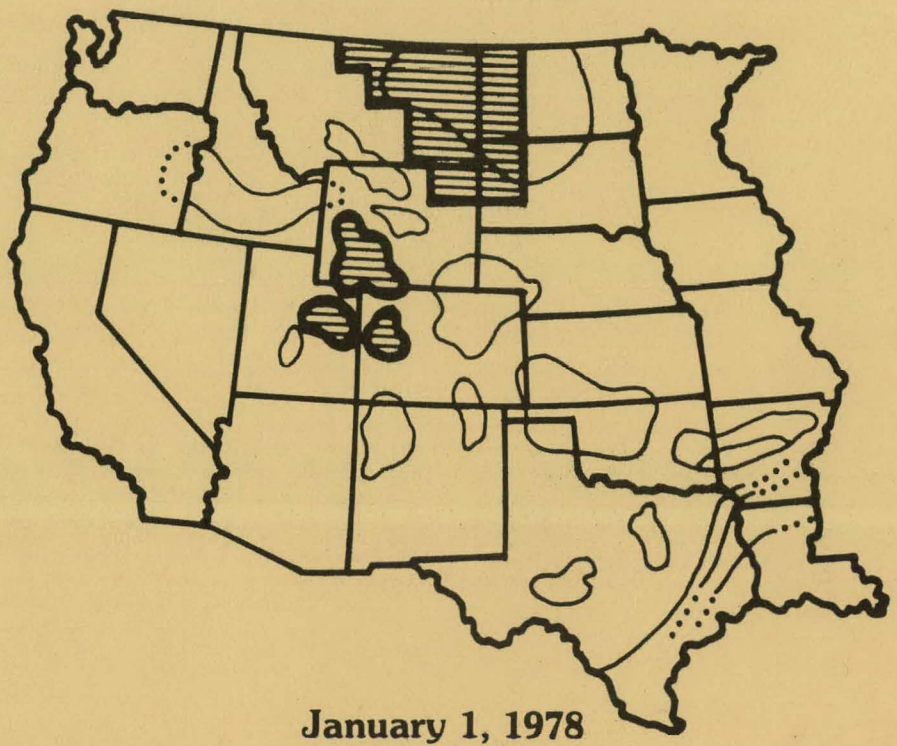
NVO/0655-103

Western Gas Sands Project Status Report



January 1, 1978

Prepared for
U.S. Department of Energy

Bartlesville Energy Research Center
Charles H. Atkinson
Project Manager

Compiled by CER Corporation
Las Vegas, Nevada

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1. SUMMARY

This issue of the Western Gas Sands Project Status report compiles information on many of the activities which have been and are being undertaken in the low permeability gas sands of the western United States.

Meetings with technical people in Bartlesville Energy Research Center (BERC) and United States Geological Survey (USGS) during November, established some of the requirements necessary for the Western Gas Sands Project Coring Program. A coordinating meeting is scheduled for January 25, 1978 at CER Corporation's office in Las Vegas, Nevada.

The Western Gas Sands Project Implementation Plan, Project Plan Document FY 78, and the Quarterly Basin Activities report are in various stages of preparation.

Resource assessment by the USGS is continuing. Some base maps are completed and others are being prepared. Core from the Book Cliffs area has been made available to USGS for study and core sampling from the northern Green River Basin is continuing with fourteen additional samples submitted for paleoanalysis.

Research and Development by Energy Research Centers and National Laboratories funded by the Department of Energy (DOE) is continuing. These activities are directed toward the development of new tools and instrumentation systems, rock mechanics, mathematical modeling and data analysis.

The field tests and demonstrations being carried out in the Uinta and Piceance Basins are:

Gas Producing Enterprises (GPE)	Natural Buttes No. 14, 18, 19, 20, 21 and 22
Mobil Research and Development	F-31-13G
Rio Blanco Natural Gas	498-4-1

Colorado Interstate Gas (CIG) is preparing to commence field activities in January, 1978 in the Wattenberg Field of northeastern Colorado.

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2. PROJECT MANAGEMENT

Meetings with technical people in BERC and USGS during November established some of the requirements necessary for the Western Gas Sands Project Coring Program. Additional information was obtained in December. A coordinating meeting, scheduled for January 25 will be held at the CER office in Las Vegas. The meeting will establish priorities for the use of an anticipated limited supply of core.

The proposal from Mitchell Energy Company has been reviewed and contract negotiations are pending.

The Project Plan Document FY 78 is being reviewed and will be published early in FY 78. Work is continuing on the Project Implementation Plan.

Information covering the Western Gas Sands Project activities in research and development work in fossil energy technology was furnished to the Department of Energy for their 1977 Fossil Energy Program Report. The Quarterly Report on Basin Activities is in the final stages of preparation and work has started on the status report dated February 1, 1978.

Progress is being made on the establishment of the project files containing the available raw data and published reports on each Western Gas Sands Project contractor task.

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3. RESOURCE ASSESSMENT

Resource assessment includes geological and geophysical studies to understand the resource base. The majority of the resource assessment work is being performed by the USGS. Other activities, however, provide data input and support to their work, primarily in the area of field tests, obtaining core samples, and special core tests.

3.1 U.S. Geological Survey Activities

U.S. Geological Survey activities follow:

Uinta-Piceance Basin:

a) USGS is working with USGS Conservation Division to obtain cores in Lower Mesaverde of southern Piceance Basin.

b) Some low permeability reservoir bearing units from eastern Uinta Basin to central Wasatch Plateau have been traced. Many of the units may contain oil and/or gas in some regions along the trace of this section.

c) The construction of a chart of Upper Cretaceous and Lower Tertiary rocks exposed at Price River Canyon in southwest Uinta Basin, Utah began. The chart will illustrate results of X-ray, palynomorph, microfossil, macrofossil, petrographic, and environments of deposition studies. These units are similar to beds containing low permeability reservoirs in the Uinta and Piceance Basins.

d) Core from the Book Cliffs area was made available to USGS by a coal company. The core represents a continuous interval from the Paleocene through much of the Upper Cretaceous section.

Greater Green River Basin:

a) USGS is continuing correlation of a log cross section network.

b) 1:250,000 base maps are being prepared.

c) Approval has been secured from Forest Oil to do a hydrocarbon source-bed thermal maturation study on a wildcat well (T22N, R106W) in Sweetwater County, Wyoming.

d) The Washakie Basin log cross section is in review for open-filing.

e) The sampling of cores from the Northern Green River Basin is ongoing.

f) Fourteen additional core samples have been submitted for paleoanalysis.

Northern Great Plains Province:

a) The Administrative Report No. 3 has been prepared and is entitled "Basic Data Tabulation, Tertiary and Cretaceous Oil and Gas Fields of Montana, North and South Dakota" by W.W. Mallory.

b) The following abstracts are in preparation:

"Upper Cretaceous Paleotectonic Activity Related to Lineaments in Western South Dakota" by G.W. Shurr.

"Paleotectonic Controls on Upper Cretaceous Sedimentation and Potential Gas Occurrences in Western South Dakota" by G.W. Shurr.

c) The following open-file report is in preparation:

"Landsat Lineaments in Western South Dakota" by G.W. Shurr.

d) USGS has acquired three enhanced Landsat images for north-central Montana from EROS. These will be used for lineament analysis.

3.2 Coring Program

The USGS has recommended several coring sites in the Northern Great Plains Province and the Uinta Basin where cores are needed for improved resource assessment.

Basin drilling activities are being monitored for wells being drilled in these same areas so that coring can be arranged.

The core aquisition and analysis program is progressing. Core requirements and analysis capabilities of the participating laboratories have been received and a meeting with representatives from BERC, USGS, LLL and Sandia is scheduled January 25, 1978, at CER's office to establish procedures and priorities.

3.3 Study of Basin Activities

Monitoring of the drilling and testing activities in the four main study areas is continuing. Figure 3-1 shows the four areas with recent wells

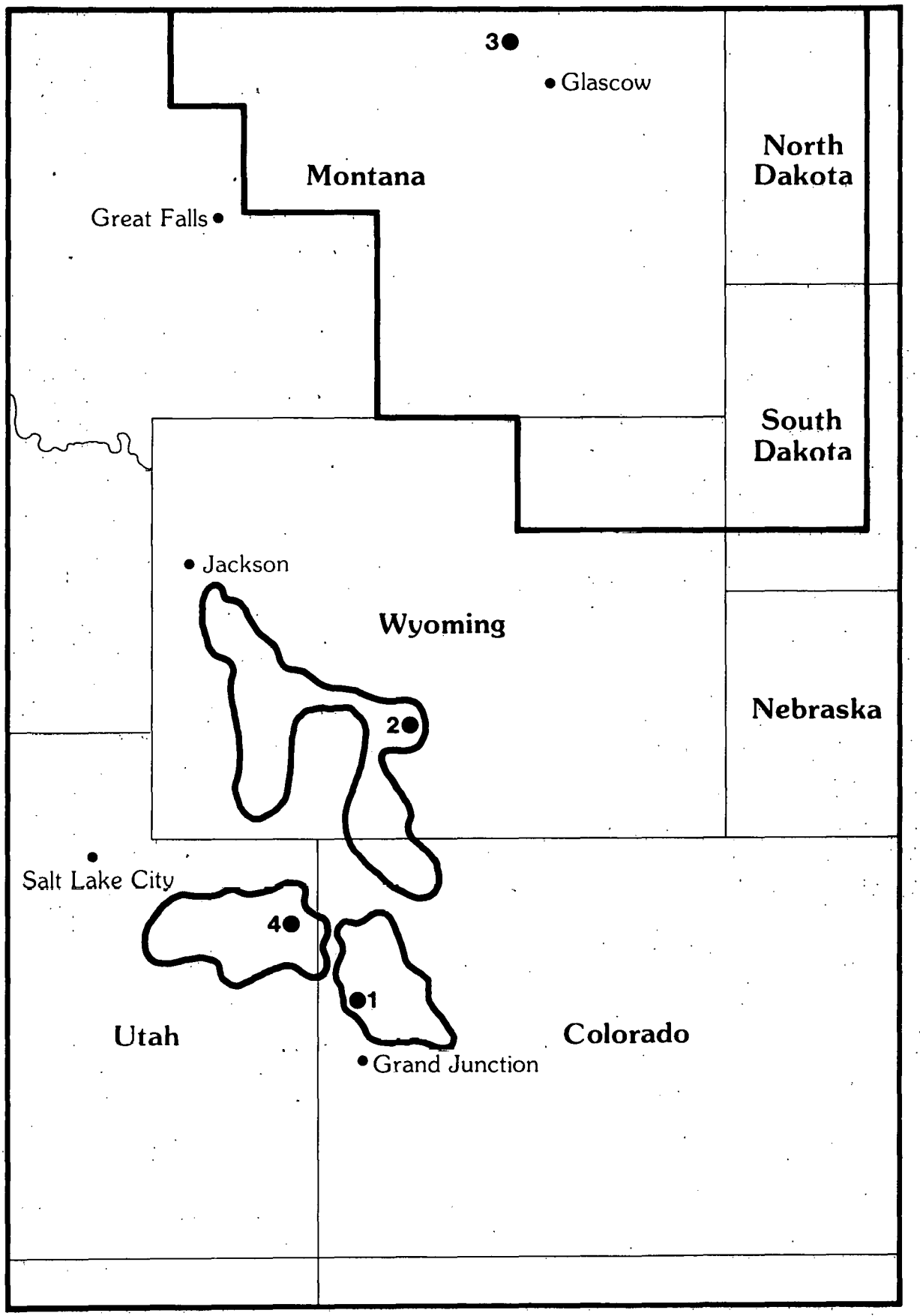

FIGURE 3-1 TARGET BASINS WITH WELLS OF INTEREST LOCATED

of interest to the WGSP located by numbered callouts. The following is a brief resume of the study area activities. A detailed quarterly report on each area is in the final stage of preparation.

3.3.1. Piceance Basin

Activity in the Piceance Basin is concentrated in Rio Blanco County, Colorado with the main objective being the Mancos Zones. Currently in Rio Blanco County there are about 50 ongoing Mancos tests. An American Resources Management well is producing 800 MCFD from the Mancos Zone; utilizing a 220,000 lb sand fracture (callout 1).

Significant gas fields in the Piceance Basin include Plateau and Powder River Fields, Mesa County, and Dragon Trail, Lower Horse Draw, Trail Canyon, South Douglas Creek, Thunder and Cathedral Fields, Rio Blanco County. Presently, there are 26 Mancos tests scheduled in the Cathedral Field.

3.3.2 Greater Green River Basin

Activity in the Greater Green River Basin is mostly in the very productive Sweetwater County. Significant activity is also evident in Carbon, Sublette and Lincoln Counties. The main objectives are the Mesaverde and Frontier Zones. Sweetwater County represents the most extensive testing of the Mesaverde Group. Currently the county has about 65 Mesaverde tests ongoing. Amoco has a well in Sweetwater County with an initial production of 1,003 MCFD from the Mesaverde. The well was sand and emulsion fractured and represents a new field discovery for the Mesaverde (callout 2).

Lincoln, Sublette and Sweetwater Counties all have a significant number of tests in the Frontier. The entire Greater Green River Basin has about 53 Frontier tests in various stages of development.

3.3.3 Northern Great Plains Province

Activity is concentrated in the northern area of the Northern Great Plains Province in the Bowdoin Dome of Phillips and Valley Counties and the Bear Paw Arch of Blaine, Chouteau and Hill Counties.

In Phillips County, Joseph J.C. Paine and Associates have a well in an unnamed field with commingled Bowdoin, Greenhorn, and Phillips production. The well was fractured with 70,000 lbs of sand and the initial production was 2,604 MCFD (callout 3).

Gas Producing Enterprises has abandoned 13 locations in Laredo Field, Hill County. All the locations were scheduled for Eagle tests.

Jerry McCutchin has set pipe to 2,000 ft at a Shannon test in South Dakota's Harding County. The McCutchin gas discovery completed last month for 980 MCFD has lead to the scheduling of 3 rigs to begin drilling. Severe cold weather has slowed operations thus far.

3.3.4 Uinta Basin

Activity of concern to the Western Gas Sands Project in the Uinta Basin is almost exclusively in the Natural Buttes Unit of Uintah County, Utah. The major objective is the Wasatch Formation. Belco Petroleum has a well in the Natural Buttes Field with an initial production of 3,560 MCFD from the Wasatch. The well was sand and emulsion fractured (callout 4).

CALLOUTS

Callout 1

American Resources Management
1-3 Trail Canyon
Sec 1, T4S, R101W
Rio Blanco County, Colorado
Mancos Production (3,300 - 3,530 ft)
Development Gas Well
Frac: 220,000 lbs of sand
IPF: 800 MCFD

Callout 2

Amoco Production
1 Champlin 272 Amoco A
Sec 11, T21N, R90W
Sweetwater County, Wyoming
Mesaverde Production (12,970 - 13,130 ft gross)
Mesaverde Discovery - New Field
Frac: 5,880 BBL emulsion, 575,000 lbs of sand plus acid
IPF: 1,003 MCFD, 34 BC

Callout 3

Joseph J.C. Paine and Associates
1-1261 Scott
Sec 12, T36N, R31E
Phillips County, Montana
Commingled production Bowdoin (1,282 - 1,341 ft),
Greenhorn (1,491 - 1,495 ft),
Phillips (1,524 - 1,543 ft)
Development Gas Well
Frac 70,000 lbs of sand
IPF: 2,604 MCFD

Callout 4

Belco Petroleum
10-29B Natural Buttes Unit
Sec 29, T9S, R22E
Uintah County, Utah
Wasatch Production (5,087 - 6,144 ft gross)
Development Gas Well
Frac: 270,000 gal emulsion, 340,000 lbs of sand
IPF: 3,560 MCFD

4. RESEARCH AND DEVELOPMENT BY ENERGY RESEARCH CENTERS AND NATIONAL LABORATORIES

4.1 Bartlesville Energy Research Center (BERC)

4.1.1 Improved Pressure Coring System

Absorbtion tests were performed using Dow Corning 200 (dimethyl siloxanegel) in an experimental test cell with saturated and unsaturated sandstone samples. The tests were conducted at 500 psi and 70°F. The dry sandstone absorbed the same amounts of gel and water but the saturated sandstone absorbed only 0.02 percent gel, indicating very little invasion. A new experiment is being conducted to determine gel penetration depths when the water saturated rock is subjected to pressure gradients of about 300 to 500 psi.

A small stratapax core bit (1-7/8 in. inside diameter) has been obtained for lab testing in a vertical milling machine. Plans to test this bit with the test gel being displaced by the core have been made. The amount of invasion and chip removal efficiency will be determined.

Preliminary design work for the core barrel has been started.

4.1.2 Interface Conductivity Effects on Electric Logs

A Hewlett Packard 4262A Digital LCR meter has been ordered for the conductivity measurements. The instrument's bridge automatically balances, and operation can be remotely controlled through a standard IEEE-48 interface.

A pressure vessel has been obtained which is suitable for resistivity measurements at high temperature and pressure. The preliminary design for an initial pressure control system has been completed. The system will allow the pore pressure build-up to lag the applied overburden pressure by a set pressure difference. The overburden pressure will be applied using a hand operated hydraulic pump. An analog controller having a Consta-Metric II pump as an actuator will be used to maintain the desired pressure difference.

4.1.3 Mapping and Contouring Formation Water Resistivity

Geologic background information in the form of maps and published reports has been received. Base maps of the Uinta Basin with well locations have been received and distributed. A search for data on cored intervals and water analysis has been completed by Petroleum Information (PI), Denver.

4.1.4 Logging Techniques and Interpretations

A proposal from Texas A & M to study density, neutron and acoustic measurements on cores recovered in the Western Gas Sands Project is under consideration. This involves the study of acoustic, density and neutron logs of western tight gas sands for an improved understanding of the interpretation techniques and for their application to specific formations.

A survey and critique of techniques to measure water resistivity has been proposed by Sandia and is under consideration.

4.1.5 Rock-Fluid Interaction

Review of material found in the literature search has continued. Laboratory equipment and techniques described in similar work have been considered from current literature. These will be assembled into a review.

Fabrication of a thick-walled pressure vessel and end plugs for operation in the 2,000 to 6,000 psi range has been completed. Two Milton-Roy pumps have been ordered and a Coleman Magnetic pump operating up to 20,000 psi has been obtained.

During the next month available equipment will be assembled to initiate some preliminary frac-fluid flow experiments.

4.2 Lawrence Livermore Laboratory

4.2.1 Theoretical Model Development and Application

The initial development of the hydraulic fracturing models was pursued with the simplest, most straightforward programming of the defining equations in the computer models. This procedure was followed to test the various concepts to be included in the models since the hydraulic fracturing process had not previously been modeled with this degree of completeness. This procedure allowed testing of various numerical solution schemes and the incomplete Cholesky solution scheme was found to be the most acceptable for the elastic matrices. These initial models provided solutions, which when compared with available analytic solutions, indicate that the basic concepts of the models have been correct. However, recent calculations have also shown that the boundaries of the calculational mesh can significantly alter the results. A numerical model cannot normally be used to simulate the entire continuum. Artificial boundaries are therefore a normal consequence of numerical continuum models. These boundaries are usually placed as far from the region of interest as possible, subject to the constraints of computer storage and time required for the calculation. In any case, they are placed far enough from the regions of interest so that their effect on the calculation is insignificant.

Obviously, the calculational mesh can be enlarged by increasing the number of zones in the calculation. The number of zones is limited by the computer storage requirements and the computing time. This problem was solved by increasing the zonal size near the boundaries, while retaining the finer zones in the center of the mesh where the detail is required. Consequently, the mesh was enlarged but the number of zones did not increase. During November, the required modifications were developed to allow an expansion of the zonal sizes near the boundaries. These modifications have been programmed into the code and debugged. Some calculations were started to fully test these modifications.

4.2.2 Experimental Program

During the month of November a new high pressure pump system for driving hydraulic fractures was assembled. This system includes a transducer and strip chart recorder for continuous pressure monitoring. A system of presses was also modified for the purpose of measuring coefficients of friction between rock surfaces.

Brazil tensile tests were performed on Nugget sandstone to measure tensile strengths parallel and perpendicular to bedding planes. It was found that the mean tensile strength parallel to bedding was approximately 76 bars while the mean tensile strength perpendicular to (across) the bedding was approximately 53 bars.

4.2.3 Reservoir Analysis

Mobil Research and Development Corporation has supplied the results of buildup tests conducted on three zones near the 10,000 ft depth in Piceance Creek Unit Well F31-13G. Three tests were conducted on each zone; before formation breakdown, after breakdown, and after hydraulic fracturing. The data from these nine tests appear to be of good quality, and presently, an attempt is being made the match the data through computer modeling in an effort to obtain fracture length and conductivity.

4.2.4 Other Activities

LLL has submitted two abstracts as candidates for presentation at the 19th Annual U.S. Rock Mechanics Symposium at Lake Tahoe, scheduled in May 1978. These abstracts discuss research findings from the Laboratory's Gas Stimulation Program.

4.3 Sandia Laboratories

4.3.1 Hydraulic Fracture Mapping

4.3.1.1 Natural Buttes No. 22

Sandia Laboratories (Division 5733) participated in a MHF experiment on Gas Producing Enterprises' Natural Buttes No. 22 southeast of Vernal, Utah. The fracture was performed by Dowell on November 21, 1977. Fractures were created through perforations at depths between 5,800 ft and 8,500 ft. A total of 13,035 BBL of fluid was pumped at a rate of approximately 50 BPM.

Surface potential measurements were taken at two-minute intervals during the operation. Extremely rugged terrain prevented potential measurements in a 75^{o} sector.

Data analysis will be initiated upon return of the trailer from Utah to Albuquerque, New Mexico. These results will be available in December.

4.3.1.2 NTS Mineback - Seismic Data Analysis

On November 30, a meeting was held at Sandia with Kei Aki, MIT; Mike Sorrels, Teledyne-Geotech; and Tom Dobeki, George Griswold and Robert Seavy from Sandia to present details of the seismic monitoring of the August 1977 NTS hydrofracture. Analog records of some of the seismic fracture signals were examined. Drs. Aki and Sorrels were impressed with the quality of the seismic signals and both felt that a great deal of information could be obtained by analysis of the data, including the possibility of obtaining a model which represents the fracturing mechanism. Dr. Aki does have some thoughts on fracture models and the data does not contradict his initial ideas.

4.3.2 Mineback Stimulation Test Program

The reduced pressure and flow rate data for the second fracture of the Hole 6 "Interface" Experiment have been obtained. On October 20, 1977, the densest section of the welded tuff was broken down with 30 BBL of water and the fracture was propagated with 5,000 gal of blue grout. Injection rate, wellhead pressure and bottom hole pressure were recorded during fracturing using an Amerada bomb and Hewlett Packard (HP) transducer.

The correlated data for the breakdown are shown in Figure 4-1. The apparent breakdown occurring at 1220 hrs was immediately shutdown due to a leak at the wellhead. When pumping resumed at 1234 hrs, a second possible breakdown spike was recorded. Afterwards, pumping continued for 8 minutes during which time 30 BBL of water were injected. The instantaneous shut-in pressure was on the order of 500 psi. Figure 4-2 shows the correlated data for fracture propagation. From 1331 to 1336 hrs, an attempt was made to fill the well bore with water. Once pumping commenced, the fracture extension pressure increased from about 600 psi

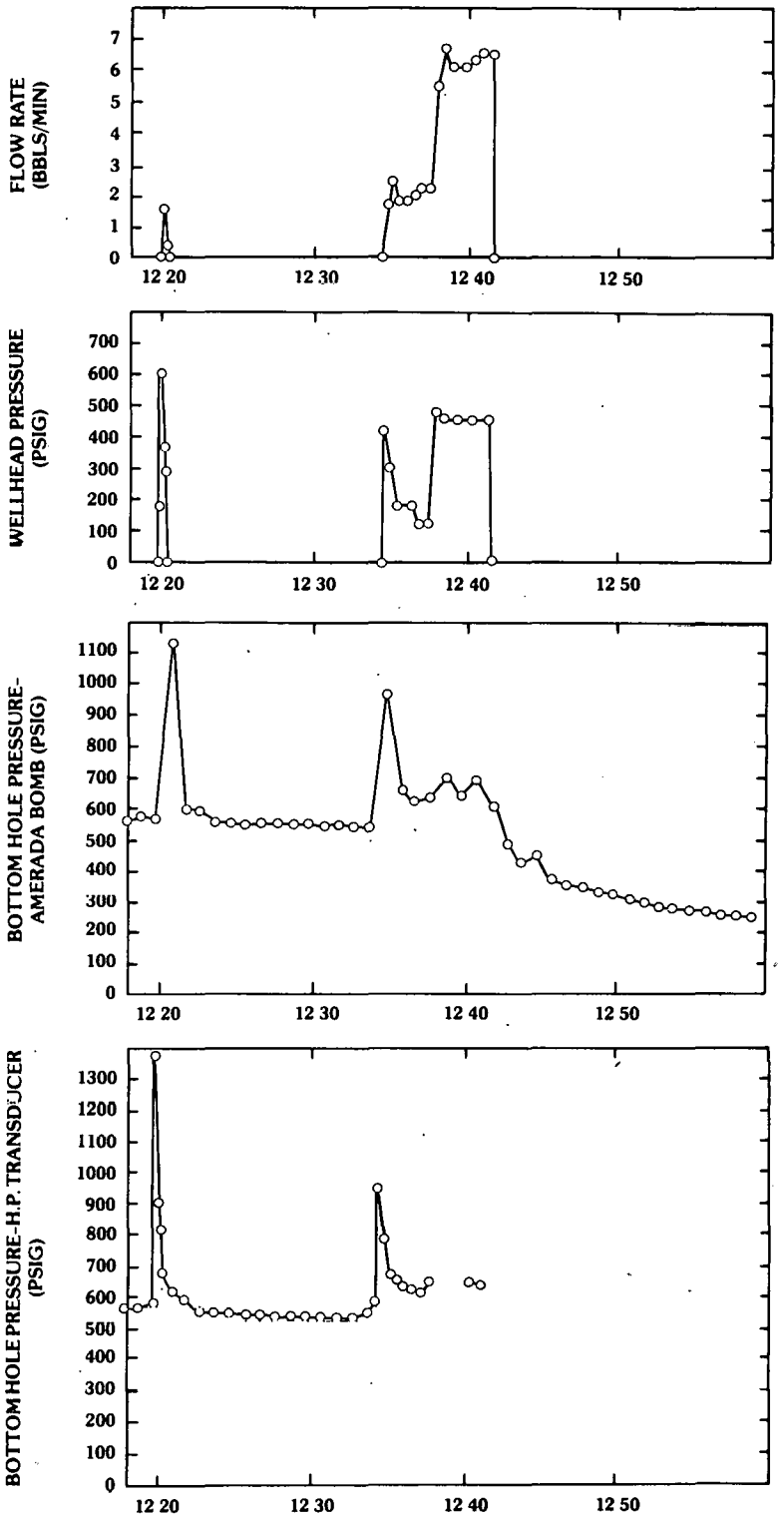

FIGURE 4-1 FRACTURE DATA DURING BREAKDOWN. UPPER FRAC, HOLE 6 INTERFACE EXPERIMENT (OCTOBER 20, 1977).

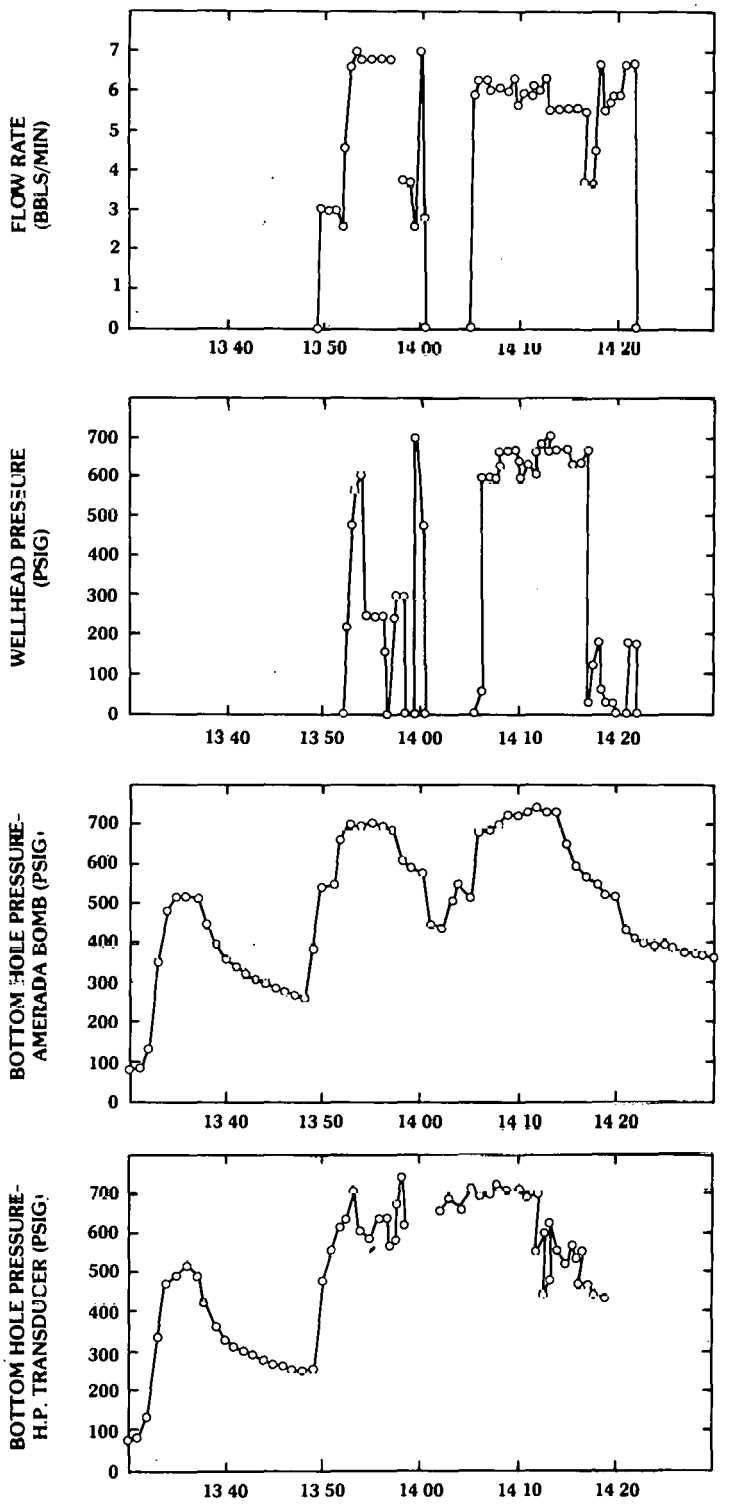

FIGURE 4-2 FRACTURE DATA DURING FRACTURE PROPAGATION. UPPER FRAC, HOLE 6 INTERFACE EXPERIMENT (OCTOBER 20, 1977).

to 700 psi, except for the shutdown at 1400 hrs which was due to another leak at the wellhead. The instantaneous shut-in pressure was about 450 psi. Breaks in the data indicate loss of signals from the HP transducer and the flow meter.

The bottom hole pressure data of Figure 4-2, and the pressure data of the ash fall zone indicate that neither fracture broke out of the zone in which it was initiated. Mineback operation, which will provide the final answer, has reached location CS 3 + 18, shown in Figure 4-3. This is 60 percent of the distance to UE12g.10 #6. A fault with 6 - 8 ft of vertical displacement was intersected at CS 2 + 47 and, due to this displacement, the mineback is presently proceeding through the lower transition zone of the welded tuff. When the mineback has intercepted the fracture, planning of further in situ stress measurements and material sampling will be initiated.

4.3.3 Mobile Well Test Unit

The mobile test unit needed for testing the experimental wells in the Western Gas Sands Project, consists of the following major pieces of equipment:

A mast truck for installing lubricator and running instruments in the well without a workover rig.

A 10' x 50' trailer which will include the instrumentation, draw works and controls, surface recording equipment, work space and a minimum living facility for the operators.

A generator trailer for supplying power to the test system equipped with one 30 kw and one 90 kw generator.

The mast truck has been completed and the assembly of components continues for the instrument trailer with the expected completion date being February 1, 1978.

The mast truck has a two section hydraulically powered 50 ft telescoping mast with a rated capacity of 15,000 lbs. The unit is also equipped with a small hydraulically powered winch with a 4,000 lbs pulling capacity for raising the lubricator. The unit is mounted on a model C-60 Chevrolet truck bed complete with tool compartments and racks.

Fabrication by Gearhart-Owens is continuing on the draw works and instrumentation trailer. The following instrumentation and equipment is on hand or has been purchased.

PDP 11-10 Computer

Two Electric Generators (30 and 90 kw)

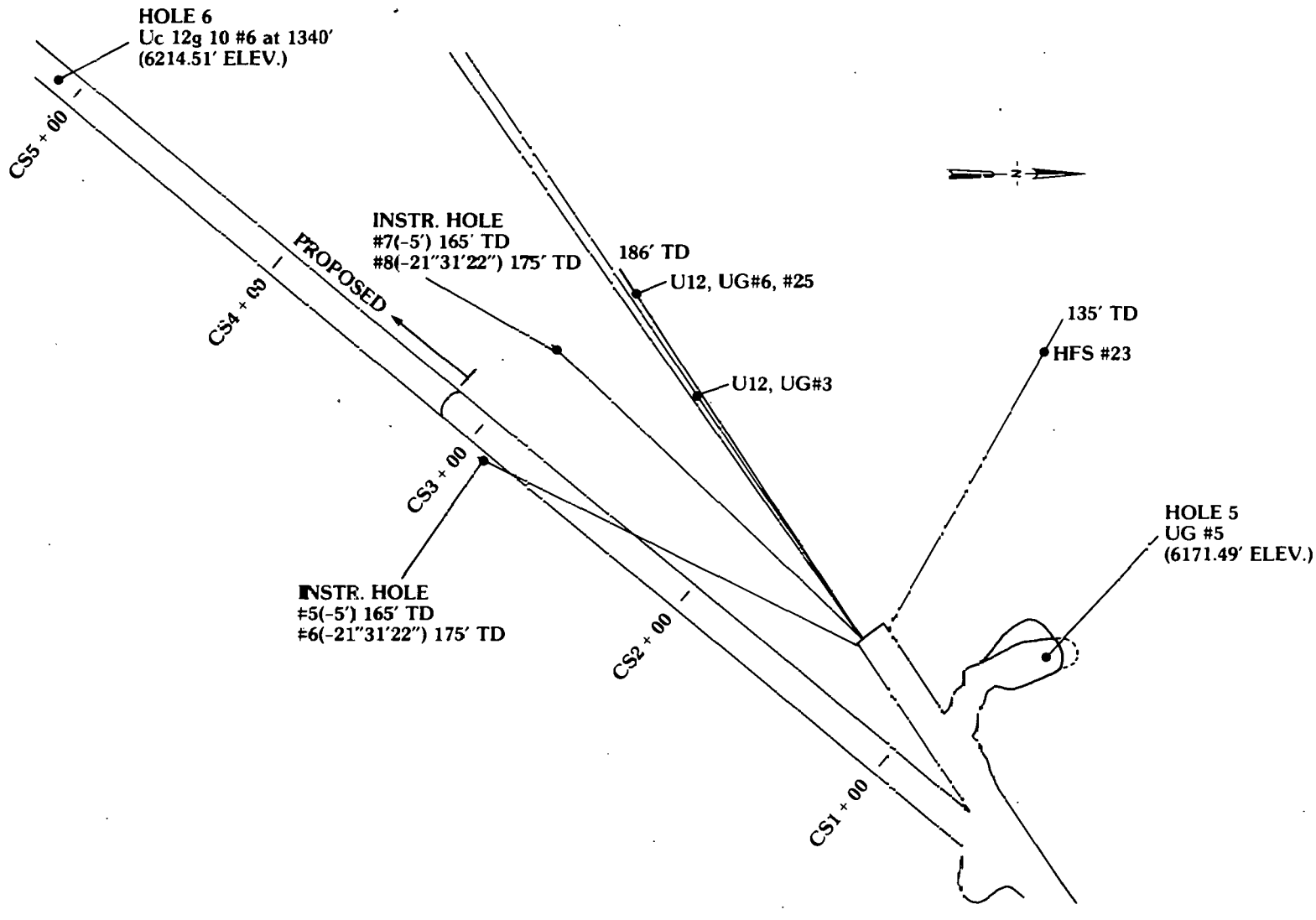

FIGURE 4-3 TUNNEL OPERATIONS, THROUGH NOVEMBER, 1977.

Grease Injection System

Analog Filters

Tape Search and Control Unit

Time Code Generator and Translator

Instrument Signal Amplifiers

Phase - Gain Meter

Calculator

Bank of Discriminators

Bottom Hole Orientation Device

Miscellaneous Electronic Equipment from Sandia Laboratories

The following is additional instrumentation and equipment required.

Temperature Probe

Standby Pressure Gauge

Gas Gravity Meter

Gas Cromatograph

Water Analysis Laboratory

Meter Runs (gas flow rate)

Miscellaneous well head equipment such as pipe fittings, wireline BOP, additional lubricator and various spare parts.

4.3.4 Other Activities

D.A. Northrop, N.R. Warpinski and R.A. Schmidt of Sandia met with R.L. Huggins, R.W. Veatch, M.B. Smith and K.G. Nolte of Amoco in Tulsa, Oklahoma. An update of mineback activities was presented. The primary purpose of the meeting was to further Amoco's involvement in the program. Most discussion focused upon the measurements Amoco thought would be necessary for proper analysis of the mineback results. Details for careful, comprehensive in situ stress distributions, material property measurements, and microscopic examinations were defined. An idea for an in situ, combined fracture toughness and stress measurement made from a well bore was formulated; the idea will be pursued and could be easily tested during mineback operations.

The annual report for Sandia's Enhanced Gas Recovery Projects during FY 77 has been compiled. Final drafts are being prepared for publication in December.

4.4 U.S. Geological Survey (USGS) Borehole Gravity Meter

The new meter has been instrumented by the USGS and is now being bench tested at LaCoste in Austin by USGS personnel.

4.5 U.S. Geological Survey/Menlo Park—Tiltmeter

Hydraulic fracture mapping activity during this period is related to the monitoring and analysis of data from a series of high explosive (HE) fracturing experiments at the Laramie Energy Research Center (LERC). These tilt monitoring experiments were made in support of Sandia's shale rubblization project at the LERC test site.

Results from the first experiment on fracturing and propping indicated a horizontal fracture and uplift as high as 4 mm. A best fit model for a pressurized slit with the measured input parameters, i.e. injection pressure, bulk rock properties, and depth of fracture initiation, indicated that the fracture design was attained. Details of the data indicated a somewhat elliptical pattern with the center of uplift offset from the injection well. This geometry might be related to a superficial natural fracture system.

The objective of the second experiment was to monitor uplift during the injection of HE into the propped fracture. The results indicated no significant uplift or any results comparable with the previous experiments. Detonation of the HE did not occur. Careful review of the data suggested that chances for a successful detonation might be improved if information from real time monitoring of the uplift was made available to the principal investigators in order to modify the injection rates and pressures during the treatment.

The objective of past and present experiments is to dynamically maintain the optimum fracture width necessary for an efficient burn. To achieve this objective, first a calibration experiment with water was performed to provide a comparison with previous results on the relationship between changes in the injection pressure and changes in the tilt response (fracture width). Excellent agreement was obtained between multiple flexures of the fracture and the results from previous experiments.

The volume of water required to initiate response was much larger than for the theoretical fracture initiated by hydraulic treatment. The well was shut-in and the experiment repeated on the following day. Tilt

response to flexure of the fracture was again in excellent agreement with previous experiments. The volume of water required to initiate response was small compared to the previous day's experiment. These two days of monitoring indicated that a significant natural fracture system was in communication with the hydraulically induced fracture. This could, therefore, take on so much of the HE that an acceptable burn might be threatened. The volume of the water pad required prior to gaining favorable uplift for HE injection was determined. Tilt data recorded on the day of the HE injection was in excellent accordance with the injection data and previous experiments. Detonation of approximately 20,000 lbs of HE was successful.

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5. FIELD TESTS AND DEMONSTRATIONS

5.1 Background

There are three active MHF tests in the Uinta Basin in Utah and the Piceance Basin in Colorado. These are experiments in the Upper Cretaceous tight gas sand formations. The organizations involved are:

Gas Producing Enterprises (GPE)	Natural Buttes No. 14, 18, 19, 20, 21 and 22
Mobil Research and Development	F-31-13G
Rio Blanco Natural Gas	498-4-1

The CER Corporation MHF 3 is on inactive status pending satisfactory contractual arrangements to perform additional tests, and for final disposition of the well.

Colorado Interstate Gas Company has been awarded a contract to determine if productivity in low permeability reservoirs can be improved by reducing the interstitial water saturation. They are using two wells, the Sprague No. 1 and Miller No. 1, completed in the Dakota J Formation in the Wattenberg Field in north central Colorado.

The following sections summarize the progress of active projects.

Table 5-1 summarizes the tests and demonstrations that are active in addition to those that have been completed.

TABLE 5-1 MHF CONTRACT LOCATIONS AND FRAC DATA

COMPANY, BASIN AND FORMATION	LOCATION	WELL	INTERVAL FRACTURED	FRAC. DATE	FRAC TREATMENT	FLUID INJECTED
	T / R / Sec		Feet		Lbs. of Sand	10^3 Gal.
AUSTRAL Piceance, Mesaverde	7S, 94W, S3 Garfield Co. Colorado	Federal 3-94	5,170-6,333	8-25-76	1,140,000	542 gel H_2O
CONSORTIUM MANAGED BY CER CORPORATION Piceance, Mesaverde	3S, 98W, S11 Rio Blanco Co. Colorado	RB-MHF-3	8,048-8,078 7,760-7,864 5,925-6,016 5,851-5,869	10-23-74 5- 2-75 5- 4-75 11- 3-75	400,000 880,000 815,000 448,000	117 Gel 285 Gel 400 Gel 228 Gel
GAS PRODUCING ENTERPRISES, INC. Uinta, Wasatch and Mesaverde	10S, 22E, S10 Uintah County Utah	Natural Buttes No. 18	6,490-8,952	9-22-75	1,480,000	745 Gel
	10S, 21E, S21 Uintah County Utah	Natural Buttes No. 19	7,224-9,664	9-21-75 9-28-75	1,053,000	655 Gel
	9S, 21E, S22 Uintah County Utah	Natural Buttes No. 14	6,646-8,004	3-15-77	1,093,000	544 Gel
	9S, 21E, S28 Uintah County Utah	Natural Buttes No. 20	8,498-9,476	6-22-77	826,000	322 Gel
	10S, 22E, S21 Uintah County Utah	Natural Buttes No. 21				
	10S, 22E, S18 Uintah County Utah	Natural Buttes No. 22	6,858-8,550	11-21-77	1,091,000	479 Gel

COMPANY, BASIN AND FORMATION	LOCATION	WELL	INTERVAL FRACTURED	FRAC. DATE	FRAC TREATMENT	FLUID INJECTED
	T / R / Sec			Feet	Lbs. of Sand	10^3 Gal.
DALLAS PRODUCTION Forth Worth, Bend Cong.	Ben D. Smith Survey A-779 Wise County, Texas	Ferguson A-1	5,957-6,794	9-10-76	506,000	139 Foam 198 Emul.
EL PASO NATL. GAS Northern Green River, Fort Union	30N, 108W, S5 Sublette Co. Wyoming	Pinedale Unit No. 5	10,950-11,180 10,120-10,790	7- 2-75 10-20-75	518,000 1,422,000	183 Emul. 8 Gel 459 Gel
MOBIL Piceance Mesaverde	2S, 97W, S13 Rio Blanco Co. Colorado	F-31-13G	10,549-10,680 9,392- 9,534	6-22-77 8-24-77	580,000 600,000	316 Gel 260 Gel
PACIFIC TRANSMISSION Uinta, Mesaverde	8S, 23E, S25 Uintah County Utah	Fed 23-25	NO FRACS PERFORMED			
RIO BLANCO Piceance, Mesaverde	4S, 98W, S4 Rio Blanco Co. Colorado	Fed 498-4-1	6,150-6,312 5,376-5,960	10-22-76 11-30-77	776,000 275,500	276 Gel 4 Gel
WESTCO Uinta, Mesaverde	10S, 19E, S34 Uintah County Utah	Home Fed. No. 1	7,826- 9,437 10,014-10,202	12-21-76 10- 1-76	500,000 600,000	412 Gel 248 Gel

RIO BLANCO MASSIVE HYDRAULIC FRACTURING EXPERIMENT

EY-76-C-08-0623

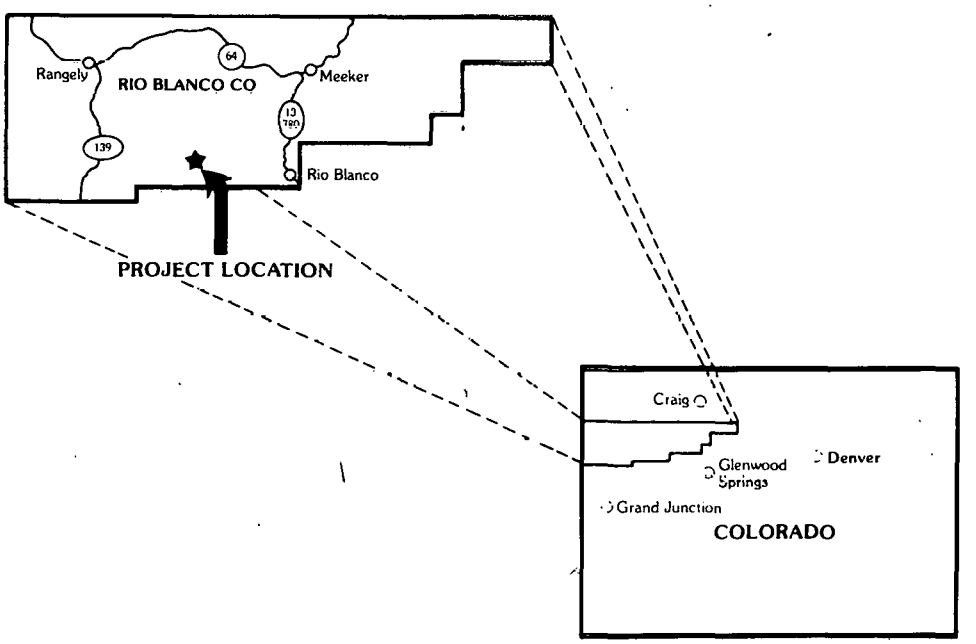
CER Geonuclear Corp.
Las Vegas, Nevada

Status: Awaiting Advisory Committee Decision

Interagency Agreement Date:	June 19, 1974
Project Cost (estimated):	
DOE	$1,975,000
Industry	1,630,000
Total	$3,475,000
Principal Investigator:	G. R. Luetkehans
Technical Advisor for DOE:	Charles H. Atkinson, Bartlesville Energy Research Center

OBJECTIVE

This stimulation experiment is being conducted in low-permeability, massive gas-bearing sandstone reservoirs in the Piceance Basin in western Colorado, to test advanced hydraulic fracturing technology where it has not been possible to obtain commercial production rates. This test is located about 1 mile from the 1973 Rio Blanco nuclear stimulation site to permit comparison of nuclear and hydraulic fracturing techniques in this area.



5.2 CER Corporation

5.2.1 Scope of Work

DOE Contract EY-76-C-08-0623 was signed with CER Corporation in March, 1974. The Rio Blanco Massive Hydraulic Fracturing Project was fielded in 1974 as a joint Industry/DOE demonstration to test the relative formations that were stimulated by the Rio Blanco Nuclear fracturing experiment. The project is essentially a companion effort to and a continuation of the preceding nuclear stimulation project, which took place in May, 1973. Both projects are located in the northern part of the Piceance Basin of northwestern Colorado.

5.2.2 Current Status

The field activities on the MHF 3 well have been curtailed. Any further action is dependant upon completion of satisfactory contractual arrangements with an outside party to complete the comingling of the fractured gas zones and perform additional testing in return for the well and subsequent gas production.

WATTENBERG FIELD

EY-77-C-08-1514

Colorado Interstate Gas Company
Colorado Springs, Colorado

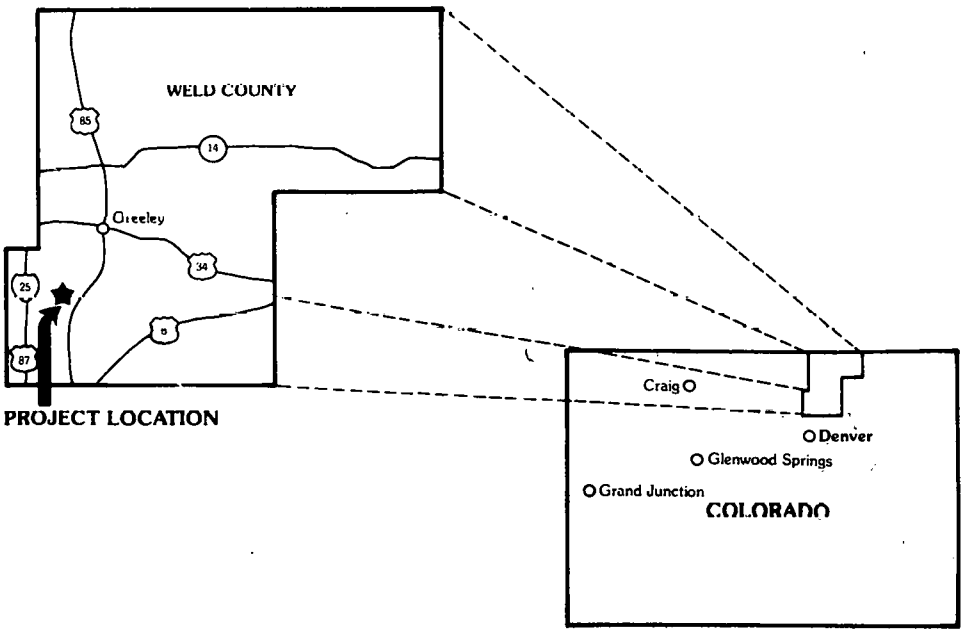
Status: Activity to Commence
January 1, 1978

Total Project Cost:	DOE	$ 75,000
	CIG	99,000
	Total	$174,000

Principal Investigator: Howard Fredrickson
Technical Project Officer for DOE: C. H. Atkinson, Bartlesville Energy Research Center

OBJECTIVE

Cyclic injection of dry natural gas is the method to be used to increase productivity of tight gas sands.



5.3 Colorado Interstate Gas Company

5.3.1 Scope of Work

On September 1, 1977, Contract No. EY-77-C-08-1514 was entered into between DOE and Colorado Interstate Gas Company in the amount of $75,000. The contractor will fund the program in the amount of $99,000+.

The Colorado Interstate Gas Company will attempt to determine if the productivity of wells completed in low permeability natural gas reservoirs can be improved by reducing the interstitial water saturation. The method used to accomplish this reduction of water saturation will be a cyclic injection of dry natural gas. In addition, cyclic injection of dry natural gas may improve the productivity through dehydration of matrix clays and the removal of formation damage adjacent to the surfaces of the induced fracture.

5.3.2 Current Status

Engineering design and specifications for the necessary equipment, such as the compressor and dehydrator are being prepared prior to solicitation of bids. Coastal States Gas Corporation will prepare and solicit the bids, and all of the necessary information will be sent to Houston.

In the field, CIG engineering has surveyed a pipeline route between the two wells and preliminary constructions plans have been made.

An environmentalist, Ms. Kathy Tonnessen, of Lawrence Livermore Laboratory, visited the site and collected information in order to prepare an environmental assessment report.

NATURAL BUTTES UNIT, UINTAH COUNTY, UTAH MASSIVE HYDRAULIC FRACTURING DEMONSTRATION

EY-76-C-08-0681

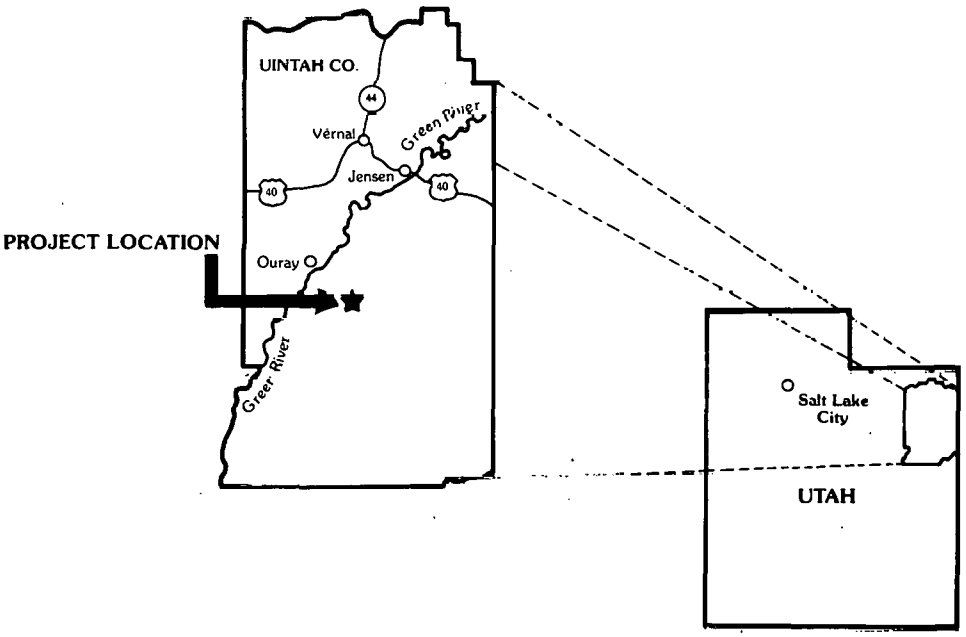
Gas Producing Enterprises, Inc.
Subsidiary of Coastal States Gas Co.
Houston, Texas

Status: Active

Contract Date:	July 1, 1976
Anticipated Completion:	Sept. 30, 1978
Total Project Cost:	DOE $2,827,000
	Industry (prior costs) 1,881,000
	Industry (new costs) 3,051,000
	Total $7,759,000
Principal Investigator:	W. E. Spencer
Technical Project Officer:	C. H. Atkinson, Bartlesville Energy Research Center

OBJECTIVE

To evaluate the effectiveness of massive hydraulic fracturing for stimulating natural gas production from thick, deep sandstone reservoirs having low permeability.



5.4 Gas Producing Enterprises Inc.

5.4.1 Scope of Work

On July 1, 1976, a Contract, EY-76-C-08-0681, was entered into between DOE and Gas Producing Enterprises Inc. concerning the conduct of a MHF experimental program. The GPE program was greater in scope compared to the other MHF contracting companies. Orginally, two old wells; Natural Buttes 18 and 14, and four new wells; 19, 20, 21 and 22 were to be fractured. Variations between wells were to consist of amounts of frac fluid, sand size, porosity of zone tested and fluid design. Contract Modification No. 1 added Natural Buttes No. 9, an old well, to the fracturing program. Another contract modification for Phase V of the MHF Demonstration Contract provides for an add-on to the Natural Buttes 21 (tentative new designation is CIGE No. 21) for coring, running of extra logs, and to run production and buildup tests on individual sand members within two sections of the Mesaverde. The core data, including special interpretation, and production test data will be correlated. In addition, there will be an attempt to obtain post MHF performance of these individual sand members for better prediction of potential productivity of a sand member by electric log interpretation alone.

5 4.2 Current Status

Natural Buttes Unit wells No. 18, 19, 14 and 20 are still on production and will continue flowing to sales through December. Specific production data for these four wells appears in Figure 5-1, 5-2, 5-3 and 5-4.

Natural Buttes well No. 22 was fractured on November 21, 1977. The well will be flowed to clean up and a workover rig moved in to clean out the frac sand to allow all zones to clean up. A Gamma Ray tool will be run to determine the location of the fractured intervals.

Table 5-2 is a description of the additional cores (No. 11, 12, 13 and 14) recovered from Natural Buttes No. 21 well.

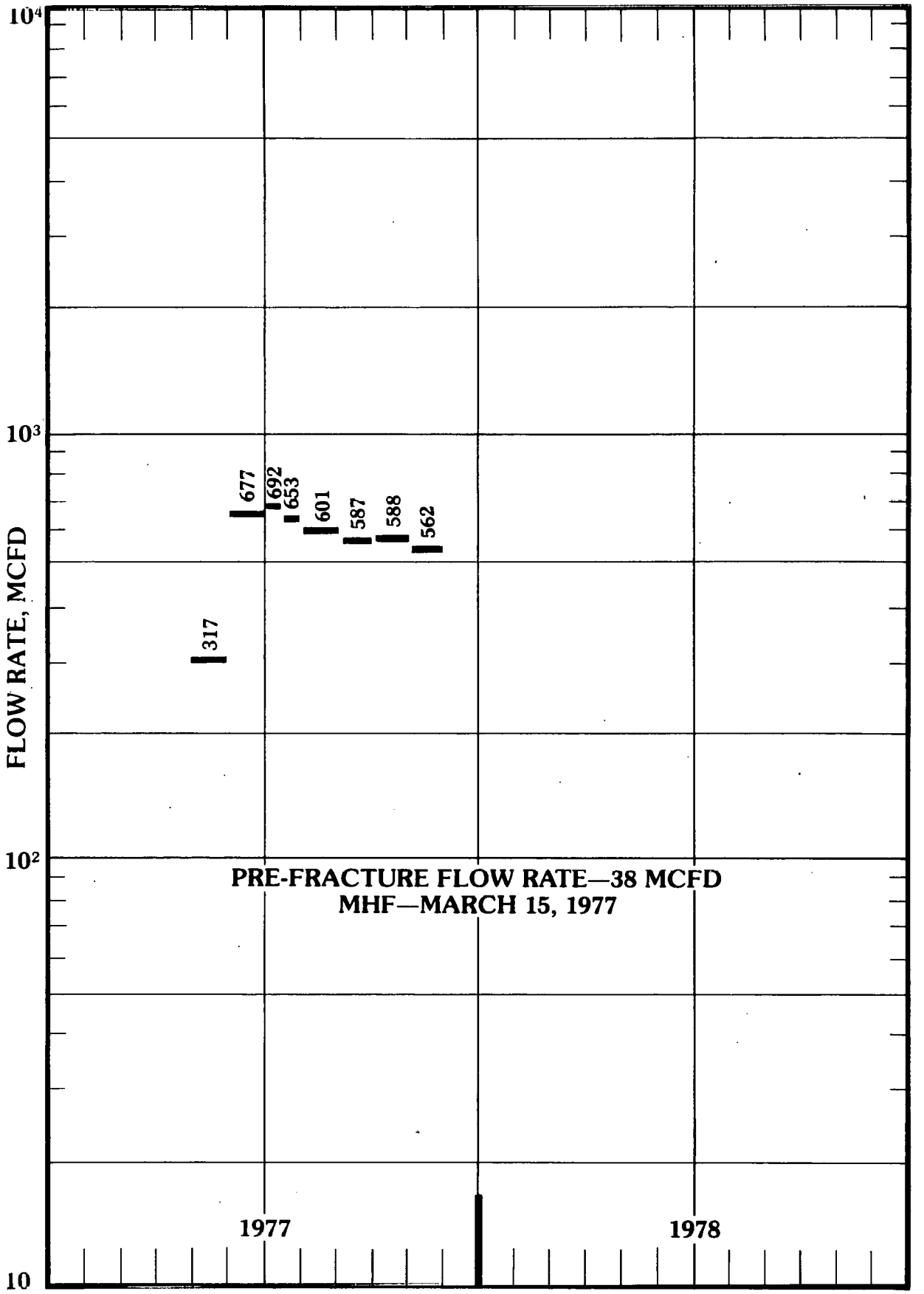


FIGURE 5-1 FLOW RATE PERFORMANCE OF NATURAL BUTTES NO. 14 WELL

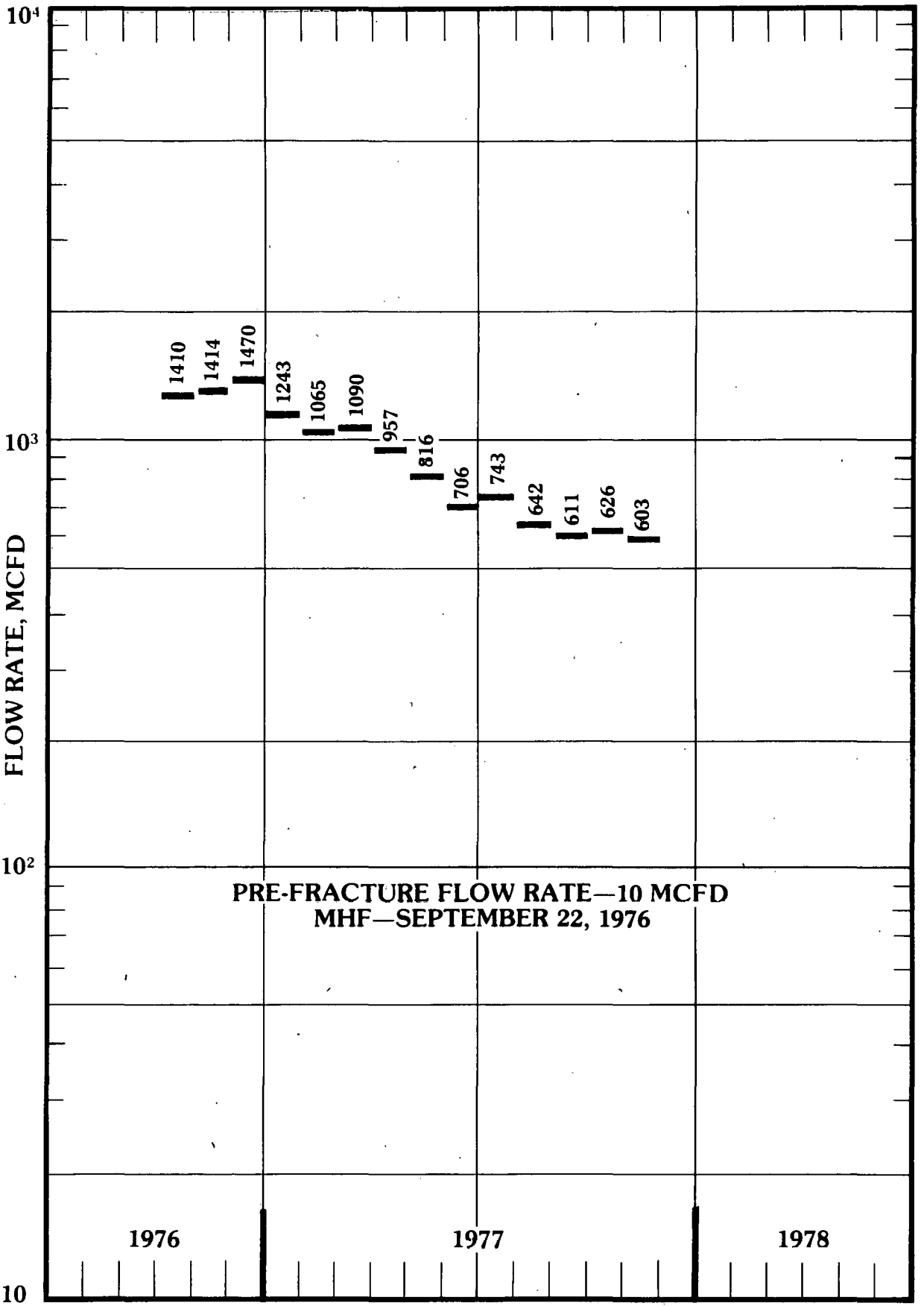


FIGURE 5-2 FLOW RATE PERFORMANCE OF NATURAL BUTTES NO. 18 WELL

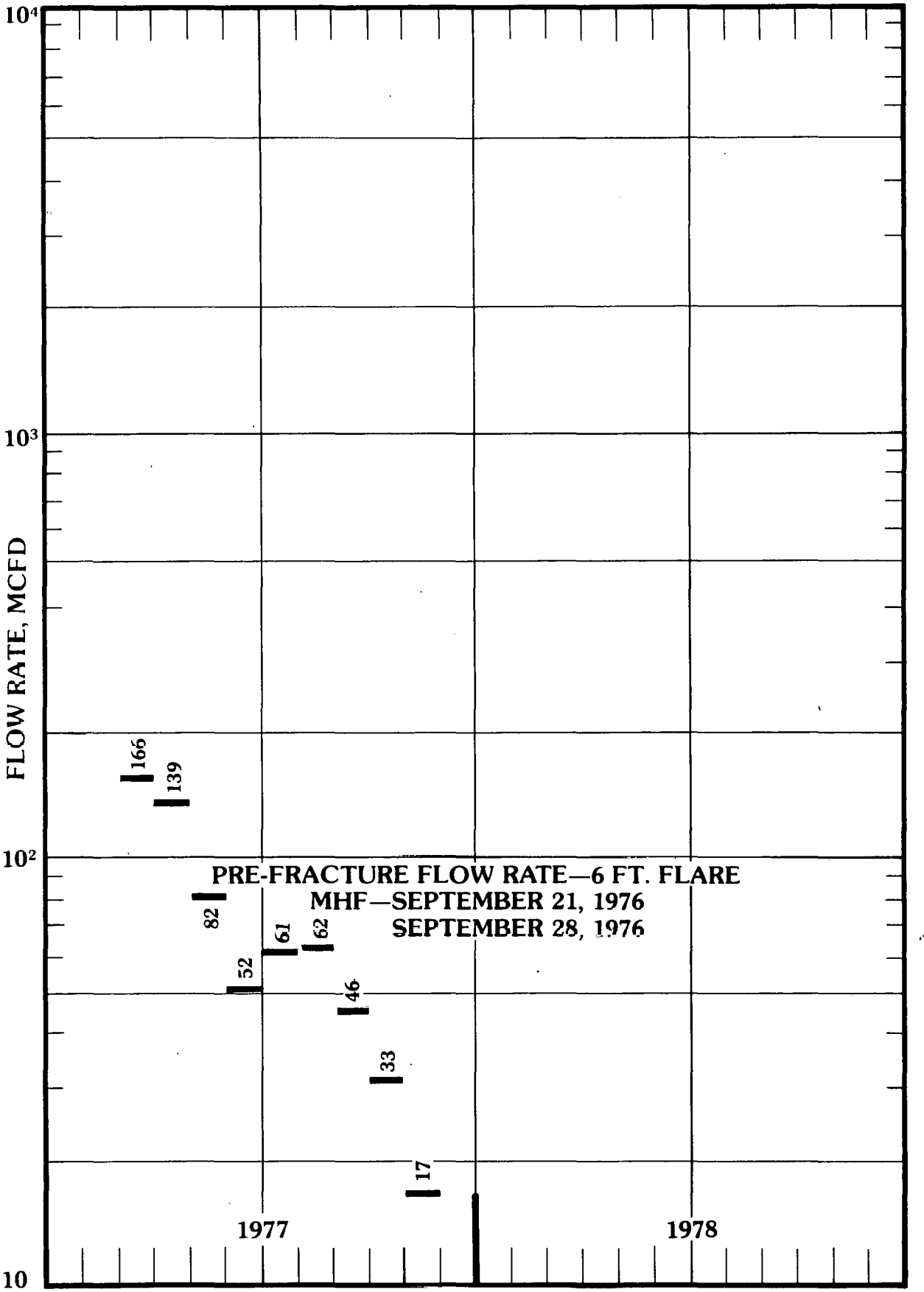


FIGURE 5-3 FLOW RATE PERFORMANCE OF NATURAL BUTTES NO. 19 WELL

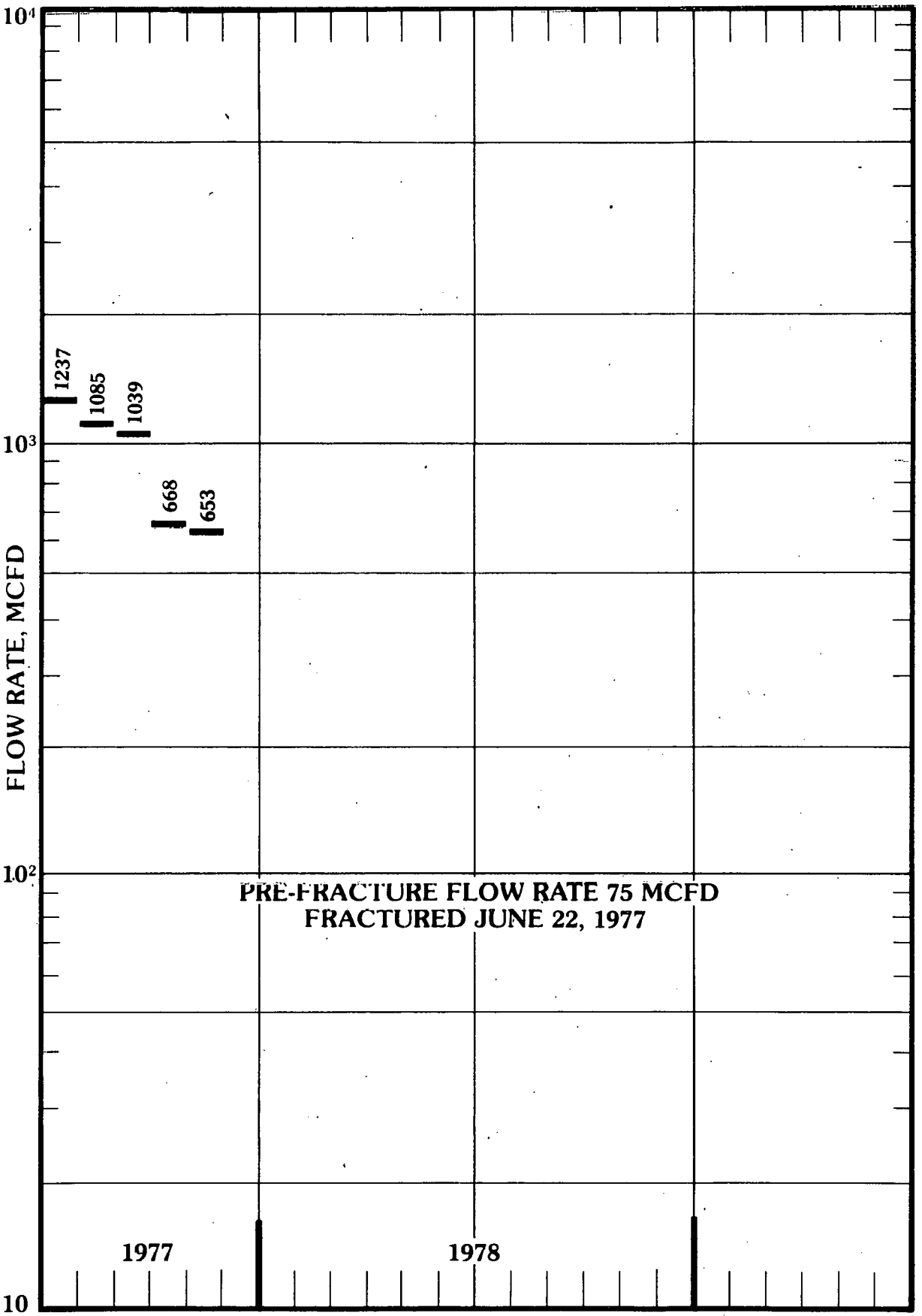


FIGURE 5-4 FLOW RATE PERFORMANCE OF NATURAL BUTTES NO. 20 WELL

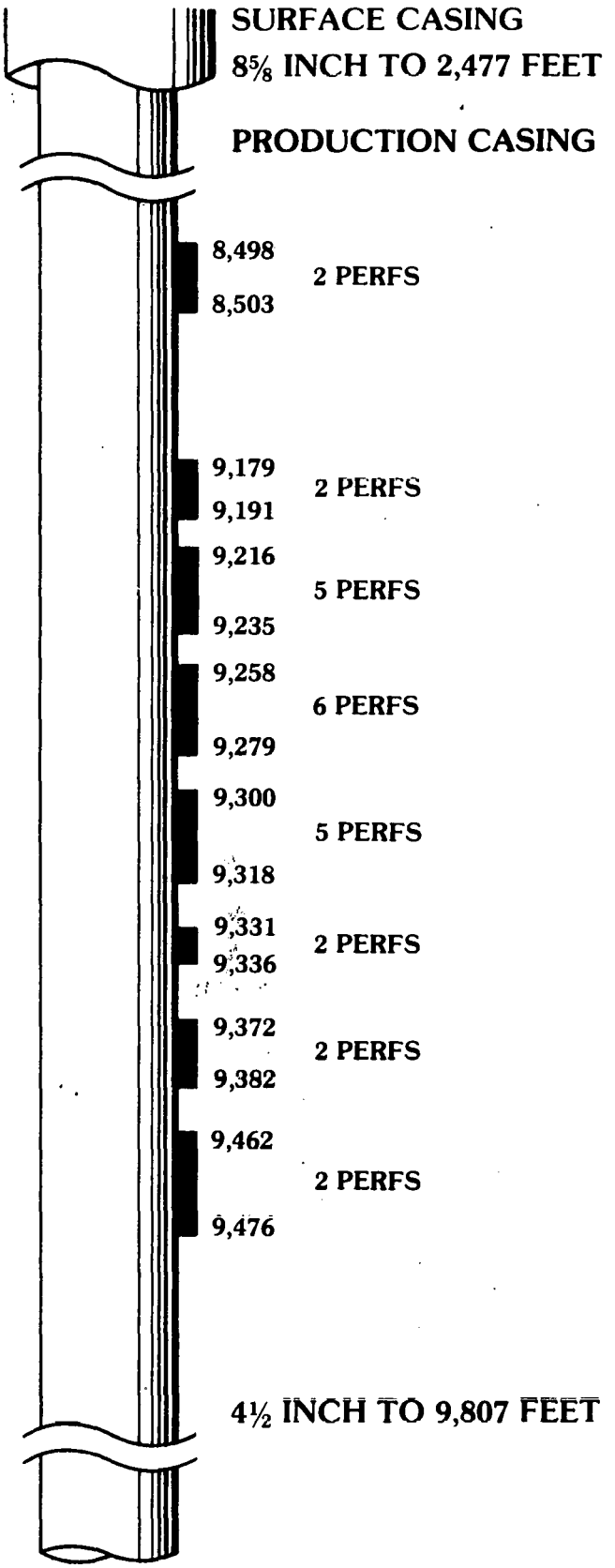


FIGURE 5-5 SCHEMATIC OF NATURAL BUTTES NO. 20 WELL SHOWING PERFORATIONS FOR EACH GROSS INTERVAL

TABLE 5-2 CORES RECOVERED FROM NATURAL BUTTES NO. 21 WELL

DEPTH INTERVAL	CORE DESCRIPTION
	Core #11: 8422' - 8435.4' **Recovered 14.0'**
8422.0' - 8432.4'	Shale, light gray to black, very coally, silty, locally sandy, many horizontal and vertical fractures.
8432.4' - 8436.0'	Sand, light gray, very fine grain, very silty, horizontal cross bedded, thin shaley streaks.
	Core #12: 8435.4' - 8466.0' **Recovered 31'**
8435.4' - 8438.0'	Sand, light to medium gray, very fine grain, silty, shaley, salt and pepper, tight.
8438.0' - 8439.2'	Shale, medium to dark gray, locally very coally, silty.
8439.2' - 8441.6'	Sand, light to medium gray, very fine grain, silty, shaley, salt & pepper, tight, horizontal cross beds.
8441.6' - 8442.5'	Shale, medium to dark gray, not coally.
8442.5' - 8448.3'	Sandstone, light to medium gray, very fine grain, silty tight, thin shaley intervals.
8448.3' - 8463.7'	Shale, medium to dark gray, locally very sandy, not coally, interbedded with thin sand beds.
8463.7' - 8464.7'	Sandstone, light to medium gray, very fine grain, silty, tight, thin shaley intervals.
8464.7' - 8466.4'	Shale, medium to light gray, locally very sandy, not coally.
	Core #13: 8466' - 8507.4' **Recovered 41.4'**
8466.0' - 8467.5'	Shale, light to medium gray, silty, not coally.
8467.5' - 8469.2'	Sandstone, very fine grain, salt & pepper, well sorted, locally shaley, tight, becoming more shaley at base.
8469.2' - 8485.5'	Shaley light to medium gray, silty, interbedded with sand, horizontal fracture, vertical fracture, locally coally.
8485.5' - 8486.5'	Sandstone, very fine grain, salt & pepper, well sorted, locally shaley, tight, becoming more shaley at base.
8486.5' - 8491.2'	Shale, light to medium gray, silty, locally thin sandy intervals.
8491.2' - 8495.7'	Sandstone, very fine grain, salt & pepper, well sorted, locally shaley, tight, becoming more shaley at base.

DEPTH INTERVAL	CORE DESCRIPTION
8495.7' - 8504.0'	Coal, very shaley.
8504.0' - 8507.4'	Shale, light to medium gray, silty, locally coally.

Core #14: 8507.5' - 8564.7'
Recovered 57.3'

8507.4' - 8534.2'	Shale, light to medium gray, silty, local coal near top, locally sandy, horizontal, vertical fracture.
8534.2' - 8538.0'	Sandstone, very fine grain, salt & pepper, well sorted, locally shaley, tight, becoming more shaley at base.
8538.0' - 8548.8'	Shale, light to medium gray, silty, locally coally.
8548.8' - 8549.6'	Sandstone, very fine grain, salt & pepper, well sorted, locally shaley, tight, becoming more shaley at base.
8549.6' - 8553.8'	Shale, light to medium gray, silty, local coal.
8553.8' - 8554.8'	Sandstone, very fine grain, salt & pepper, well sorted, locally shaley, tight, becoming more shaley at base.
8554.8' - 8564.7'	Shale, light to medium gray, silty, local coal.

TABLE 5-3 CORE SUMMARY—NATURAL BUTTES UNIT NO. 21

Cut 14 Cores with following recovery;

	RECOVERY			
	Cored	**Recovered**	**Sand**	**% Sand**
Wasatch	118.5	112	47.8	42.7
Mesaverde (Total)	(456.9)	(440.6)	(79.2)	(18.0)
Upper	159.2	150.4	33.1	22.0
Middle	155.0	146.5	17.9	12.2
Castlegate	142.7	143.7	28.2	19.6
Total Core	575.4	552.6	127.0	23.0

PICEANCE CREEK FIELD, COLORADO, MASSIVE HYDRAULIC FRACTURING DEMONSTRATION

EY-76-6-08-0678

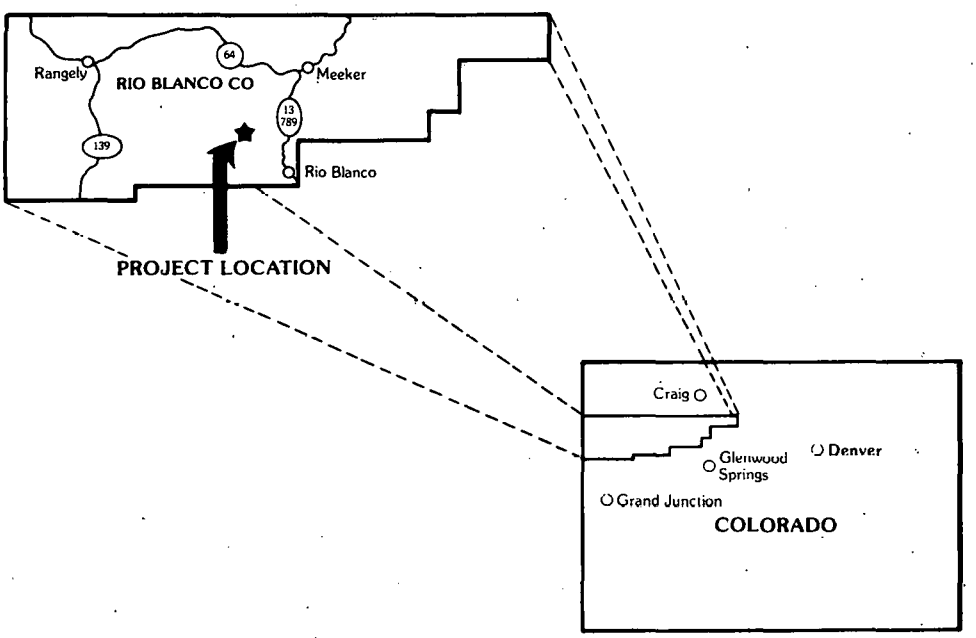
Mobil Research and Development Corporation
Dallas, Texas

Status: Active

Contract Date:	July 1, 1976
Anticipated Completion:	December 31, 1978
Total Project Cost:	DOE $2,600,000
	Contractor (prior costs) 2,376,485
	Contractor (new costs) 1,590,515
	Total $6,567,000
Principal Investigator:	John L. Fitch
Technical Project Officer:	C. H. Atkinson, Bartlesville Energy Research Center

OBJECTIVE

To evaluate the effectiveness of massive hydraulic fracturing for stimulating natural gas production from thick, deep sandstone reservoirs having extremely low permeability.



5.5 Mobil Research and Development Corporation

5.5.1 Scope of Work

Mobil was awarded DOE Contract EY-76-C-08-0678, along with Signal Drilling for the amount of $2.6 million for a MHF experiment in Rio Blanco County, Colorado. The scope of work under the contract is to be performed in three phases involving a well to be drilled in the Piceance Creek Gas Field, Rio Blanco County, Colorado.

5.5.2 Current Status

Testing of the interval 9,086 - 9,125 ft was completed on November 14, for Mobil well F-31-13G. A plot of the buildup data is shown in Figure 5-5. Preliminary analysis of the data indicates that kh of the zone is about 0.03 md-ft. As in previous tests, the after-breakdown data indicate that a negative skin is present. Flow rate data were obtained on the zone as follows:

Date	Rate, MCFD
Nov. 7	400
Nov. 8	185
Nov. 9	158
Nov. 10	125

The results are indicative of a good flow test since all operations proceeded normally. Details of the completion procedure are, briefly, the interval 9,086 - 9,125 ft was perforated on November 4 with 32 jet shots using a centralized, 4 in. carrier gun. The perforations were broken down on November 7 with 5,000 gal of KCl water at 12.5 BPM; maximum pressure was 6,900 psi and initial instantaneous shut-in pressure was 1,600 psi. Ball-off was achieved. Flow back began at 1230 hrs on November 7 with the flow rate reaching about 400 MCFD at 1700 hrs. The well flow rates are shown by the table above. Noise/temperature logs during the flow period indicated that most of the perforated interval was producing some gas, especially near the bottom and near the top of the interval. The low flow rate made interpretation of the logs difficult. The well was shut-in November 10.

Following the pressure buildup, a decision was made to discontinue work toward additional fracturing until Spring, 1978, since the intervals 9,254 - 9,320 ft and 9,086 - 9,125 ft did not appear to have sufficient kh to warrant fracturing. Plans were made to perform a flow test to the sales line of the two fractured intervals during the winter months. It is believed that this relatively long-term flow data will greatly aid in estimating the production decline characteristics of the formation.

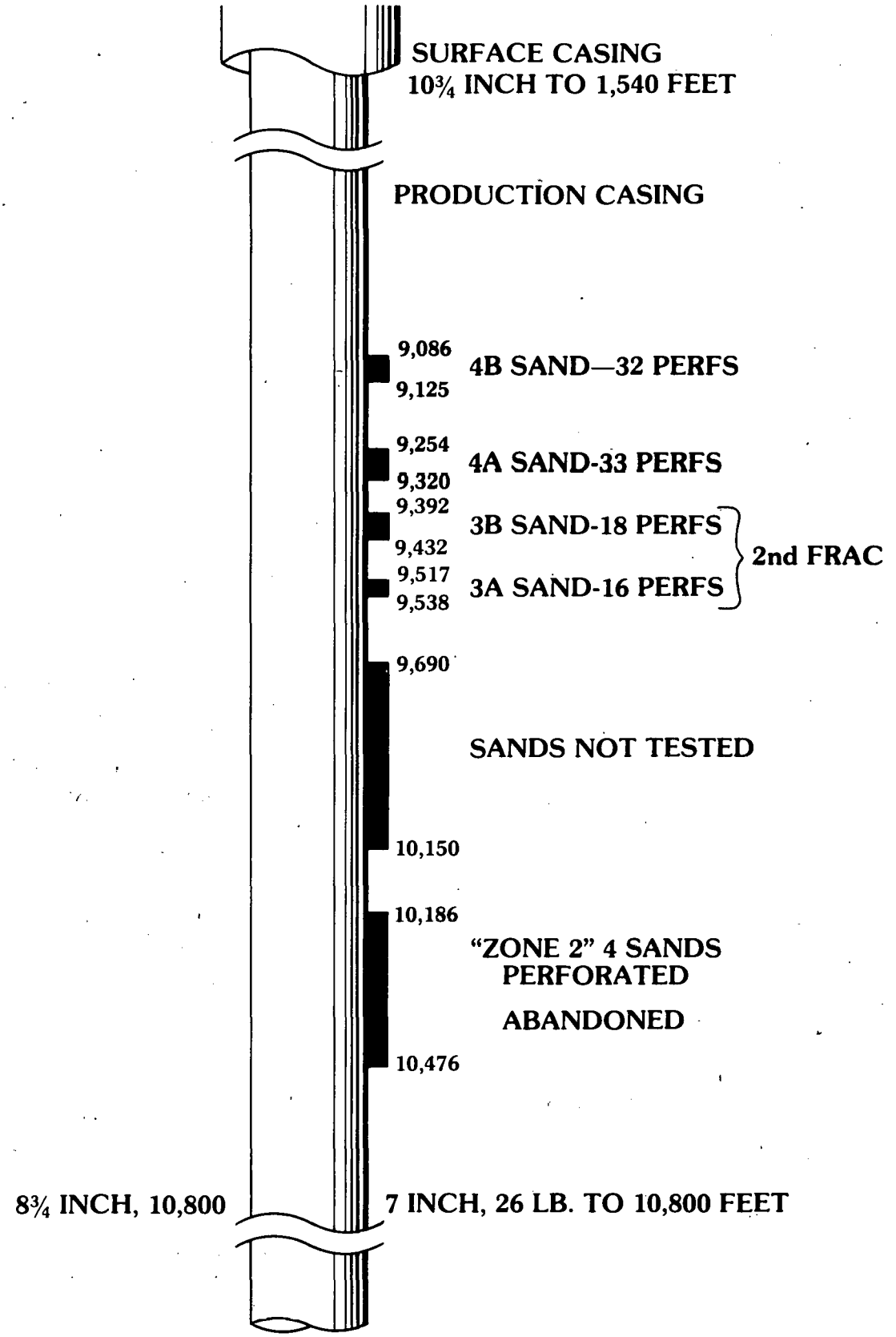


FIGURE 5-6 SCHEMATIC OF MOBIL F-31-13G WELL SHOWING 3A AND 3B ZONES

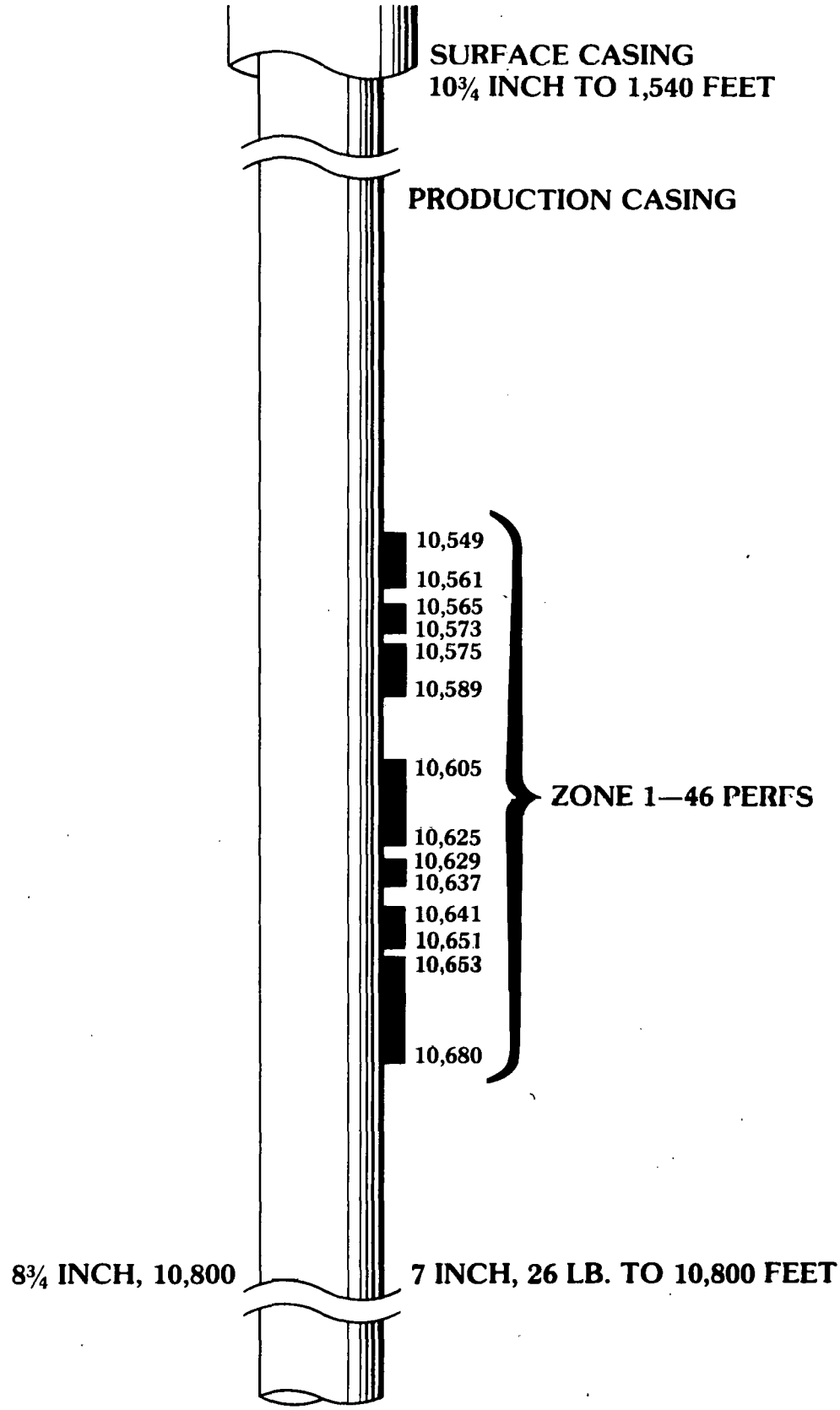


FIGURE 5-7 SCHEMATIC OF MOBIL F-31-13G WELL

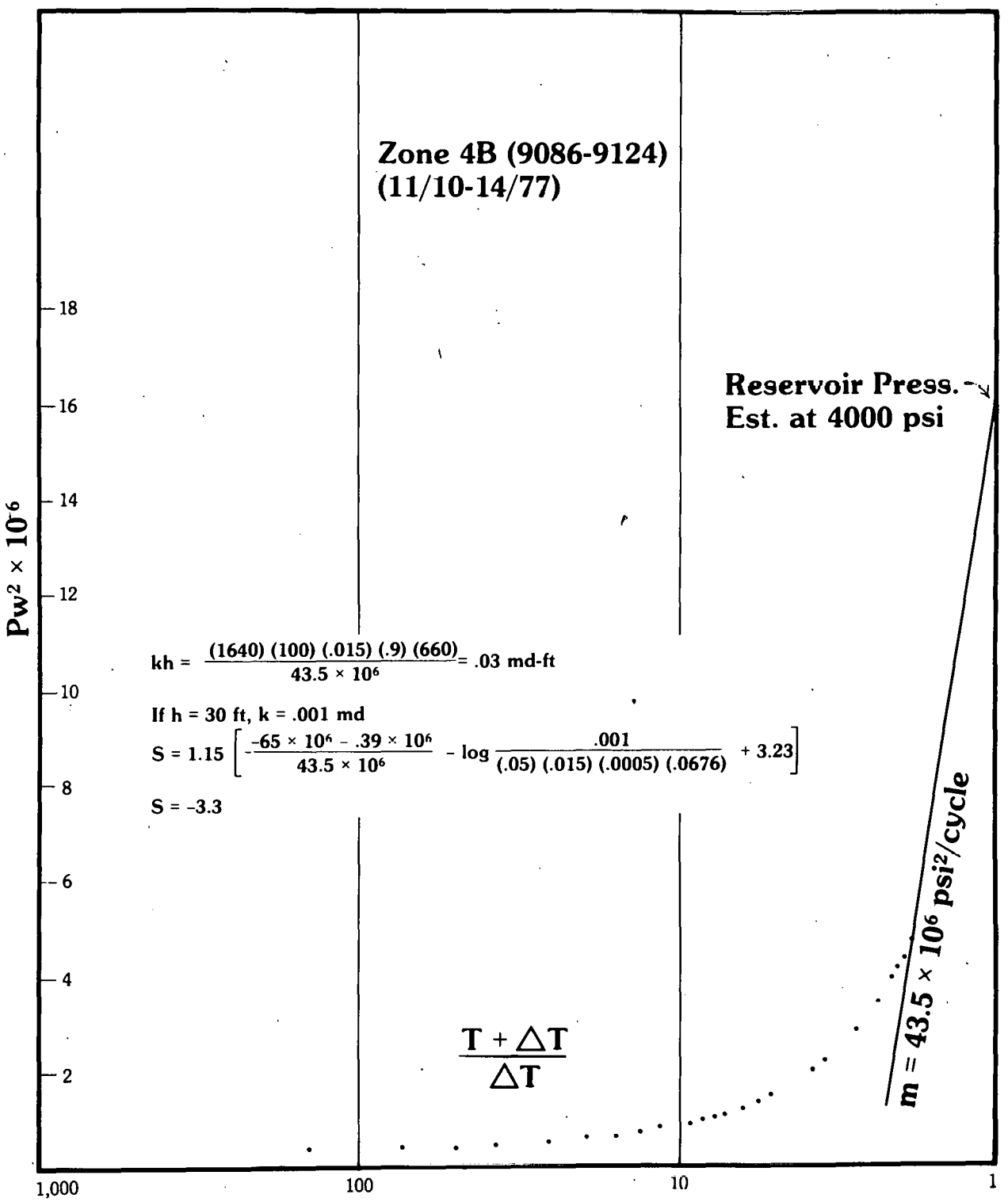


FIGURE 5-8 MOBIL F-31-13G (BEFORE FRAC) ZONE 4B

Mobil now has plans to clean the well out to total depth and flow it until sometime in April, depending on the weather. As of December 12, both bridge plugs had been removed from the well and about 100 ft of fill was being circulated out of the well. Provision is being made to run tubing to the lower perforations. At the end of the flow period the tubing will be pulled up to expose all of the perforations for flow logging. In order to withdraw the tubing without killing the well it will be necessary to install a stripper head.

RIO BLANCO COUNTY, COLORADO MASSIVE HYDRAULIC FRACTURING DEMONSTRATION

EY-76-C-08-0677

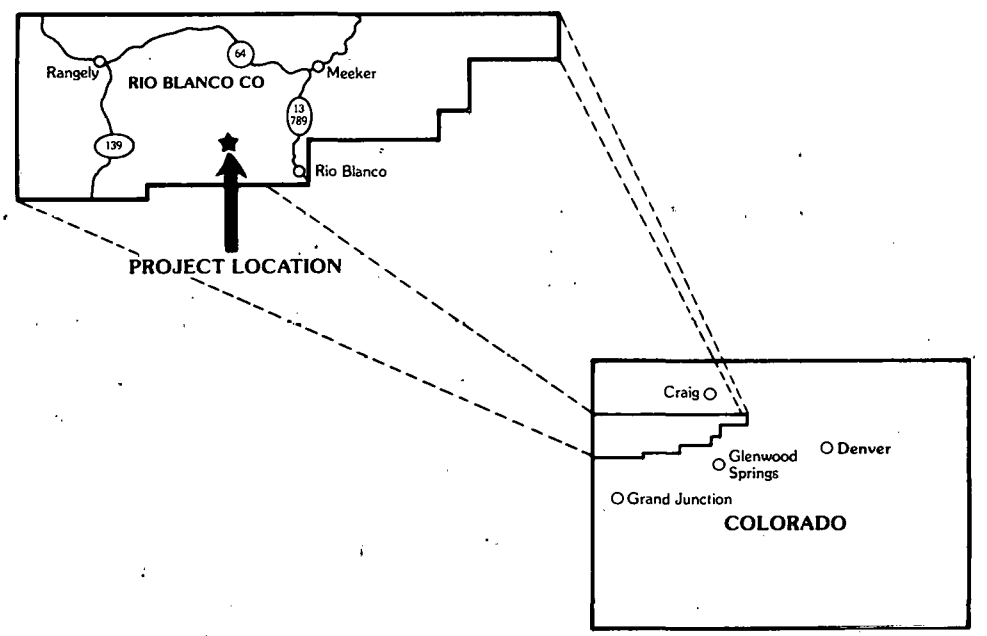
Rio Blanco Natural Gas Company
Denver, Colorado

Status: Active

Contract Date:	August 1, 1976
Anticipated Completion:	March 31, 1978
Total Project Cost:	DOE ..... $ 410,000
	Contractor 593,000
	Total $1,003,000
Principal Investigator:	Robert E. Chancellor
Technical Project Officer:	C. H. Atkinson, Bartlesville Energy Research Center

OBJECTIVE

To evaluate the effectiveness of massive hydraulic fracturing for stimulating natural gas production from thick, deep sandstone reservoirs having extremely low permeability.



5.6. Rio Blanco Natural Gas Company

5.6.1 Summary of Past Activities

In June 1976, DOE Contract EY-76-C-08-0677 was signed with Rio Blanco Natural Gas Company. The scope of work consisted of preparing an existing well (Federal 498-4-1) for the MHF treatment. This well, located in Section 4, T4S, R98W, Rio Blanco County, Colorado, was drilled and cased to a total depth of 6,963 ft in March 1975. The Mesaverde Formation was stimulated in two separate treatments before the contract MHF was performed.

The massive hydraulic fracturing was performed on October 22, 1976 with a total of 276,000 BBL pumped, including sand volume and flush.

5.6.2 Contract Modifications for an Additional Fracture

DOE and Rio Blanco Natural Gas Company entered into a supplemental agreement, effective October 1, 1977, to determine whether the previous fracture may have closed due to proppant crushing or whether less gas is available than originally estimated. It was felt that it would be beneficial to perform an additional fracture using 12/20 mesh galss beads, a high strength propping material, mixed with the normally used sand proppant in the latter part of the fracture treatment.

5.6.3 Current Activities

The Rio Blanco Natural Gas well, Federal 498-4-1, was fractured on November 30, 1977. The surface treating pressure ranged between 1,200 and 3,100 psi. Instant shut-in pressure was 900 psi. The fracture rate was 40 BPM and 14 BPM for the overflush. The treatment consisted of 3,900 BBL of gelled water, 44,000 lbs of 100 mesh sand, 199,000 lbs 20/40 mesh sand and 22,500 lbs of 12/20 glass beads.

A temperature log was run and the field interpretation indicated that the upper 3 zones were treated but little or no cooling effect was observed adjacent to the lowest zone.

During cleanup, sustained water production prevented high gas flow rates and it was concluded that the upper sand member of the zone fractured could be producing formation water. This sand was isolated by setting the production packer just below it and production was resumed with a substantial reduction in water production. During the last two weeks in December, the production rate was steady at 285 MCFD. Water production was approximately 1 BBL/hr.