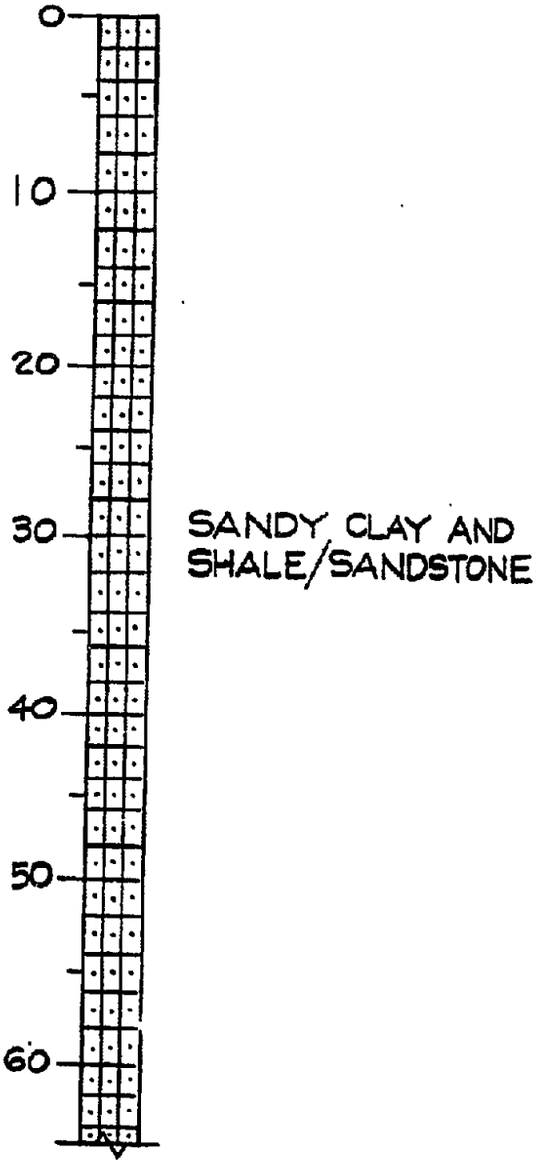
Test hole 121D, which is located in the southern portion of the site, indicates that the upper 65 feet is composed of sandy clay, sandstone and shale. This is underlain by a 12 foot layer of the Wasatch Formation. This formation is chiefly yellowish gray, friable, fine-grained sandstones with interbedded shales. The Wasatch Formation is founded on layers of shale and sandstone. The remainder of the test hole is composed of alternating sandstones, shales, clay materials and stray coal seams.

LOGS OF TEST

TEST HOLE-123D
GRD. ELEV. 4358



TEST HOLE-121D
GRD. ELEV. 4371

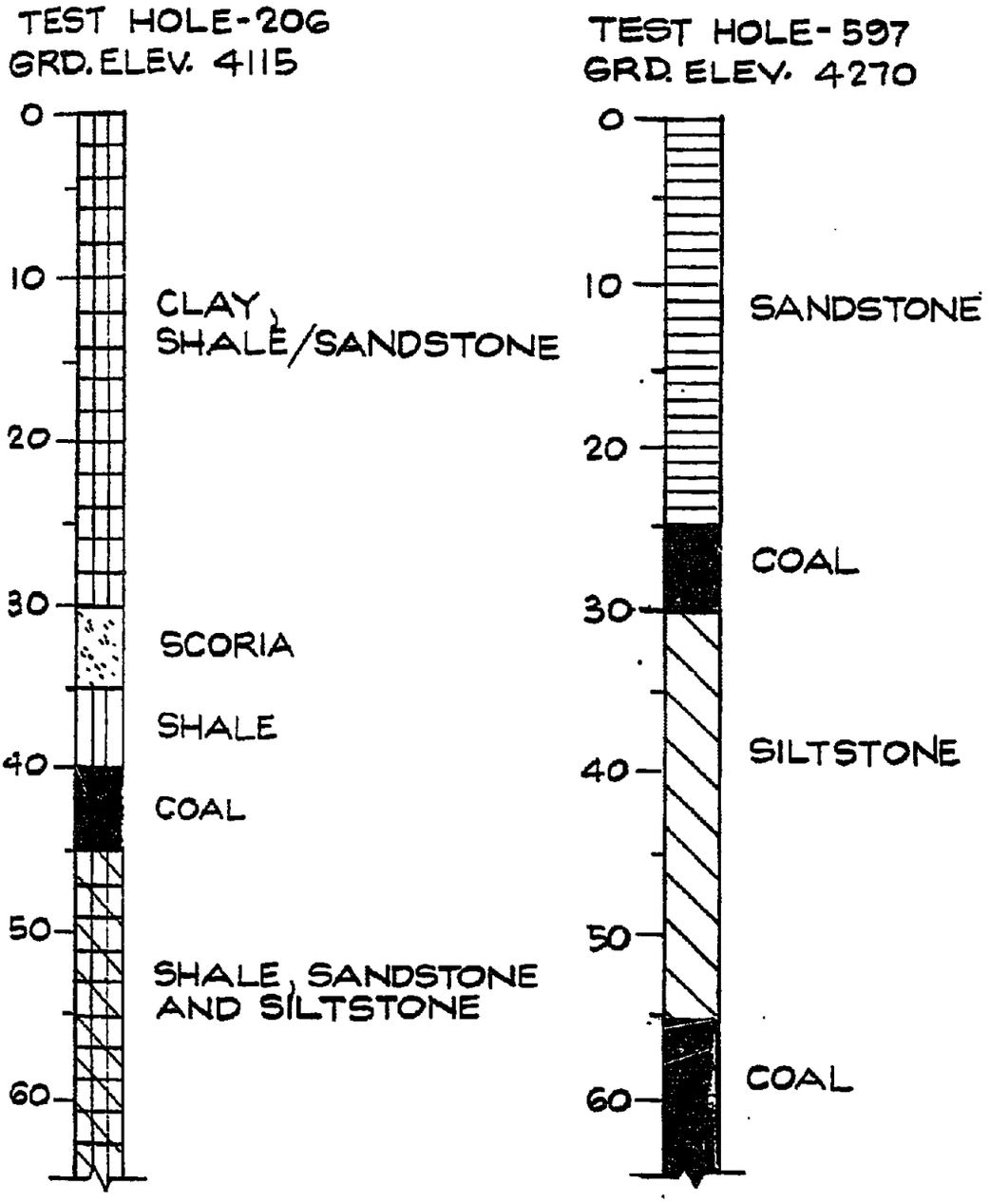


SOURCE: SHELL OIL COMPANY

NO.	DATE	REVISION DESCRIPTION		
1	6/3/82	ISSUED FOR STUDY	L.C. DRAWN / CHECK	6/3/82 DATE

FLUOR

TEST HOLES



AND
TONE

FLUOR

DRAWN BY: L. CUEVAS			
CHECKED BY: M. DORIN			
SUPERVISOR: A. QUINONES	RELEASE DATE: 6/3/82		
SUPERVISING ENGR.: M. DORIN	INITIALS: M. Dorin		
PROJECT ENGR.: R. LANG	APP. DATE: RAL 6/3/82	SCALE: 1"=10 FT.	DRAWING NUMBER: 835704-00-2-109
CLIENT	APP. DATE		REVISION: 1

SITE #23 SUMMARY LOGS OF TEST HOLES

SYNFUELS FEASIBILITY STUDY

CROW TRIBE OF INDIANS — MONTANA

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5.2.8.3 (Continued)

Test hole 123D, which is located on the plant northernly boundary, indicates that the upper 5 foot layer is composed of sandstone and is underlain by a 20 foot layer of shale. The next layer is composed of 6 feet of the Wasatch Formation. The remainder of the test hole is composed of alternating sandstones, shales, clay materials and stray coal seams.

Test hole 206 is located southerly of the plant and indicates that the upper 30 foot layer is composed of clay, sandstone and shale. This is underlain by thin layers of scoria, shale and coal. The remainder of the test hole is composed of alternating sandstones, shales, clay materials and stray coal seams.

Test hole 597 is located southwesterly of the plant site and shows that the upper 25 foot layer is composed of sandstone. This is underlain by a thin 5 foot layer of coal. The next layer is composed of a 25 foot layer of siltstone followed by a 10 foot layer of coal. The remainder of the test hole is composed of alternating sandstones, shales and coal seams.

The stray coal seams present beneath Site 23 are not of economic importance because of the deep overburden, the thinness of the coal seams, and the intermixing of the coal with other soils.

5.2.8.4 Existing Onsite Structures

There are no known existing above grade or below grade onsite structures.

5.2.8.5 Existing Roads

There are no existing paved roads in the immediate area of the site as indicated on Drawing 835704-00-5-082. The nearest highways are Highway 87 to the west and Highway 338 to the south. Highway 87 runs along an existing railroad in a north-south direction connecting Lodge Grass, Montana with Sheridan, Wyoming. Highway 87 also spans the uncompleted length of Interstate 90 between the two cities. Highway 338 runs in a northeasterly direction branching from Highway 87 north of Sheridan.

A new road is to be constructed by the Shell Oil Company to connect the mine with Highway 338.

There will be two separate plant access roads connecting the site with the existing highways.

5.2.8.6 Existing Railroad

The existing Burlington Northern rail lines in the region are shown on the Area Map, Drawing 835704-00-5-082. The existing rail lines serve Billings, Montana; Hardin, Montana; and Sheridan, Wyoming. The mainline parallels Interstate 90 and Highway 87. An existing spur track branches to the north from the mainline near Sheridan.

A new railroad is to be constructed by the Shell Oil Co., the mine operators, from the existing spur track to the site. A railroad facility serving Site 23 will be constructed at the southerly end of the Shell mine.