GL00138

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PRELIMINARY DATA FOR MADISON LIMESTONE TEST WELL 2, SE¼SE¼ SEC. 18, T. 1 N., R. 54 E., CUSTER COUNTY, MONTANA

By D. L. Brown, R. K. Blankennagel, J. F. Busby, and R. W. Lee

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Open-File Report 77-863

Study of Madison aquifer in cooperation with
Montana Bureau of Mines and Geology
Montana Department of Natural Resources and Conservation
North Dakota State Water Commission
South Dakota Division of Geological Survey
Wyoming State Engineer

This report has not been edited or reviewed for conformity with Geological Survey stratigraphic nomenclature.

Denver, Colorado

December 1977

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ILLUSTRATIONS

(Plates are in pocket)

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CONVERSION FACTORS

In this report, figures for measures are given only in English units. Factors for converting English units to metric units are shown in the following table:

English	Multiply by	Metric
in (inches)	25.4	mm (millimeters)
ft (feet)	.305	m (meters)
ft^3 (cubic feet)	.02832	m^3 (cubic meters)
mi^2 (square miles)	2.59	km^2 (square kilometers)
gal (gallons)	3.785	L (liters)
gal/min (gallons per minute)	.0631	L/s (liters per second)
(gal/min)/ft (gallons per minute per foot)	.207	(L/s)/m (liters per second per meter)
lb (pounds)	.4536	kg (kilograms)
lb/in^2 (pounds per square inch)	6.8948	kPa (kilopascals)
md (millidarcys)	.000987	μm^2 (square micrometers)

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Abstract

This report provides the preliminary data for the Madison Limestone test well 2 including test-well history, geology of the test well, hydrologic testing, and geochemistry. It also discusses the preliminary results and future testing plans.

The test well was drilled as part of the study to determine the water-resource potential of the Madison Limestone and associated rocks to meet future water needs in a 188,000-square-mile region that includes the coal-rich area of the Northern Great Plains. Drilling and testing were designed to yield a maximum of stratigraphic, structural, geophysical, and hydrologic information.

The test well was drilled in the SE¼SE¼ sec. 18, T. 1 N., R. 54 E., Custer County, Montana, to a depth of 9,378 feet below land surface. The well is cased with 13-3/8-inch casing from land surface to 4,661 feet and 9-5/8-inch casing from 4,519 to 6,487 feet below land surface. It is an 8-1/2-inch-diameter open hole from 6,487 feet to 8,422 feet. The well is plugged below that depth by two cement plugs--one from 9,378 to 9,084 feet and the other from 8,884 to 8,422 feet. The well is so constructed that additional hydrologic tests and geophysical logs can be made at a later date.

Nineteen cores were taken from selected intervals totaling 754 feet; 722.4 feet of core was recovered. The cores were photographed, slabbed, and plugged, and selected parts were tested for density, porosity, and vertical and horizontal permeability. Gamma and density scans of the cores were made, and thin sections are being prepared for detailed examination.

Seventeen conventional drill-stem tests and packer-swabbing tests were attempted, 13 of which give clues to the pressure heads of water in the intervals tested. Water samples were obtained during 10 of the tests, 7 of which were flow tests.

Water from the open-hole part of the well had a shut-in pressure of 333 pounds per square inch and flowed about 44 gallons per minute. The temperature of the water, measured at the surface, was about 48 degrees Celsius.

With the possible exception of the Lakota Sandstone, no major potential sources of ground water were found in the test well. Also, no freshwater (less than 1,000 milligrams per liter dissolved solids) was found in any of the zones tested in the well. Water salinities ranged from about 2,000 to 46,500 milligrams per liter dissolved solids.

Additional geophysical logs and tests will be made in the test well during the summer and fall of 1977. The logs may include televiewer, gamma spectrometer, trace ejector, and spinner-surveys. A vertical seismic profile will be made in the well in August.

Introduction

Development of coal in the Northern Great Plains will place a heavy demand on the available water resources of the region. Surface water in the region is poorly distributed in time and space. Its use for coal development in places would require storage reservoirs and distribution systems; in the rest of the region, surface water is fully appropriated and its use would deprive present users of their supply. The Paleozoic rocks which underlie most of the region contain water-bearing zones that might supply, at least on a temporary basis, a significant percentage of the total water required for coal development. One such source of water supply is the Madison aquifer, which includes the Madison Limestone and associated rocks.

In 1975 the U.S. Geological Survey, in cooperation with the Old West Regional Commission, prepared a plan of study (U.S. Geological Survey, 1975) for evaluating the water-supply potential of the Madison Limestone and associated rocks. That report not only presents a plan of study for the Madison, but also gives references relating to the regional geology and hydrology, cites the current geohydrologic studies being made by Federal and State agencies and by private companies, and summarizes the available data and the deficiencies of these data.

During the development of the study plan, a liaison committee was formed. The members were drawn from agencies of State governments that have an active interest in or responsibility for control or development of water from the Madison aquifer. These agencies include Montana Bureau of Mines and Geology, Montana Department of Natural Resources and Conservation, North Dakota State Water Commission, South Dakota Division of Geological Survey, and Wyoming State Engineer. The purpose of the committee is to maintain open communication between investigating hydrologists and State officials relative to all aspects of the U.S. Geological Survey's studies of the Madison aquifer.

During the 1976 fiscal year, the U.S. Geological Survey, in cooperation with the States of Montana, North Dakota, South Dakota, and Wyoming, began a study to determine the water-resource potential of the Madison Limestone and associated rocks to meet the future water needs in a 188,000-mi^2 region that includes the coal-rich area of the Northern Great Plains, and to evaluate these rocks (the Madison aquifer) as a source of water for industrial, agricultural, public, and domestic supplies. The study area includes eastern Montana, western North and South Dakota, a small part of Nebraska, and northeastern Wyoming (fig. 1). The area of greatest interest, however, is the Powder River Basin of Montana and Wyoming, and the area surrounding the Black Hills in Wyoming, Montana, the Dakotas, and Nebraska.

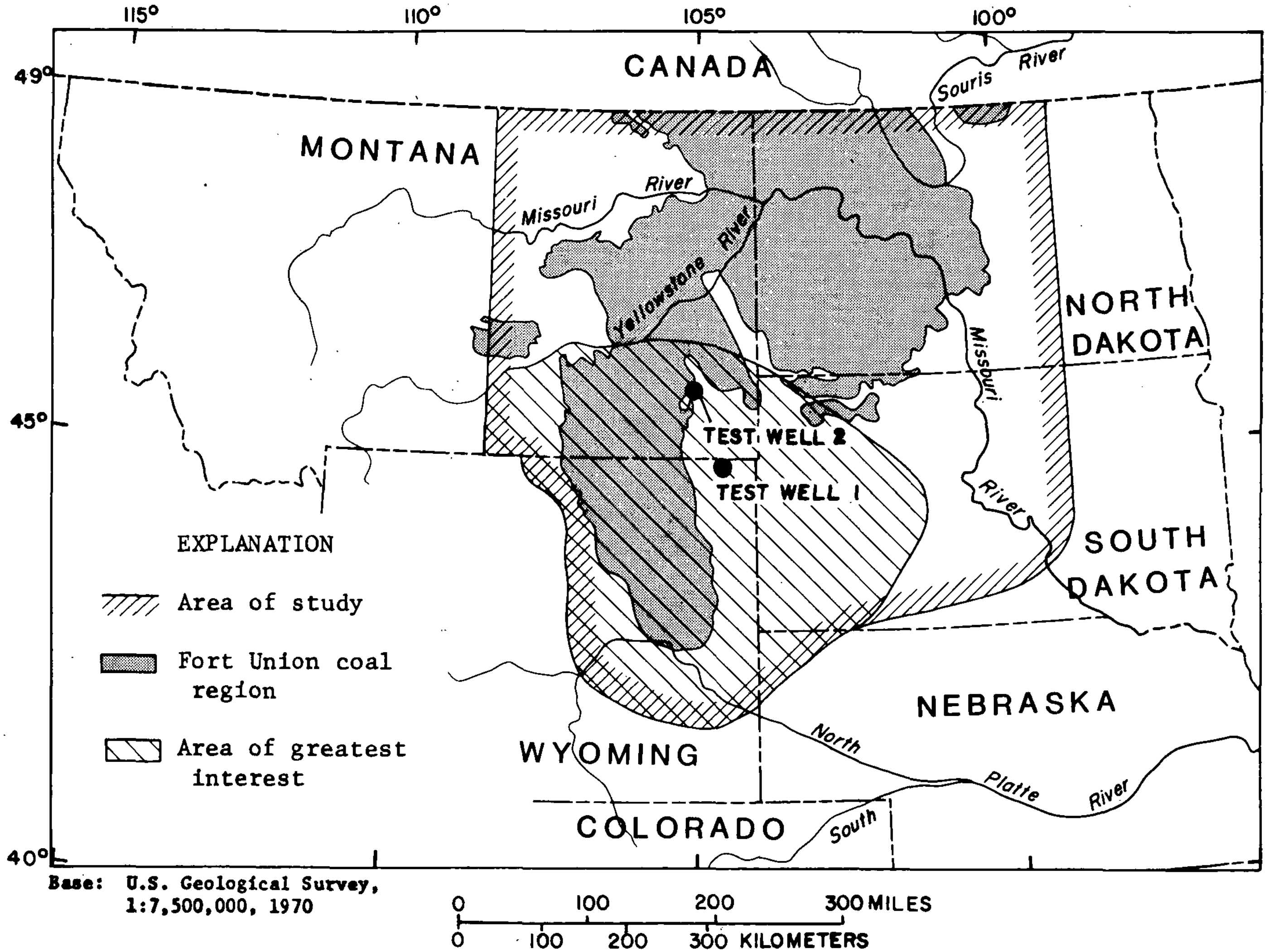

Figure 1.--Location of study area, Fort Union coal region, and test wells 1 and 2.

Within the scope of available funds and manpower, the objectives and approach are those outlined in the plan-of-study report. The objectives include:

1. The quantity of water that may be available from the Madison aquifer.
2. The chemical and physical properties of the water.
3. The effects of existing developments on the potentiometric head, storage, recharge and discharge, springs, streamflow, and the pattern of ground-water flow.
4. The probable hydrologic effects of proposed withdrawals of water for large-scale developments at selected rates and locations.
5. The locations of wells and the type of construction and development of deep wells that would obtain optimum yields.

Many oil tests have been drilled to the Madison aquifer in the study area. Most did not completely penetrate the aquifer, but were drilled to develop oil fields or were exploration tests on known geologic structures. Few data from these tests were collected for hydrologic purposes, but the information is useful in defining the geologic framework and some of the aquifer characteristics such as water quality, temperature, porosity, and potentiometric head.

To obtain better subsurface hydrologic and geologic information, it was recognized that test wells would have to be drilled. Drilling and testing were designed to yield a maximum of stratigraphic, structural, geophysical, and hydrologic information. Stratigraphic and structural information, obtained from drill cuttings, cores, and geophysical logs, is critical for reconstructing the paleogeologic history of the region as well as defining the present structural and sedimentary framework. Careful analysis of cuttings and cores, and correlation with geophysical log characteristics will have transfer value with data obtained from oil-well tests and surface geophysical surveys.

Hydraulic tests are designed to yield pressure data and subsurface water samples from discrete intervals. These data are used to determine the degree of isolation and (or) interconnection of aquifers, the water yield of isolated zones, the composite yield of the well, and the quality of water.

Madison Limestone test well 2 is the second in a series of proposed test wells that are designed to test a preliminary regional conceptual model relating porosity to lithology, and, in turn, transmissivity to structure and other rock properties.

Test well 1 (Blankennagel, Miller, Brown, and Cushing, 1977) was drilled in the NE°SE° sec. 15, T. 57 N., R. 65 W., Crook County, Wyo. (fig. 1). Preliminary geological facies maps showed this area along the eastern part of the Montana-Wyoming border to have a high percentage of dolomite in the Madison and associated rocks, thus indicating possible high primary porosity. Also, because this area was apparently structurally active, good potential for secondary fracture porosity was indicated. Other considerations in selecting the site were (1) depth to Precambrian rocks at about 5,000 ft below land surface, (2) adequate pressure to be reasonably certain that the well would flow at land surface, (3) location on State or Federal land, (4) good accessibility to the drilling site, (5) availability of water for drilling and an area for disposal of water from the well, and (6) nearness to source of electrical power. The well, although not completely developed at this time (June 1977), will yield at least 700 gal/min. It penetrated formations having good porosity, permeability, and open fractures to a depth of at least 3,200 ft below land surface (Blankennagel, Miller, Brown, and Cushing, 1977).

The site for Madison test well 2 was chosen with considerations 2-6 (listed in previous paragraph) being the same. The main differences in this site selection were in the depth to Precambrian basement and lithology of the Madison and associated rocks. Preliminary geological facies maps showed the Madison and associated rocks, at the site for test 2, to be predominantly limestone and deeper than 6,000 ft below land surface.

The choice of a structurally active area for the test should permit the relation between lithology, structure, and secondary porosity to be more fully understood. Also specific questions need answers: (1) Are fractures open or healed below 6,000 ft? (2) Does limestone tend to fracture less than dolomite? (3) Does the porosity decrease in direct proportion to the percentage of limestone in the section?

Madison test well 2 is in the SE¼SE¼ sec. 18, T. 1 N., R. 54 E., Custer County, Mont. (figs. 2 and 3). It is along an all-weather gravel-surfaced road, about a quarter of a mile west of the Powder River. The well is about 6 mi northeast of Powderville, Mont., and 55 mi southeast of Miles City, Mont.

The well was spudded in the Hell Creek Formation of Late Cretaceous age on November 17, 1976, and bottomed 94 ft below the top of the Precambrian rocks at 9,378 ft below land surface on March 23, 1977. It is cased with 13-3/8-in diameter casing from land surface to 4,661 ft, and with 9-5/8-in diameter casing from 4,519 to 6,487 ft. It is 8-1/2-in diameter open hole from 6,487 to 8,422 ft. The well is sealed off below 8,422 ft by two cement plugs--one from 9,378 to 9,084 ft and the other from 8,884 to 8,422 ft below land surface--to isolate the upper part from the Cambrian sandstones that contained saline water and gas shows (fig. 4). The well is so constructed that additional hydrologic tests and geophysical logs can be run at a later date (figs. 5 and 6).

Seventeen drill-stem and packer-swabbing tests were attempted; 13 yielded head and quality-of-water information for the intervals tested. Based on the test data, all water-bearing units in the Paleozoic rocks had sufficient head to cause the water in them to flow at land surface. Water from the uncased part of the well, 6,487 to 8,422 ft, had a head of 333 lb/in^2 above land surface.

Nineteen cores were taken from selected intervals totaling 754 ft; 722.4 ft of core was recovered. The cores were photographed, slabbed, plugged, and selected parts were tested for density, porosity, and vertical and horizontal permeability. Gamma and density scans of the cores were made, and thin sections are being prepared for detailed examination.

This report provides the preliminary data for Madison Limestone test well 2 including test-well history, geology of the test well, hydrologic testing, and geochemistry, and it discusses the preliminary results and future plans.

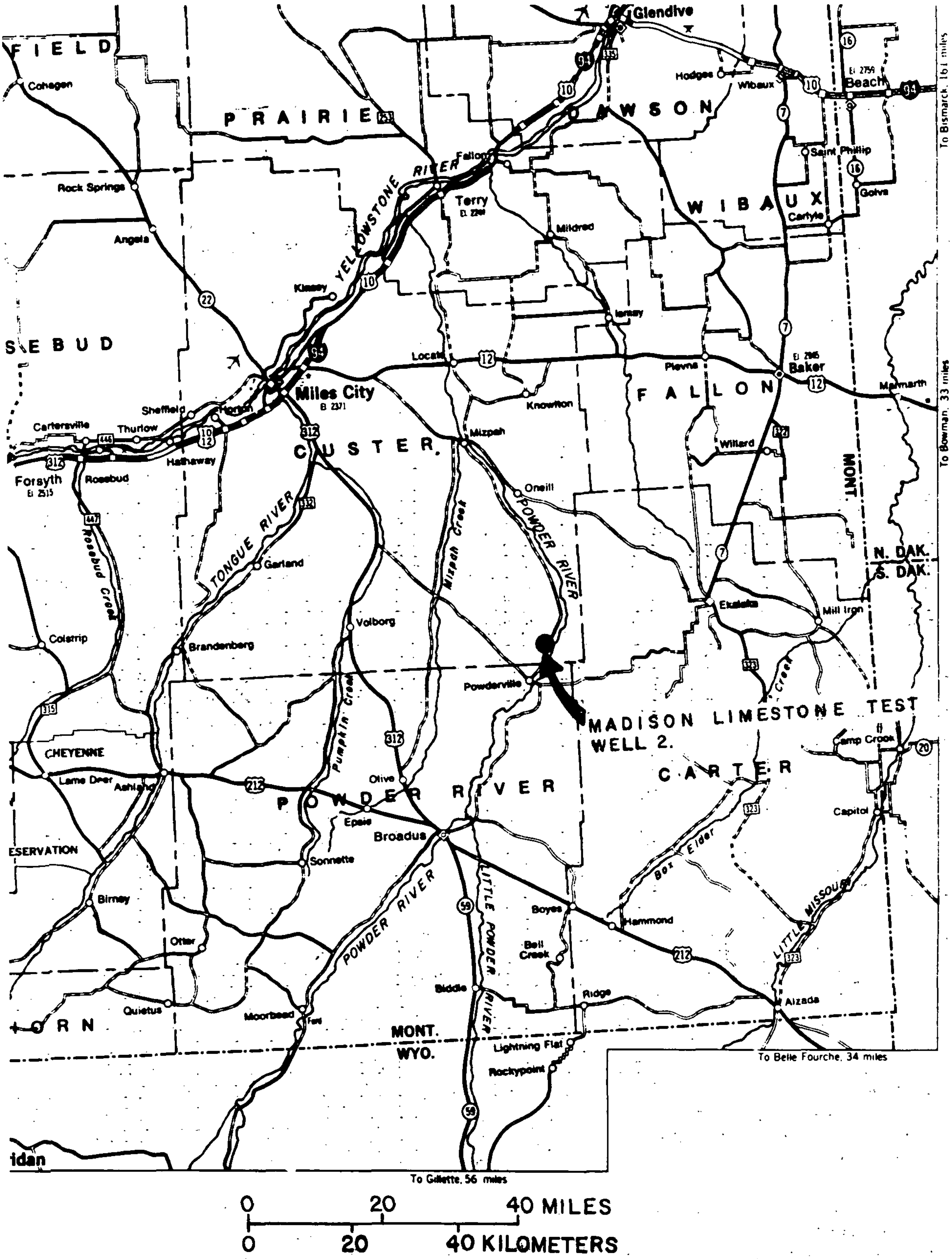

Figure 2.--Location of Madison Limestone test well 2 in southeastern Montana.

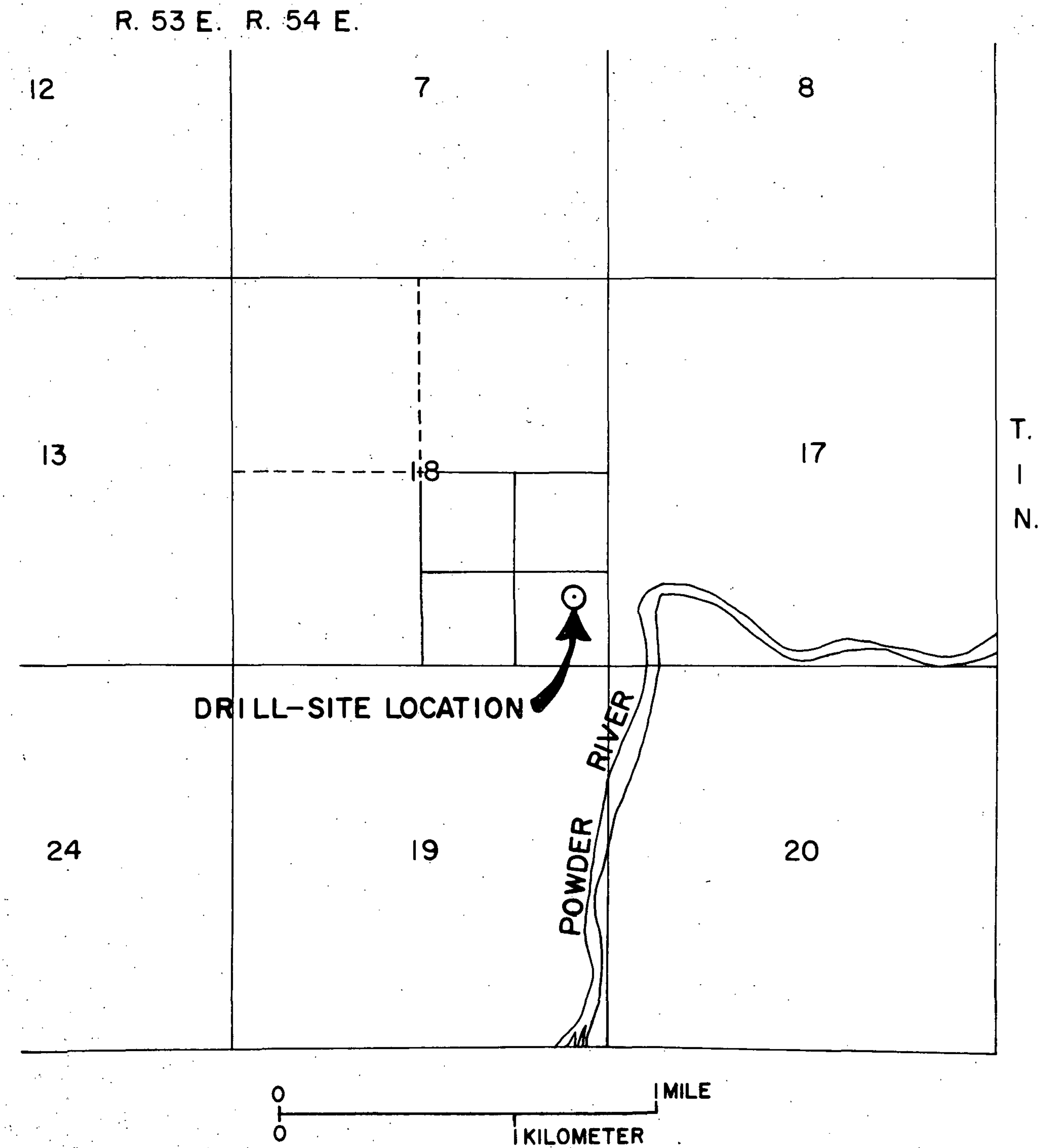

Figure 3.--Location of drill site for Madison Limestone test well 2.

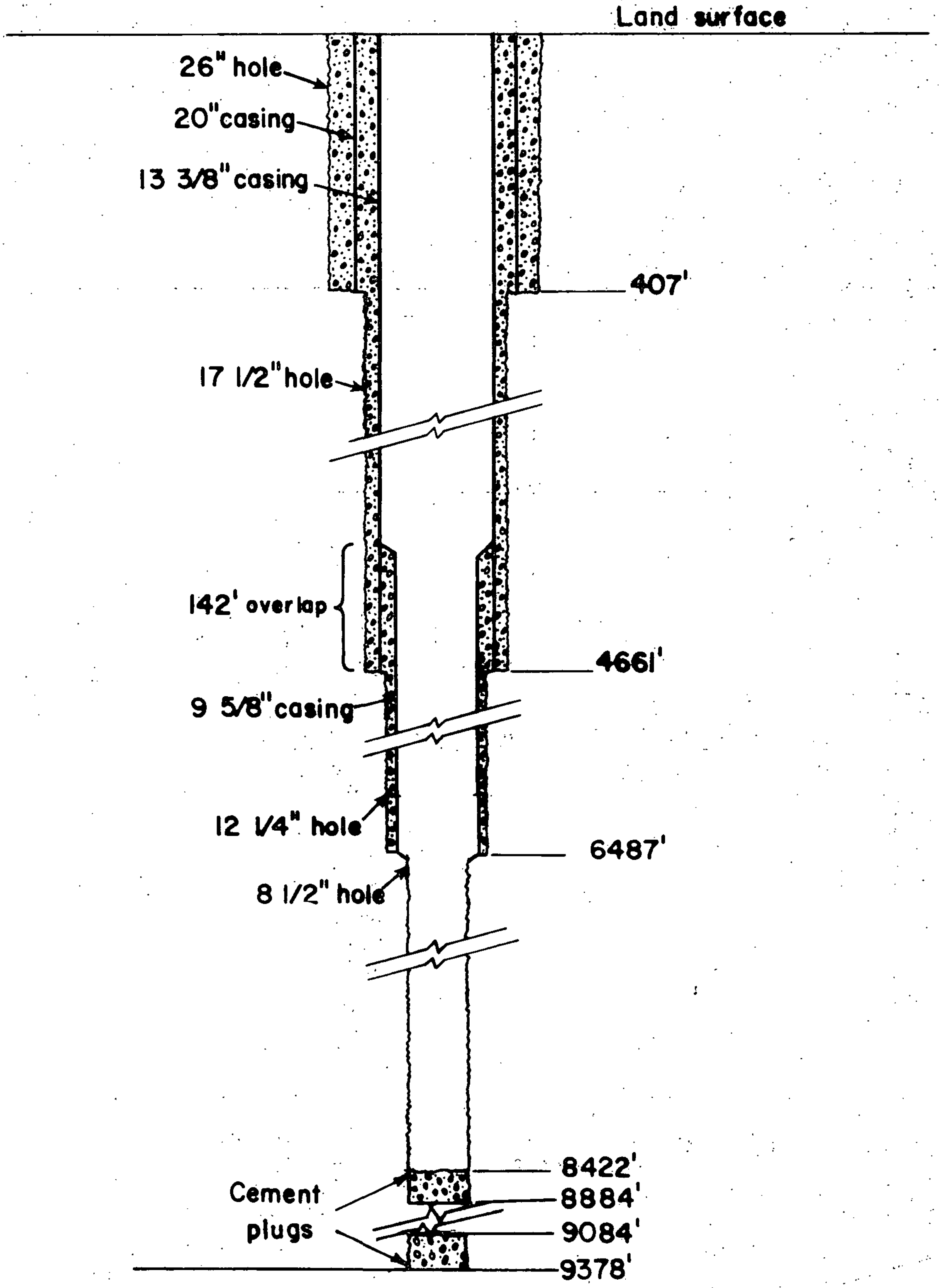

Figure 4.--Construction of Madison Limestone test well 2.

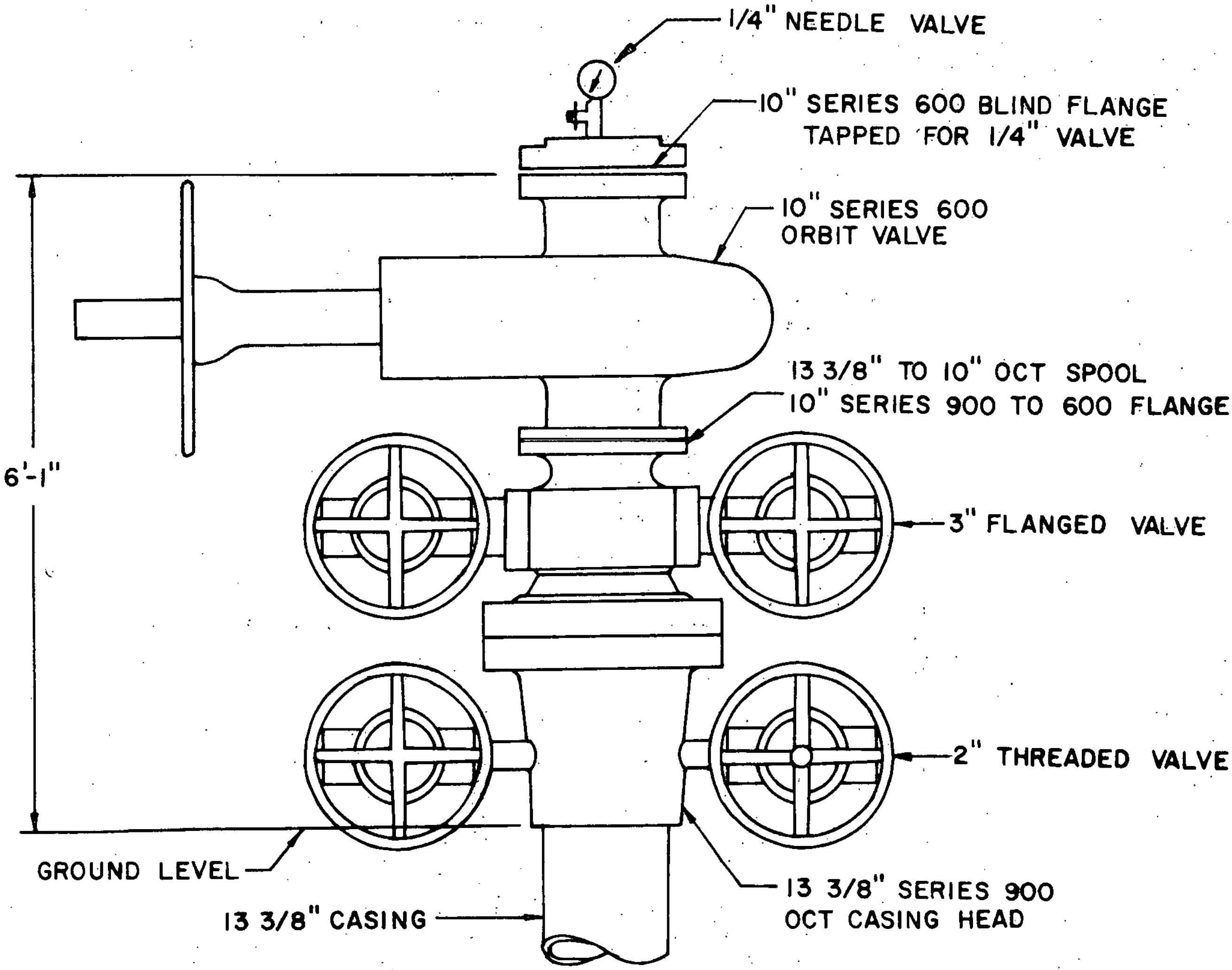

Figure 5.--Well-head equipment of Madison Limestone test well 2.

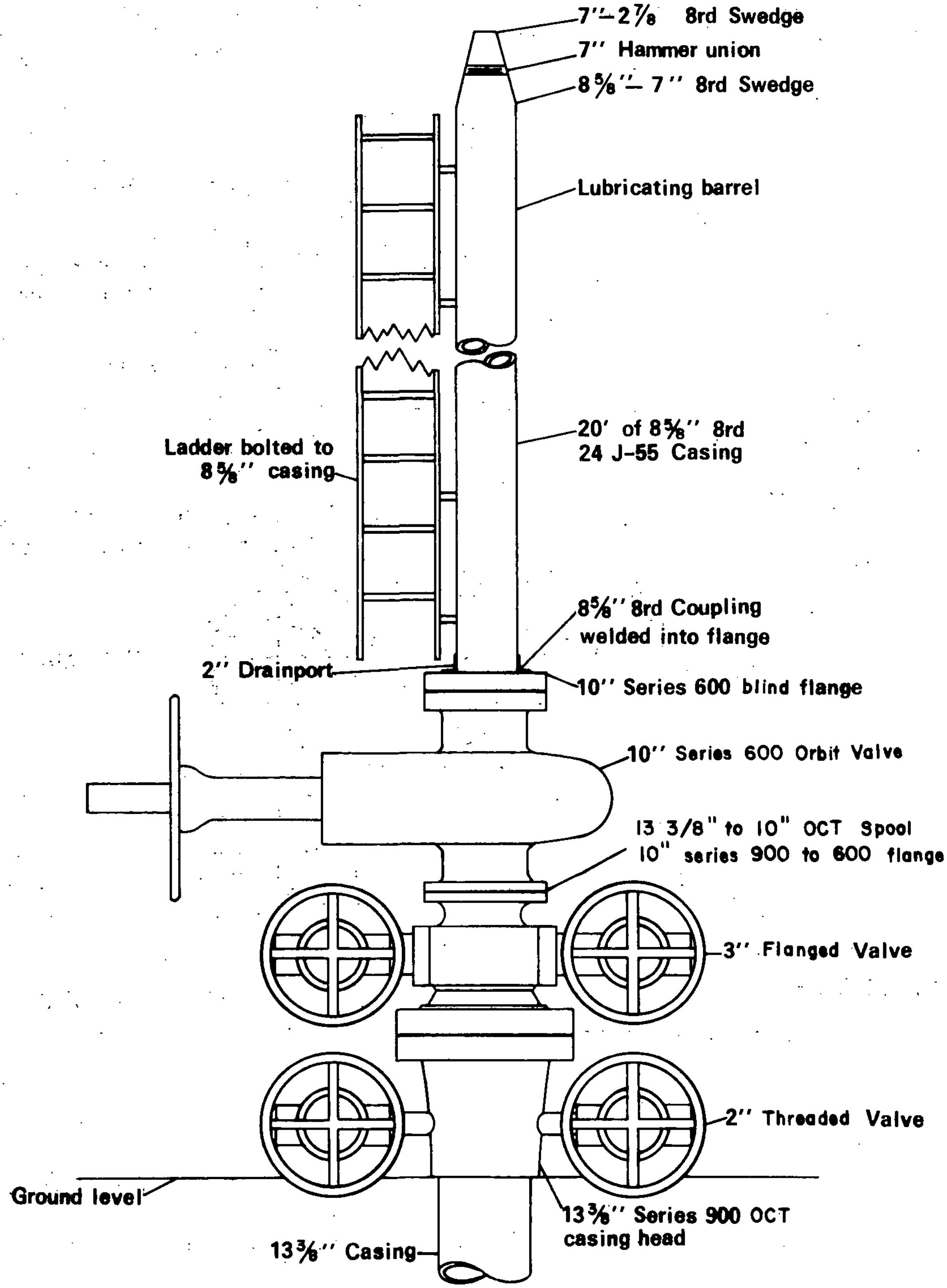

Figure 6.--Well-head equipment of Madison test well 2, with lubricating barrel attached.

Many individuals from the U.S. Geological Survey, other Federal agencies, State agencies, and industry contributed to the successful completion of the Madison test well 2. No attempt will be made to list all the U.S. Geological Survey personnel involved in the operation; however, special recognition must be given to James A. Peterson, Thad W. Custis, James R. Marie, William J. Head, Gilbert Ortiz, Wilbur C. Ballance, Donald L. Coffin, Robert W. Maclay, Lewis W. Howells, William R. Miller, William B. Borchert, Steve A. Strausz, and Marvin A. Crist, for their contributions in the site selection, drilling, operations, and testing of the well.

Fenix and Scisson, Inc., of Tulsa, Okla., prime contractor for the Energy and Research Development Administration (ERDA) at Las Vegas, Nev., assisted with preparation of the drilling specifications and provided a drilling specialist, Ken Ward, at the drill site. Fenix and Scisson also prepared the well history included in this report.

J. R. Kerns and E. T. Hegna of Hegna, Kerns, and Traut, consulting geologists, Casper, Wyo., were employed by the drilling contractor during drilling operations. They assisted with selection of cored intervals and identified formation tops. Their descriptions of cuttings and cores are included in this report. Continental Laboratories were employed by the drilling contractor to supply a hydrocarbon well log (pl. 2). Geophysical logging was done by Birdwell Division, Seismograph Service Corp., and Schlumberger Well Services. Packer tests were run by Lynes, Inc., with interpretation by Roger L. Hoeger. Other companies, too numerous to mention, were involved in the drilling, coring, fishing, and cementing operations.

Core preparation, photographs, and gamma-ray-attenuated-porosity-evaluator (GRAPE) logs were provided by Marathon Oil Research Center, Denver, Colo. Analysis of core and hydrologic properties was by Core Laboratories, Inc., Denver, Colo.

Test-well history

The following historical data on the test well including time breakdown, hole history, core record, bit record, deviation surveys, and log index sheet were photo copied from the Fenix and Scisson report provided to the U.S. Geological Survey at the completion of the drilling, coring, and preliminary logging and testing of Madison Limestone test well 2. The mud report is from the Hegna, Kerns, and Traut report.

FENIX & SCISSON, INC.

HOLE HISTORY DATA

DATE: 6-16-77 APPROVED:

HOLE NO.: Madison #2	W. O. NO.:	I. D. NO.:
USER: USGS	TYPE HOLE: Exploratory	
LOCATION Montana	COUNTY: Custer	AREA: Powderville
SURFACE COORDINATES: SE/4, SE/4, Sec. 18, T1N, R54E		
GROUND ELEVATION: 2793'	PAD ELEVATION:	TOP CASING ELEVATION:
RIG ON LOCATION: 11-10-76	SPUDDED: 11-17-76	COMPLETED: 4-28-77
CIRCULATING MEDIA: Mud		
MAIN RIG & CONTRACTOR	NO. OF COMPRESSORS & CAPACITY:	

BORE HOLE RECORD			CASING RECORD							
FROM	TO	SIZE	I. D.	WT./FT.	WALL	GRADE	CPL'G.	FROM	TO	CU. FT. CMT.
0'	7'	Excav.*		(8' x 8' cellar)				0'	7'	Dirt
7'	54'	36"*	30"			CMP		7'	54'	?
54'	407'	26"	19.124"	94#		H-40	Buttress	3'	407'	1001**
407'	4663'	17½"	(See Page 4)					0'	4662'	6305***
4663'	6489'	12¼"	8.835"	40#		S-80	ST&C	4519'	6487'	1122
6489'	9378'	8½"								

TOTAL DEPTH: 9378' GL	AVERAGE MANDREL DEPTH:	FROM REFERENCE ELEVATION @
JUNK & PLUGS LEFT IN HOLE: Plugged back from 8422' to 9378'		
SURVEYS PAGE: 14	CORING PAGE: 12	CU. FT. CMT. TOTAL IN PLUGS, ETC: 525
LOGGING DATA: Page 15		
BOTTOM HOLE COORDINATES:		REFERENCE:

RIGS USED *(Site Prep Rigs *)*

RIG NO.	NAME	TYPE	CLASS	DAYS OPERATING	SECURED W CREW	SECURED W/O CREW	TOTAL DAYS ON LOC.
8	JRK Drilling Co. (Anderson Drilling Co. Rig)	National 80B		162.08	0.45	-	162.53

REMARKS: * *Site Prep Items*

** Approximately 200 ft^3 circulated to surface.

*** Approximately 728 ft^3 circulated to surface.

NOTE: Depths shown are from ground level elevation 16' below kelly bushing elevation. T.D. 9378' (G.L.) = 9394' (KB)

PREPARED BY: WDS:sjw TIME BREAKDOWN ON NEXT PAGE

Madison #2

TIME BREAKDOWN

SITE PREPARATION

DRILLING OPERATION TIME (DOT)		OTHER SCHEDULED TIME (OST)		OPERATIONAL DELAY TIME (ODT)	
DRILL		MOVE		RIG REPAIRS	
TRIPS		RUN CASING		W. O. DRILLING SUPPLIES	
SURVEYS		CEMENT CASING		CLEAN OUT FILL	
				SECURED WITH CREWS	
SITE DOT ____ DAYS		SITE OST ____ DAYS		SITE ODT ____	

TOTAL SITE PREP TIME ____ DAYS | REMARKS:

MAIN HOLE CONSTRUCTION

DRILLING OPERATION TIME (DOT)		OTHER SCHEDULED TIME (OST)		OPERATIONAL DELAY TIME (ODT)	
DRILL	29.19	MOBILIZATION & DEMOBILIZATION		RIG REPAIRS	1.92
TRIPS	10.67	CORE	16.19	W. O. EQUIPMENT & Supplies	2.25
DRESS DRILLING ASSEMBLY		LOG	6.00	FISH	10.17
SINGLE SHOT DEV. SURVEYS	0.80	CASED HOLE DIR. SURVEYS		CLEAN OUT FILL	0.99
OPEN HOLE DIRECTION SURVEYS		UNLOAD CASED HOLE		UNLOAD WATER INFLOW	
Open Hole	34.10	RUN MANDREL		REAM CROOKED HOLE	
		HYDROLOGICAL TESTS	29.86	PLUG BACK	
		Nipple Up	4.37	DRILL OUT PLUGS	
MAIN HOLE DOT 74.76 DAYS		Circulate Samples	1.37	SECURED WITH CREWS	0.45
CASING OPERATION TIME (COT)		Plug Back	1.00		
RUN 20" CASING	0.43	Lay Down Drill Pipe	0.92	Clean Out Plugged Bit	1.40
RUN 13-3/8" CASING	1.49				
CEMENT 20" CASING	0.67			Repair Blow Out Preventer	1.18
CEMENT 13-3/8" CASING	1.12			Circulate & Mix Mud	1.18
DRILL OUT SHOE	1.84			Thaw Out Rig	1.18
*	1.79				
MAIN HOLE COT 7.34 DAYS		MAIN HOLE OST 59.71 DAYS		MAIN HOLE ODT 20.72 DAYS	

TOTAL MAIN HOLE CONST. TIME 162.53 DAYS | REMARKS:

TOTAL ELAPSED TIME

TOTAL SITE PREP TIME		DAYS
TOTAL MAIN HOLE CONST. TIME	162.53	DAYS
SEC. W/O CREW SITE PREP		DAYS
SEC. W/O CREW MAIN HOLE CONST.		DAYS
TOTAL SUSPENDED (NO RIG)		DAYS
TOTAL ELAPSED TIME	162.53	DAYS

REMARKS:

* Run 9-5/8" Liner	0.37 Days
Cement 9-5/8" Liner	1.42 Days

MADISON #2

HOLE HISTORY

11-7-76	Site prep work consisted of an 8' x 8' cellar set at 7' below ground level with 30" CMP set at 54' below ground level in a 36" hole and cemented with ready mix cement.
11-10-76	Anderson Drilling Company rig #8 was moved in and crews started rigging up.
NOTE:	All depths reported from kelly bushing elevation (KB) 16' above ground level (GL) unless otherwise noted.
11-17-76	Rigging up was completed at 0330 hours. Drilled 17½" hole from 70' to 330' using conventional circulation with mud.
11-18-76	Drilled 17½" hole from 330' to 430'. Pulled out of hole and made up 26" hole opener. Opened 17½" hole to 26" from 70' to 146'.
11-19-76	Opened 17½" hole to 26" from 146' to 357'.
11-20-76	Opened 17½" hole to 26" from 357' to 423'. Rigged up to run casing.
11-21-76	Ran 10 joints (425.62') of 20" O.D., H-40, 94# buttress thread casing and landed at 406.62' (GL). Casing had a Baker BX guide shoe on bottom and a Baker latch-in type float collar at 363.62' (GL). Centralizers were placed at 406', 367', 326', 283', 243', 201', 159' and 117'. All ground level measurements. Ran latch-in tool in the hole and latched into the float collar. Cemented annulus using Halliburton with 520 sacks (801 ft^3) of "Light" cement, 3% calcium chloride and 1/4# per sack of Flocele followed by 200 sacks (230 ft^3) of Class "G" cement, 2% calcium chloride and 1/4# per sack of Flocele. Cement in place at 1115 hours. Approximately 200 ft^3 of "Light" cement circulated to surface. Waited on cement.
11-22-76	Cut off 20" O.D. casing and welded on a 20" National Series 600 casinghead. Started connecting up blow out equipment.
11-23-76	Completed connecting up blow out equipment consisting of a 20" Shaffer single ram preventer on top of the casinghead followed by a 20" Hydril MSP-2000 preventer with a Grant rotating head on top. Drilled out float collar with a 17½" bit and pressured up on the Hydril preventer, top seals were out of the preventer. Removed connections and waited on repairs at 1915 hours.
11-24-76	Waited on Hydril serviceman to 0600 hours. Worked on preventer and found piston cemented in. Replaced with a new Hydril preventer.
11-25-76	Connected up new preventer and tested to 1000 psi for 30 minutes. Drilled out cement and shoe with a 17½" bit. Made trip for 8½" bit.
11-26-76	Ran 8½" bit in the hole with a junk sub. Circulated hole clean and drilled 8½" hole from 430' to 778'. Circulated hole, ran out of water at 1900 hours.

11-27-76	Thawed out rig to 1230 hours, ice in diesel oil lines. Drilled 8½" hole from 778' to 950'. Shut down at 2130 hours to thaw out diesel lines.
11-28-76	Thawed out rig to 1245 hours. Drilled 8½" hole from 950' to 1078'. Pulled out of hole.
11-29-76	Made up Christensen core barrel with an 8½" x 4" diamond bit and cut core #1 from 1078' to 1108', recovered 28'.
11-30-76	Ran 8½" bit in the hole, washed and reamed 60' to bottom and drilled from 1108' to 1430'.
12-1-76	Drilled 8½" hole from 1430' to 1935'.
12-2-76	Drilled 8½" hole from 1935' to 1969' and pulled out of hole. Made up core barrel with 8½" core bit and cut core #2 from 1969' to 1999', recovered 25'. Ran 8½" bit in the hole, reamed 30' to bottom and drilled from 1999' to 2250'.
12-3-76	Drilled 8½" hole from 2250' to 3055'.
12-4-76	Drilled 8½" hole from 3055' to 3621'. Made trip for bit at 3442' and reamed 60' to bottom.
12-5-76	Drilled 8½" hole from 3621' to 4154'.
12-6-76	Drilled 8½" hole from 4154' to 4343' and pulled out of hole. Made up core barrel with an 8½" core bit and ran in hole. Core barrel was plugged, pulled out of hole.
12-7-76	Cleaned out core barrel. Ran 8½" bit in the hole and washed 106' to bottom at 4343'. Pulled bit and ran core barrel back in hole. Cleaned out 25' of fill and cut core #3 from 4343' to 4369'.
12-8-76	Recovered 26' on core #3. Ran 8½" bit in the hole, reamed core hole and drilled from 4369' to 4640'.
12-9-76	Drilled 8½" hole from 4640' to 4682'. Measured out of hole and corrected depth to 4677'. Ran Birdwell logs.
12-10-76	Continued running logs.
12-11-76	Completed logging. Ran 8½" bit in the hole and washed 25' to bottom. Conditioned hole for testing and pulled bit.
12-12-76	Made up Lynes test tool and ran drill stem test #1 from 4300' to 4680'. Tool opened at 0512 hours and completed test at 0830 hours. Laid down tool. Made up 12¼" hole opener and reamed hole from 406' to 430'. Opened 8½" hole to 12¼" from 430' to 746'.

12-13-76	Opened 8½" hole to 12¼" from 746' to 1354'.
12-14-76	Opened 8½" hole to 12¼" from 1354' to 1870'.
12-15-76	Opened 8½" hole to 12¼" from 1870' to 2356'.
12-16-76	Opened 8½" hole to 12¼" from 2356' to 2769'. Made trip for hole opener at 2538'.
12-17-76	Opened 8½" hole to 12¼" from 2769' to 3340'.
12-18-76	Opened 8½" hole to 12¼" from 3340' to 3698'. Pulled out of hole and left 3 cutters in the hole. Picked up junk sub and made up 12¼" reamer.
12-19-76	Ran in hole and opened 8½" hole to 12¼" from 3698' to 4130'.
12-20-76	Opened 8½" hole to 12¼" from 4130' to 4324'. Made trip for hole opener at 4162'.
12-21-76	Opened 8½" hole to 12¼" from 4324' to 4668'.
12-22-76	Opened 8½" hole to 12¼" from 4668' to 4677'. Pulled out of hole and left 1 cutter in the hole. Made up 17½" hole opener and ran in hole. Opened 12¼" hole to 17½" from 430' to 828'.
12-23-76	Opened 12¼" hole to 17½" from 828' to 1310'. Made trip at 1180', bit had balled up.
12-24-76	Opened 12¼" hole to 17½" from 1310' to 1870'.
12-25-76	Opened 12¼" hole to 17½" from 1870' to 2437'.
12-26-76	Opened 12¼" hole to 17½" from 2437' to 2980'
12-27-76	Opened 12¼" hole to 17½" from 2980' to 3430'. Made trip for hole opener at 3286'.
12-28-76	Opened 12¼" hole to 17½" from 3430' to 3888'.
12-29-76	Opened 12¼" hole to 17½" from 3888' to 4156'. Pulled out of hole, had a few tight places in hole.
12-30-76	Trip in hole with new reamer, cleaned out bridges, washed and reamed to bottom. Opened 12¼" hole to 17½" from 4156' to 4216'.
12-31-76	Opened 12¼" hole to 17½" from 4216' to 4410'.
1-1-77	Opened 12¼" hole to 17½" from 4410' to 4626'.
1-2-77	Opened 12¼" hole to 17½" from 4626' to 4677'. Conditioned mud.
1-3-77	Pulled out of hole and ran Birdwell logs. Made up 11-5/8" O.D. Globe basket and junk sub and ran in hole.

1-4-77 Pulled out of hole, no recovery. Made second trip with the basket, no recovery. Ran 10½" O.D. magnet in the hole, recovered approximately 1 quart of bearings and pieces of cones. Ran magnet back in hole.

1-5-77 Pulled magnet, no recovery. Made trip with 17½" hole opener and conditioned hole to run casing. Started running 13-3/8" O.D. casing.

1-6-77 Completed running 13-3/8" O.D., ST&C casing, set at 4677.70' (4661.70' GL) with a Baker guide shoe on bottom and a latch-in type float collar at 4631.13' (4615.13' GL). The casing was run as follows:

No. Joints	Weight Per Foot	Grade	Interval (GL)
21	68.00#	S-80	4661.70' - 3733.48'
37	61.00#	S-80	3733.48' - 2086.63'
53	54.50#	K-55	2086.63' - 0'

Centralizers were placed at 4649', 4625', 4558' and 4520', all ground level measurements. Then one centralizer on every other collar to 1136' and one on every fourth collar to 515' and then one at 250' from surface. Ran latch-in tool in the hole on 4½" drill pipe and latched into collar. Cemented annulus using Halliburton with 6017.5 ft^3 (2065 sacks) of Class "G" cement, 16% gel, 3% salt, 0.2% CFR-2 and 1/4# per sack of Flocele followed by 287.5 ft^3 (250 sacks) of Class "G" cement and 1/4# per sack of Flocele. Cement in place at 1610 hours. Circulated out 250 sacks (728 ft^3) of cement. Waited on cement.

1-7-77 Waited on cement to 0900 hours. Cut off the 20" O.D. casing below ground level and welded a flange on the 13-3/8" O.D. casing.

1-8-77 Installed Cameron and Hydril blow out preventers on the flange and started nippling up.

1-9-77 Completed nippling up. Pressure tested blow out equipment to 1000 psi. Ran 12¼" bit in the hole and drilled out float equipment.

1-10-77 Completed drilling out cement and shoe. Pressure tested blow out equipment to 1000 psi. Pulled out of hole and made up 8½" drilling assembly. Ran in hole and corrected total depth from 4677' to 4679' for hole made while fishing with a 11-3/4" Globe basket. Drilled 8½" hole from 4679' to 4831'.

1-11-77 Drilled 8½" hole from 4831' to 4870', measured out of the hole and corrected depth to 4877'. Made trip with a magnet, no recovery. Made up Christensen 6-3/4" core barrel with an 8½" diamond core bit and cut core #4 from 4877' to 4907'.

1-12-77 Pulled out of hole and recovered 25' on core #4. Made up 8½" drilling assembly and drilled from 4907' to 5108'.

1-13-77	Drilled 8½" hole from 5108' to 5410'.
1-14-77	Drilled 8½" hole from 5410' to 5654'.
1-15-77	Drilled 8½" hole from 5654' to 5850'.
1-16-77	Drilled 8½" hole from 5850' to 6085'.
1-17-77	Drilled 8½" hole from 6085' to 6140'.
1-18-77	Drilled 8½" hole from 6140' to 6327'.
1-19-77	Drilled 8½" hole from 6327' to 6470'. Circulated samples to surface.
1-20-77	Pulled out of hole and made up core barrel with 8½" bit. Cut core #5 from 6470' to 6540'.
1-21-77	Continued cutting core #5 from 6540' to 6556', recovered 88'. Ran Schlumberger logs.
1-22-77	Completed running logs. Made trip with 8½" bit and conditioned mud.
1-23-77	Made up Lynes straddle packers and ran in hole on 4½" drill pipe for drill stem test #2. Set packers from 6138' to 6248' and opened tool at 0715 hours, packer failed at 0930 hours. Pulled out of hole. Repaired tool and ran back in hole for drill stem test #3. Set packers from 6134' to 6244', opened tool at 2310 hours.
1-24-77	Completed test at 0700 hours. Worked packers loose and pulled out of hole. Made trip with 8½" bit and conditioned mud.
1-25-77	Made up test tool and ran in hole, set packers from 4898' to 4916' for drill stem test #4. Opened tool at 0537 hours and completed test at 1007 hours. Made up 12¼" hole opener and ran in hole.
1-26-77	Opened hole from 4679' to 4976'. Made trip for hole opener at 4715', bit locked.
1-27-77	Opened 8½" hole to 12¼" from 4976' to 5337'.
1-28-77	Opened 8½" hole to 12¼" from 5337' to 5588'. Made trip for hole opener at 5485'.
1-29-77	Opened 8½" hole to 12¼" from 5588' to 5625'. Made trip for hole opener at 5621'.
1-30-77	Opened 8½" hole to 12¼" from 5625' to 5789'. Pulled out of hole.
1-31-77	Changed out hole opener and ran in hole. Opened 8½" hole to 12¼" from 5789' to 5900'.

2-1-77	Opened 8½" hole to 12¼" from 5900' to 6056'. Pulled out of hole.
2-2-77	Changed out reamer and ran in hole. Opened 8½" hole to 12¼" from 6056' to 6107'.
2-3-77	Opened 8½" hole to 12¼" from 6107' to 6181'.
2-4-77	Opened 8½" hole to 12¼" from 6181' to 6230'. Made trip for reamer at 6204'.
2-5-77	Opened 8½" hole to 12¼" from 6230' to 6291'.
2-6-77	Opened 8½" hole to 12¼" from 6291' to 6357'.
2-7-77	Opened 8½" hole to 12¼" from 6357' to 6388'. Made trip for hole opener at 6367'.
2-8-77	Opened 8½" hole to 12¼' from 6388' to 6429'. Made trip for hole opener at 6409'.
2-9-77	Opened 8½" hole to 12¼" from 6429' to 6461'.
2-10-77	Opened 8½" hole to 12¼" from 6461' to 6505'. Conditioned hole and pulled hole opener.
2-11-77	Ran Birdwell caliper log. Ran 45 joints of 9-5/8" O.D., 40#, S-80, Range 3, ST&C casing for a liner in the hole on 4½" drill pipe with a Brown Oil Tool float shoe on bottom and a Brown type 1 landing collar at 6455' (6439' GL). Overall length of liner assembly was 1968.20'. Tagged bottom at 6505' and landed liner at 6503' (6487' GL) with the top of the Brown CMC liner hanger at 4535' (4519' GL). Centralizers at 6493', 6466' and 6445' KB with centralizers on every other collar from joint #4 thru #35, joint #35 and #39.
2-12-77	Cemented annulus using Halliburton with 532 ft^3 (350 sacks) of "Light" cement, 10% salt and 0.75% CFR-2 followed by 590 ft^3 (500 sacks) of Class "G" cement, 10% salt and 0.75% CFR-2. Cement in place at 0500 hours. Displaced cement with 5 barrels of water followed by 191 barrels of mud, good returns to surface. Released liner running tool and pulled out of hole. Waited on cement to 2000 hours. Ran 12¼" bit in the hole and tagged cement at 3908'.
2-13-77	Waited on cement until 0500 hours. Drilled cement from 3908' to 4520'. Made trip for 8½" bit and drilled cement from 4520' to 4579', had void to 6379'. Top of liner at 4535'.
2-14-77	Pressured up to 1000 psi for 30 minutes. Drilled out cement, landing collar and shoe from 6379' to 6503' and cleaned out fill to 6554'.

2-15-77 Cleaned out fill to 6559' and drilled 8½" hole to 6574'. Circulated hole clean and pulled out of hole. Made trip with a magnet and junk basket, recovered bearings and buttons. Ran back in hole.

2-16-77 Fished with magnet, recovered 1 quart of junk. Magnet had hit the top of the liner and the skirt was torn up. Made trip with the magnet and recovered 1 quart of junk. Made trip with an 8½" bit to check liner top, liner not damaged. Made up 8½" diamond bit and core barrel. Reamed 30' to bottom and cut core #6 from 6574' to 6577'.

2-17-77 Completed core #6 from 6574' to 6664', recovered 89'. Made up 8½" bit and 3 point reamer. Trip in hole.

2-18-77 Reamed 23' to bottom and drilled 8½" hole from 6664' to 6715'. Circulated samples and pulled out of hole. Made up core barrel and ran in hole. Cut core #7 from 6715' to 6745'.

2-19-77 Recovered 27.2' on core #7. Cut core #8 from 6745' to 6775', recovered 30.7'. Ran 8½" bit in the hole, measuring drill pipe.

2-20-77 Corrected depth from 6775' to 6784'. Drilled 8½" hole from 6784' to 6948' and twisted drill pipe off. Pulled out of hole and left drilling assembly, 7 drill collars in the hole.

2-21-77 Made up overshot and ran in hole, latched onto fish and recovered same. Ran 8½" bit in the hole and drilled from 6948' to 7034'.

2-22-77 Drilled 8½" hole from 7034' to 7070'. Pulled out of hole and ran magnetic particle inspection on the drill collars. Made up core barrel with an 8½" core bit and ran in hole. Cut core #9 from 7070' to 7078'.

2-23-77 Completed core #9 from 7078' to 7128', recovered 54'. Trip in with 8½" bit.

2-24-77 Drilled 8½" hole from 7128' to 7267'.

2-25-77 Drilled 8½" hole from 7267' to 7370'.

2-26-77 Pulled out of hole and ran 8½" core bit. Cut core #10 from 7370' to 7401', hole making water.

2-27-77 Completed core #10 from 7401' to 7422', recovered 51'. Face of core bit damaged. Ran 8½" bit and junk sub in the hole. Drilled 8½" hole from 7422' to 7444'.

2-28-77 Drilled 8½" hole from 7444' to 7600'. Circulated samples and pulled out of hole.

3-1-77 Made up 8½" coring assembly and ran in hole. Cut core #11 from 7600' to 7623'.

3-2-77	Recovered 22.5'on core #11. Cut core #12 from 7623' to 7625', recovered 2'. Ran 8½" bit in the hole and drilled from 7625' to 7640'. Circulated samples.
3-3-77	Pulled out of hole. Ran 8½" core bit in the hole and cut core #13 from 7640' to 7693'.
3-4-77	Completed core #13 from 7693' to 7700', recovered 59'. Cut core #14 from 7700' to 7760'.
3-5-77	Recovered 59' on core #14. Cut core #15 from 7760' to 7820', recovered 60'.
3-6-77	Cut core #16 from 7820' to 7865', recovered 38'. Ran 8½" bit in the hole and drilled from 7865' to 7924'.
3-7-77	Drilled 8½" hole from 7924' to 8083'. Circulated samples at 7975'.
3-8-77	Drilled 8½" hole from 8083' to 8215'. Circulated samples to surface. Pulled out of hole.
3-9-77	Made up 8½" core bit and cut core #17 from 8215' to 8238', recovered 21'. Ran 8½" bit in the hole and drilled from 8238' to 8311'.
3-10-77	Drilled 8½" hole from 8311' to 8532'.
3-11-77	Drilled 8½" hole from 8532' to 8624'. Made trip for bit at 8621' and reamed 30' to bottom.
3-12-77	Drilled 8½" hole from 8624' to 8782'. Circulated samples at 8668'.
3-13-77	Drilled 8½" hole from 8782' to 8934'. Bit plugged, pulled out of hole.
3-14-77	Ran 8½" bit in the hole and hit top of liner at 4535'. Pulled out of hole and found bit split. Changed out bit and made trip. Drilled 8½" hole from 8934' to 9045'. Circulated out approximately 200 barrels of water after being shut down for rig service.
3-15-77	Drilled 8½" hole from 9045' to 9216'.
3-16-77	Drilled 8½" hole from 9216' to 9291'. Pulled out of hole, had inflow of water. Changed out bit, reamed and washed 115' to bottom, had water inflow. Drilled 8½" hole from 9291' to 9298'. Mixed mud to control water flow.
3-17-77	Drilled 8½" hole from 9298' to 9340' and hole started flowing water. Pulled bit into casing and closed blow out preventer rams. Shut in pressure was 125 psi. Mixed mud building weight to approximately 10.5# per gallon. Ran in hole with bit and tagged 47' of fill in the hole, plugged bit. Pulled out 5 stands and cleared bit, pumped in approximately 750 barrels of mud. Pulled bit inside casing and mixed additional mud.

3-18-77 Ran back in hole and displaced water with mud. Started washing and reaming 175' off bottom. Drilled 8½" hole from 9340' to 9375'. Circulated samples.

3-19-77 Made trip for bit, washed and reamed out of gauge hole to 9375'. Made trip with a magnet, no recovery.

3-20-77 Ran 8½" core bit in the hole, washed to bottom and rotary table locked up. Pulled core barrel and replace rotary table.

3-21-77 Completed repairs. Ran core barrel back in the hole and washed to bottom. Cut core #18 from 9375' to 9388'.

3-22-77 Recovered 11' on core #18. Cut core #19 from 9388' to 9394', recovered 6'. Ran Schlumberger logs.

3-23-77 Completed Schlumberger logs. Ran Birdwell logs.

3-24-77 Completed Birdwell logs. Made trip to condition hole for testing.

3-25-77 Ran Lynes dual packers in the hole on 2-7/8" O.D. tubing. Waited on daylight to open tool.

3-26-77 Set packers from 9300' to 9394'. Opened tool at 0805 hours for drill stem test #5, fluid started dropping in the annulus. Laid down packers, packer rubber had ruptured.

3-27-77 Changed out packers. Ran back in hole with packer spacing from 9228' to 9262' and set at 1305 hours for drill stem test #6. Rigged up to swab and could not get below 50'. Replaced tubing subs and reset packers.

3-28-77 Waited until daylight to open tool. Ran drill stem test #6A from 0630 hours to 1600 hours. Opened tool to test below and between packers for drill stem test #7 at 1600 hours.

3-29-77 Continued testing. Filled tubing with water and could not release packers. Worked tubing attempting to free packers.

3-30-77 Continued working stuck test tool.

3-31-77 Continued working stuck test tool. Ran Otis bailer and sand pump and caught water samples. Ran McCullough free point indicator, tool not working properly.

4-1-77 Continued working stuck test tool. McCullough free point indicator showed 2-7/8" O.D. tubing free at 6900'. Perforated tubing with McCullough Chem Shot, two 3/8" hole 180° apart at 9119.5'. Broke circulation and circulated hole while working tubing.

4-2-77 Continued working tubing and circulating mud. Waited on Otis tools until 1930 hours. Ran Otis sand pump inside the 2-7/8" O.D. tubing.

4-3-77 Ran sand pump to 9185' for several runs and tubing began to fill up to 9150'. Recovered heavy mud with some sand and shale. Ran McCullough free point indicator, tubing stuck at 6845'. Ran chemical shot and cut tubing at 6807'. Started pulling tubing.

4-4-77 Completed pulling tubing. Ran Rucker Acme overshot, jars and bumper sub in the hole. Worked over fish and jarred loose. Pulled out of hole.

4-5-77 Laid down 2-7/8" O.D. tubing and Lynes packers, recovered all of fish except top rubber off of the top dual packer. Made trip with 8½" bit and conditioned mud for testing.

4-6-77 Made up Lynes test tool for drill stem test #8. Made 4 trips with tool, could not get past liner top on 2 trips and could not set packers on 2 trips.

4-7-77 Made trip with straddle packers and also with a standard test tool, could not set packers. Made up Lynes straddle packers and started in hole on 2-7/8" O.D. tubing.

4-8-77 Set packers to test zone from 8115' to 8335' for drill stem test #8. Started test at 0805 hours.

4-9-77 Completed test at 0530 hours. Released packers and pulled out of hole. Dressed test tool and ran in hole to test zone from 8030' to 8250' for drill stem test #9. Could not set packers.

4-10-77 Pulled tool and found bottom packer had ruptured. Made trip with 8½" bit to 8700' and conditioned mud.

4-11-77 Ran Birdwell logs. Made up Lynes straddle packers and ran in hole on 2-7/8" O.D. tubing for drill stem test #10.

4-12-77 Set packers from 8115' to 8355'. Opened tool at 0854 hours and started test.

4-13-77 Continued testing to 1830 hours. Pulled up the hole and reset packers from 7775' to 8015' for drill stem test #11.

4-14-77 Started test at 0115 hours and continued to 2100 hours. Released packers and pulled out of hole.

4-15-77 Completed pulling out of hole. Changed out test tool and ran in hole. Set packers from 6449' to 6689' for drill stem test #12. Started test at 1930 hours.

4-16-77 Continued testing to 0245 hours. Reset packers from 6814' to 7054' for drill stem test #13. Started test at 0711 hours.

4-17-77 Continued testing to 0515 hours. Reset packers from 7074' to 7314' for drill stem test #14. Started test at 0932 hours and completed at 1515 hours. Reset packers from 7064' to 7304' for drill stem test #14A. Started test at 1700 hours.

4-18-77 Completed test at 1130 hours. Reset packers from 6449' to 6689' to check drill stem test #12. Released packers at 1630 hours and pulled out of hole. Started in hole with an 8½" bit.

4-19-77 Completed trip to condition mud for further testing. Made up test tool with dual packers and started in hole with 2-7/8" O.D. tubing.

4-20-77 Completed trip in hole and set packers from 7305' to 7545' for drill stem test #15. Started test at 0800 hours and completed at 1600 hours. Reset packers from 7525' to 7765' for drill stem test #16. Started test at 1730 hours.

4-21-77 Completed test at 1700 hours. Moved up hole 10' and set packers from 7515' to 7755' for bypass test. Opened tool at 1830 hours.

4-22-77 Completed test at 0100 hours and pulled out of hole. Made up double packer test tool and ran in hole on 2-7/8" O.D. tubing.

4-23-77 Set packers at 8520' to test zone from 8520' to total depth at 9394' for drill stem test #17. Started test at 0300 hours and continued to 1430 hours. Released packers and conditioned mud and build up volume.

4-24-77 Conditioned mud, worked tool loose and laid down tubing and test tool.

4-25-77 Laid down tubing and loaded out test holes.

4-26-77 Laid down drill collars. Ran 4½" drill pipe in hole open ended and pushed packer rubber to bottom at 9394'. Plugged back hole using Halliburton with 220.8 ft^3 (120 sacks) of "Light" cement, 1# of mud kill per sack and 0.2% of HR-4. Top of cement at 9100'. Cement in place at 1905 hours. Pulled up the hole to 8900' and set plug #2 with 304.2 ft^3 (180 sacks) of "Light" cement, 1# of mud kill per sack and 0.2% of HR-4. Top of cement at 8450'. Cement in place at 1930 hours. Pulled out of hole.

4-27-77 Removed blow out preventers and installed well head equipment. Ran drill pipe in the hole and tagged cement at 8438'. Displaced mud from the hole. Laid down drill pipe. Hole flowing muddy water.

4-28-77 Laid down drill pipe and connected 2" flow line from hole to pit. Rig released at 1600 hours. Drilling operations completed.

CORE RECORD

Core No.	Interval Ft.	RPM	Weight On Bit 1000#	Circulating Pressure psi	Feet Cored	Feet Recovered
1	1078' - 1108'	60	15-18	850	30	28
2	1969' - 1999'	50	16	850	30	25
3	4343' - 4369'	50	15-18	800	26	26
4	4877' - 4907'	40	20	900	30	25
5	6470' - 6556'	42	20	800	86	88
6	6574' - 6664'	40	20	750	90	89
7	6715' - 6745'	40	20	800	30	27.2
8	6745' - 6775'	40	20	800-850	30	30.7
9	7070' - 7128'	43-40	20	900	58	54
10	7370' - 7422'	40-44	20-22	850-1000	52	51
11	7600' - 7623'	45	20-25	1000	23	22.5
12	7623' - 7625'	42	25	1000	2	2
13	7640' - 7700'	40	20-25	1000	60	59
14	7700' - 7760'	40	25	1000	60	59
15	7760' - 7820'	40	25	1000	60	60
16	7820' - 7865'	40	25	1000	45	38
17	8215' - 8238'	40	25	750	23	21
18	9375' - 9388'	44	25	1100	13	11
19	9388' - 9394'	36	25	1450	6	6
				TOTALS	754	722.4

BIT RECORD

Bit No.	Make	Size	Type	Depth Out	Feet Drilled	Rotating Hours	
1	Hughes	17½"	OSC3A	430'	360'	23½	Retip
2	Grant	26"	Hole Opener	423'	353'	31-3/4	
3	Security	8½"	S35	1078'	648'	30¼	
4	Security	8½"	S35	1965'	887'	39½	
5	Security	8½"	S3J	3442'	1443'	40¼	
6	Security	8½"	S4TGJ	4343'	901'	35-3/4	
7	Security	8½"	S4TGJ				Fill
8	Security	8½"	M44N	4677'	313'	20-3/4	
9	Grant	12¼"	Hole Opener	2538'	2108'	84½	
10	Grant	12¼"	Hole Opener	3698'	1160'	48-3/4	
11	Grant	12¼"	Hole Opener	4162'	464'	24	
12	Grant	12¼"	Hole Opener	4677'	515'	37-3/4	
13	Grant	17½"	Hole Opener	3286'	2856'	117½	
14	Grant	17½"	Hole Opener	4156'	870'	52	
15	Grant	17½"	Hole Opener	4640'	484'	65¼	
16	Grant	17½"	Hole Opener	4677'	37'	7½	
17	Security	12¼"	S4TJ				Cement
18	Security	8½"	S4TGJ	4877'	198'	14-3/4	
19	Security	8½"	S86F	6133'	1226'	17½	
20	Security	8½"	M89F	6470'	337'	46	
6 Rerun	Security						Circulate
21	Grant	12¼"	Hole Opener	4715'	38'	3	
22	Grant	12¼"	Hole Opener	5485'	770'	45½	
23	Grant	12¼"	Hole Opener	5621'	136'	24½	
24	Grant	12¼"	Hole Opener	5789'	168'	19	
25	Grant	12¼"	Hole Opener	6056'	267'	43¼	
26	Grant	12¼"	Hole Opener	6204'	148'	51	
27	Security	12¼'	Hole Opener	6367'	163'	62¼	
28	Grant	12¼"	Hole Opener	6409'	42'	21	
29	Security	12¼"	Hole Opener	6505'	96'	50½	
17 Rerun							Cement
? Rerun		8½"		6574'	15'	4-3/4	& Cement
30	Security	8½"	M4NG	6715'	51'	8¼	
31	Security	8½"	M44L	6948'	164'	19½	
32	Security	8½"	M4NJ	7070'	122'	18¼	
33	Security	8½"	M89F	7370'	242'	44-3/4	
34	Security	8½"	M84F	7600'	178'	24-3/4	
33 Rerun				7640'	15'	2½	
35	Security	8½"	M84F	8215'	350'	41½	
36	Security	8½"	S88F	8621'	383'	45½	
37	Security	8½"	M89TF	8934'	313'	37¼	
35 Rerun				9291'	357'	46¼	
38	Security	8½"	M89F	9375'	84'	13-3/4	
39	Security	8½"	H100F	9375'	0'		

CORE BITS

Bit No.	Make	Size	Type	Depth Out	Feet Drilled	Rotating Hours
1	Christensen	8½"	MC20	1108'	30'	11½
				1999'	30'	5½
				4369'	26'	2-3/4
				4907'	30'	3-3/4
				6559'	89'	15-3/4
				6664'	90'	17-3/4
				6745'	30'	6½
				6775'	30'	12½
				7128'	58'	21½
				7422'	52'	26-3/4
				7625'	25'	17
			TOTAL		490'	140-3/4
2	Christensen	8½"	MC23	7865'	225'	47½
				8238'	23'	3
				9394'	19'	13½
			TOTAL		267'	64

DEVIATION SURVEYS

Date	Depth-Ft.	Deviation-Degrees	Date	Depth-Ft.	Deviation-Degrees
11-17-76	128	1/4	12-3-76	2371	1/2
	260	3/4		2901	3/4
	321	1/2	12-4-76	3149	3/4
11-18-76	397	3/4		3395	3/4
11-26-76	499	3/4	12-5-76	3645	3/4
11-27-76	826	3/4		3900	1
11-28-76	982	3/4	12-6-76	4141	3/4
11-30-76	1196	3/4	12-8-76	4500	1
	1259	1	1-13-77	5171	1
	1339	3/4	1-14-77	5560	1/4
12-1-76	1432	3/4	1-16-77	5968	1/4
	1558	3/4	1-19-77	6375	1/2
	1747	3/4	3-8-77	8215	1
12-2-76	2027	1/2	3-13-77	8934	3/4
	2374	1/2			

LOG INDEX SHEET

Type Log	Date	Run No.	Depth Driller	Depth Logger	Logged From	Logged To
Birdwell Logs						
Electric	12-9-76	1	4677'	4657.5'	416'	4655.5'
Gamma Ray-Induction	12-9-76	1	4677'	4657.5'	416'	4652'
Guard	12-9-76	1	4677'	4657.5'	416'	4651.5'
Caliper	12-10-76	1	4677'	4658'	280'	4654'
3-D Velocity - 3'	12-10-76	1	4677'	4658'	100'	4654'
3-D Velocity - 6'	12-10-76	1	4677'	4658'	60'	4655'
Density Borehole Compensated	12-11-76	1	4677'	4658'	416'	4655'
Temperature	12-11-76	1	4677'	4658'	300'	4658'
Velocity	12-11-76	1	4677'	4658'	430'	4658'
Elastic Properties	12-20-76	1	4677'	4658'	430'	4658'
Caliper	1-3-77	1	4677'	4659'	0'	4649'
Neutron Borehole Compensated	1-3-77	1	4677'	4659'	0'	4654'
Caliper	2-11-77	2	6505'	6505'	4610'	6504'
Caliper	3-22-77	3	9394'	9384'	6400'	9382'
Temperature	3-23-77	3	9394'	9384'	100'	9384'
Gamma Ray - Caliper	4-10-77	3	9394'	NR	6490'	8500'
Schlumberger Logs						
Cement Bond	1-21-77	2	6559'	NR	0'	4678'
Electrical	1-21-77	2	6559'	6566'	4678'	6565'
Compensated Neutron - Formation Density	1-21-77	2	6559'	6566'	4678'	6565'
Dual Laterolog	1-21-77	2	6559'	6567'	4678'	6553'
Dual Induction - Laterolog	1-21-77	2	6559'	6567'	4678'	6561'
Borehole Compensated Sonic	1-21-77	2	6559'	6566'	4678'	6555'
Continuous Dipmeter	1-22-77	2	6559'	6566'	4677'	6565'
Temperature	1-22-77	2	6559'	6567'	62'	6566'
Dual Induction - Laterolog	3-22-77	3	9394'	9396'	6515'	9390'
Fracture Identification	3-22-77	3	9394'	9396'	6512'	9395'

LOG INDEX SHEET

Type Log	Date	Run No.	Depth Driller	Depth Logger	Logged From	Logged To
Schlumberger Logs (cont'd)						
Cement Quality	3-23-77	3	9394'	NR	4668'	6527'
Electrical	3-23-77	3	9394'	9397'	6518'	9396'
Dual Laterolog	3-23-77	3	9394'	9395'	6515'	9382'
Compensated Neutron - Formation Density	3-23-77	3	9394'	9397'	6516'	9396'
Borehole Compensated Sonic	3-23-77	3	9394'	9395'	6515'	9384'
Temperature	3-23-77	3	9394'	9396'	0'	9396'

NOTE: Logs furnished by the USGS.

MUD SUMMARY
(Wyoming Mud Co.)

Date	Depth	Wt.	Visc.	Yld. Pt.	Wtr. Loss	pH	% Solids
11-28-76	1078	8.9	45	5	8.9	9.0	
12- 1-76	1536	9.1	38	10	10.0	9.0	1.75
4	3304	9.2	35	5	9.8	9.5	2
5	3879	9.5	36	5	10.2	10.5	
6	4317	9.2	35	5	10.0	10.5	2
7	4343	9.4	36	5	10.4	10.5	2
8	4404	9.2	44	5	10.4	10.0	2.1
9	4682	9.2	52	10	9.8	9.5	2.3
Reaming to 12¼"							
12-13-76	1270	9.3	42	5	10.1	10.0	1.75
14	1543	9.2	39	5	9.8	10.0	1.5
15	2042	9.2	40	10	14.0	10.0	2
16	2493	9.2	37	5	12.4	10.0	1.5
17	3102	9.3	40	5	9.8	10.0	2.2
18	3465	9.4	40	5	12.4	10.0	2.1
20	4282	9.3	40	5	10.9	10.0	2.2
21	4477	9.3	40	5	12.0	10.0	2.3
Reaming to 17½"							
12-22-76	880	9.3	42	5	10.4	10.0	2.4
23	1033	9.1	40	10	13.4	10.0	2.3
24	1657	9.2	41	5	12.0	10.0	2.1
25	2049	9.3	41	5	11.8	10.0	2.3
27	3400	9.3	42	5	9.8	10.0	2.2
28	3563	9.4	43	5	12.0	10.0	2.2
29	3991	9.4	40	5	10.6	10.0	2.3
30	4156	9.5	40	5	10.2	10.0	4
31	4289	9.5	50	20	8.9	10.0	4
1 - 1-77	4579	9.4	44	5	8.8	10.0	2.3
2	4640	9.4	49	5	9.0	10.0	2.2
5	4677	9.2	55	5	9.8	10.0	2.3
11	4870	8.8	39	5	10.2	10.0	1.8
14	5543	9.0	45	10	6.4	10.0	1.8
15	5717	9.1	55	10	10.4	9.5	4.2
16	5884	9.0	36	5	18.2	10.5	1.5
17	6119	9.1	38	5	10.6	11.0	1.75
18	6267	9.1	38	5	10.2	10.5	2.1
19	6386	9.1	38	5	11.4	10.5	2.1

Mud Summary - 2

Date	Depth	Wt.	Visc.	Yld. Pt.	Wtr. Loss	pH	% Solids
1-20-77	6484	9.1	50	10	10.6	10.5	2.8
24	6559	9.2	45	10	10.8	10.0	3.2
Reaming to 12¼"							
1-28-77	5511	9.1	40	5	14.0	9.0	2.6
29	5615	9.3	39	5	10.2	10.0	2.9
30	5681	9.3	38	5	10.0	10.5	3.0
2- 1-77	6011	9.1	39	10	11.8	10.5	2.8
2	6078	9.1	34	5	12.4	10.5	1.9
4	6199	9.1	41	5	10.8	10.5	2.1
5	6268	9.1	38	5	11.2	10.5	2.0
6	6311	9.1	40	10	11.6	10.5	2.2
8	6413	9.1	38	5	10.8	10.5	2.2
9	6439	9.1	39	5	10.8	10.5	2.1
10	6471	9.1	43	10	10.4	10.5	2.2
Drilling new hole							
2-15-77	6566	8.7	34	5	16.2	10.0	1.8
16	6574	8.7	45	10	10.4	10.5	1.9
17	6624	8.8	41	10	10.8	10.5	1.9
18	6703	8.8	44	15	11.2	10.5	1.9
20	6835	8.9	43	10	11.4	10.5	1.9
22	7070	8.9	42	10	11.2	10.5	1.8
23	7123	8.9	45	10	11.0	10.5	1.9
24	7177	8.9	43	10	10.8	10.5	1.9
25	7292	8.9	42	5	10.6	10.5	1.9
26	7376	8.9	36	0	20.0	10.5	1.7
27	7417	8.9	35	5	10.8	10.5	1.9
28	7499	8.9	42	5	10.6	10.5	1.9
3- 1-77	7621	9.0	40	5	10.8	10.5	
2	7623	9.0	40	5	11.2	10.5	1.9
3	7648	8.8	40	5	11.1	10.5	1.8
4	7703	9.0	41	5	11.2	10.5	1.9
5	7778		43	10	10.6	10.5	1.9
7	7985	8.8	40	10	11.2	10.5	1.9
8	8157	8.8	40	5	11.4	10.5	1.9
11	8583	8.8	46	15	10.8	10.5	1.9
12	8675	8.7	41	10	11.4	10.5	1.8
13							

Mud Summary - 3

Date	Depth	Wt.	Visc.	Yld. Pt.	Wtr. Loss	pH	% Solids
3-14-77	8476	8.7	40	5	11.9	10.5	1.8
15	9125	8.8	40	10	11.0	9.5	1.8
16							
17	9341	9.9	48	5	16.0	9.0	5.0 Barite
18							
19	9341	9.9	48	5	16.0	9.0	5.0 "
21	9376	10.0	44	10	14.2	9.0	5.0 "

Geology of test well

The following log tops (formation tops) and lithology were photocopied from the report from Hegna, Kerns, and Traut. The stratigraphic nomenclature from their report and that on table 1 have not been checked for conformance with the nomenclature presently used by the U.S. Geological Survey.

The core-analysis results are from the report furnished by the Core Laboratories, Inc., Denver, Colo.

Table 1.--Core intervals

[Depths are from kelly bushing (2,809 ft above sea level), which is 16 ft above land surface]

Core	Interval (depth in ft)	Cored (ft)	Recovered (ft)	Formation
1	1,078-1,108	30	28	Pierre Shale (Bearpaw Shale)
2	1,969-1,999	30	25	Telegraph Creek
3	4,343-4,369	26	26	Newcastle Sandstone
4	4,877-4,907	30	25	Lakota Sandstone
5	6,470-6,556	86	88	Minnelusa and Madison (Charles)
6	6,574-6,664	90	89	Madison (Charles and Mission Canyon)
7	6,715-6,745	30	27.2	Madison (Mission Canyon)
8	6,745-6,775	30	30.7	Madison (Mission Canyon)
9	7,070-7,128	58	54	Madison (Mission Canyon)
10	7,370-7,422	52	51	Madison (Lodgepole)
11	7,600-7,623	23	22.5	Madison (Lodgepole)
12	7,623-7,625	2	2	Madison (Lodgepole)
13	7,640-7,700	60	59	Madison and Devonian
14	7,700-7,760	60	59	Devonian (Three Forks-Jefferson)
15	7,760-7,820	60	60	Devonian (Three Forks-Jefferson)
16	7,820-7,865	45	38	Devonian and Silurian (Interlake)
17	8,215-8,238	23	21	Red River
18	9,375-9,388	13	11	Precambrian
19	9,388-9,394	6	6	Precambrian
	Totals	754	722.4	

LOG TOPS

(Formation Tops)

Bearpaw Shale	420'
Judith River	1168'
Clagget	1284'
Eagle	1672'
Shannon Sandstone Member	1840'
Telegraph Creek	1852'
Niobrara	2764'
Greenhorn	3406'
Mowry	4081'
Newcastle	4282'
Skull Creek	4388'
Colorado Silt	4556'
Logger TD	4656'
Driller TD	4682'
Strap	4677'
Dakota	4680'
<u>JURASSIC</u>	
Morrison	4926'
Swift	5095'
Spearfish	5692'
Minnekahta	6024'
Opeche	6034'
Minnelusa	6094'
<u>MISSISSIPPIAN</u>	
Madison	6484'
Logger TD	6567'
Driller TD	6559'
M-12	6640'
M-8.5	6742'
Lodgepole	7182'
M-3	7374'
<u>DEVONIAN</u>	
Three Forks-Jefferson	7662'
<u>SILURIAN</u>	
Interlake	7846'
<u>ORDOVICIAN</u>	
Stony Mountain-Gunton Member	7977'
Penitentiary Shale Member	8050'
Red River	8106'
Roughlock Sandstone	8558'
Icebox Shale	8623'
Winnipeg Sandstone	8667'
<u>CAMBRIAN</u>	
Deadwood	8676'
Gros Ventre Shale	8876'
Flathead Sandstone	9224'
<u>PRECAMBRIAN</u>	9300'
Total Depth	9394'

LITHOLOGY

0- 190	Claystone, light gray, soft w/some carbonaceous interbeds, locally sandy, light gray, bentonite common
190- 230	Sandstone, light gray, fine grained, subangular, calcareous, abundant clay matrix
230- 250	Siltstone, light gray, clay infilled
250- 270	Sandstone, light gray, fine/medium grained, subangular, friable, mostly unconsolidated
270- 290	Siltstone, light gray w/abundant clay matrix
290- 310	Claystone, light gray w/some dark gray carbonaceous material
310- 350	Sandstone, light gray, very fine grained/fine grained, clay infilled, friable, subangular, calcareous, fair/good effective porosity
350- 360	Bentonite, light gray, silty
360- 400	Sandstone, light gray, fine grained, subangular, carbonaceous, calcareous, abundant clay matrix
400- 420	Claystone, light gray, very bentonitic, silty
420- 500	No samples
500- 700	Shale, medium/light gray, calcareous, silty, locally bentonitic
700- 900	Shale, medium/light gray, calcareous w/occasional shell fragment, locally very bentonitic, trace mica
900- 960	Shale, medium/light gray, calcareous w/abundant light gray bentonite
960-1000	Shale, medium/dark gray w/shell fragments, bentonitic
1000-1078	Shale, medium gray, very bentonitic, slightly calcareous, some mica and shell material
1078-1108	Core #1 - recovered 28'
1078-1108	Shale, medium/dark gray, very slight/noncalcareous, fissile ("poker chip"), locally fossiliferous, some pyrite replacement of fossils, conchoidal fracture on break, no apparent vertical fracture
1110-1140	No samples
1140-1180	Shale, medium/dark gray, occasional shell fragment
1180-1210	Shale, brownish gray, soft w/some calcareous shell fragments
1210-1220	Siltstone, light brown, very argillaceous, soft, noncalcareous
1220-1230	Shale, medium/dark gray
1230-1250	Siltstone and shale, light brownish gray, soft
1250-1270	Shale, medium gray, bentonitic
1270-1350	Shale, light brownish gray/brown, trace siltstone
1350-1360	Shale, brown/tan w/trace siltstone
1360-1370	Shale, medium gray
1370-1380	Shale, brownish gray
1380-1400	Siltstone, light gray, very argillaceous, clay infilled matrix

Lithology - 2

1400-1480	Shale, gray and brownish gray, very bentonitic, soft
1480-1500	Siltstone, medium gray, very argillaceous, very bentonitic
1500-1540	Siltstone and shale, medium gray, soft, slightly calcareous
1540-1560	Shale, gray, bentonitic
1560-1570	Siltstone, medium/light gray, calcareous, very argillaceous
1570-1580	Shale, medium gray, soft, bentonitic
1580-1590	Shale, brown, bentonitit, carbonaceous
1590-1680	Shale, medium gray, soft, bentonitic w/few inoceramus prisms and shells
1680-1700	Shale and siltstone, medium/dark gray, soft, abundant clay infill
1700-1710	Shale, medium gray w/white bentonite
1710-1720	Shale, dark gray, limy
1720-1820	Shale, medium/dark gray, soft w/white bentonite, calcareous
1820-1830	Sandstone, gray, mushy, very argillaceous, very fine grained
1830-1850	Siltstone, dark gray, argillaceous w/abundant white bentonite
1850-1880	Siltstone and shale, dark gray w/white bentonite
1880-1965	Shale as above w/trace sandstone, light gray, very fine grained, glauconitic, soft, mushy, argillaceous, SLM correction down 4'

<u>1969-1999 Core #2 - recovered 25'</u>

Shale, dark gray, soft, mushy, bentonitic, very low fissility, vertical fracture @ 1969-1970', locally silty, sandy @ 1973', 1988', 1992', and 1994', some shell debris @ 1991' w/pyrite in hairline fractures

2000-2190	Shale, dark gray, locally silty w/white bentonite, trace shell fragments, trace pyrite
2190-2370	Shale, medium gray, soft, bentonitic
2370-2410	Shale as above, very bentonitic
2410-2490	Shale, medium gray, soft, calcareous, silty, trace pyrite
2490-2630	Shale, medium gray, soft w/white bentonite, silty, calcareous
2630-2730	Shale, dark gray, soft, splintery, calcareous, occasional shell fragment
2730-2770	Shale, medium gray, soft, bentonitic

<u>NIOBRARA</u>

2770-3000	Shale, medium/dark gray w/tan, calcareous specks, very soft
3000-3300	Shale, dark gray, bentonitic, soft
3300-3350	Siltstone, light gray w/shale, medium gray
3350-3400	Shale, medium gray, silty

<u>GREENHORN</u>

Lithology - 3

3400-3490	Shale as above w/white chalky limestone, occasional tan limestone
3490-3530	Shale, medium/dark gray, soft, splintery
3530-3700	Shale as above, bentonitic
3700-3720	Sandstone, gray, fine grained, subangular, very calcareous, very argillaceous, friable, very low effective porosity
3720-3770	Siltstone, dark gray, calcareous, argillaceous w/shale, splintery, dark gray
3770-3920	Shale, dark gray, soft, splintery, locally bentonitic, some siltstone interbeds
3920-3950	Sandstone, medium gray, very fine grained, very argillaceous, white clay infill, very low effective porosity, slightly calcareous, trace glauconite
3950-4070	Shale, and siltstone, medium gray, trace glauconite, some interbedded sandstone, light gray, very fine grained, low porosity
4070-4090	Shale, dark gray, soft w/light gray bentonite, few free coarse quartz grains
4090-4260	Shale, dark gray/brownish gray, chunky, siliceous, some siltstone laminae, occasional interbedded light gray bentonite
4260-4280	Siltstone, gray, very argillaceous, slightly calcareous w/some white bentonite w/brown mica
4280-4320	Shale, dark gray, soft, bentonitic, silty

NEWCASTLE SANDSTONE

4330	Circulating Sandstone, light gray, very fine grained, glauconitic, friable, low porosity
4343	Circulating Sandstone, white/light tan, very fine grained/fine grained, hard, subangular, very siliceous, noncalcareous, trace white chert, trace pyrite, low porosity, no fluorescence, no cut

4343-4369 Core #3 - recovered 26'

4343 -4344½	Sandstone, light gray, very fine grained, subangular, friable, noncalcareous, some white clay infill, alternating w/thin bedded dark gray shale, fair porosity
4344½-4349½	Sandstone, light gray, fine grained/very fine grained, subangular, trace mica, noncalcareous, bleeding water, good porosity, few isolated shale partings
4349½-4351	Sandstone as above w/increasing shale, very thin bedded
4351 -4355½	As above, light gray, very fine grained w/shale partings, low/good porosity, some white clay infill, noncalcareous, bleeding water

Lithology - 4

4355½	2 inch section of dark gray shale
4355½-4361	Sandstone, medium gray, very fine grained, argillaceous, mica common, very thin varved bedding, "poker chip" fracture, low porosity
4361 -4364½	Sandstone, light gray, fine grained, subangular, noncalcareous, few isolated shale partings, good porosity, bleeding water
4364½-4366½	Sandstone and shale, alternating in varved bedding, sandstone, light gray, noncalcareous, clay infill, mica common, low porosity
4366½-4367	Sandstone, light gray, very fine grained, argillaceous, fair/ low porosity, bleeding water
4367 -4369	Sandstone and shale interbedded, bedding more distorted than above thin beds, fair/low porosity in sandstone
4369-4390	Sandstone, light gray, very fine grained, white clay infill w/ thin shale laminae, low porosity
4390-4410	Sandstone, light gray/white, fine grained, subangular, friable, abundant white clay infill, low porosity, mica common
4410-4560	Shale, dark gray, soft, bentonitic, splintery, calcareous

COLORADO SILT

4560-4600	Shale as above w/siltstone laminae, light gray, noncalcareous, trace pyrite
4600-4660	Shale, dark gray, splintery w/siltstone, gray, bentonitic
4660-4680	Siltstone, dark gray, hard, very argillaceous, calcareous w/ shale as above
4682	Circulating Siltstone, medium gray, hard, calcareous, occasional grading to very fine grained sandstone, very low porosity, argillaceous

4677-4678 Core #3A (Junk Sub)

4677-4678	Shale, dark gray w/interbedded siltstone, light/medium gray, abundant sedimentary flow and slump structures, thin bedded
4678-4690	Shale, dark gray w/siltstone, light gray, mushy, bentonitic

INYAN KARA

4690-4720	Sandstone, light gray, medium grained, white clay matrix w/ siltstone as above, trace orange chert, few free coarse quartz grains (sample mostly cement)
4720-4760	Siltstone/sandstone, light gray, very fine grained, argillaceous, mushy
4760-4820	Sandstone, clear/white, very fine grained/coarse, subangular, mostly unconsolidated, good porosity

4820-4870	Sandstone, white/clear, very fine grained/medium grained, siliceous, subangular, friable, fair/good porosity
4870	Circulating Sandstone as above w/trace orange chert
<u>4877-4907</u>	<u>Core #4 - recovered 25'</u>
4877 -4886½	Sandstone, medium gray, very fine grained, hard, brittle, siliceous, noncalcareous, subangular, trace mica, thin bed, low porosity w/sandstone laminae and interbeds, light gray, fine grained/medium grained, subangular
4886½-4888	Sandstone, white/light gray, fine grained/coarse, subangular, abundant white clay matrix, some low grade coal, low porosity, bleeding water
4888 -4890	Sandstone, medium gray, very fine grained, hard, low porosity, siliceous
4890 -4902	Sandstone, white/clear, coarse, subangular, clean, fair/good sort, friable/unconsolidated, soft, excellent porosity, bleeding water
4902-4920	No samples
4920-4930	Sandstone, light gray/white, coarse, subangular, mostly unconsolidated, some frosted grains

<u>MORRISON</u>

4930-5020	Shale, greenish gray, waxy, soft, trace maroon, brown and yellow
5020-5050	Sandstone, light gray/greenish gray/yellow gray, very fine grained/fine grained, subangular, fair/good porosity, few free coarse quartz grains
5050-5060	Shale, yellow, maroon, gray, green, purple, trace pyrite, soft
5060-5100	Shale as above w/sandstone, white, very fine grained/fine grained, clay infill, fair/low porosity

<u>SWIFT</u>

5100-5150	Shale, green/greenish gray, mottled, red, soft, subwaxy
5150-5170	Sandstone, white, fine grained, subangular, slightly calcareous, fair/low porosity, trace glauconite
5170-5250	Shale, greenish gray, mottled, maroon/purple, trace pyrite, some brown/yellow shale
5250-5350	Shale, gray/greenish gray, mottled, maroon, waxy, locally interbedded w/siltstone and sandstone, very fine grained, light gray, glauconitic
5350-5400	Shale, gray/light gray/greenish gray, very splintery, subwaxy

Lithology - 6

5400-5510	Shale, greenish gray, mottled, maroon, subwaxy, soft, splintery w/some sandstone, very fine grained, white, low porosity, glauconitic, calcareous, trace limestone, gray, dense
5510-5530	Limestone, light gray/white, chalky, locally sandy
5530-5570	Shale, light greenish gray, subwaxy, soft w/some limestone, tan, light gray, argillaceous, chalky, low porosity
5570-5590	Shale, greenish gray, mottled, yellow, splintery, very calcareous
5590-5620	Shale as above, mottled, maroon
5620-5690	Limestone, tan, earthy, low porosity w/gray shale as above
5690-5750	Shale/siltstone, red, very calcareous, trace white gypsum w/tan limestone, dense and gray green shale
5750-5790	Very poor sample, mostly green shale cavings, trace red/maroon shale
5790-5880	Shale, maroon, silty w/some white anhydrite, some white chalky limestone
5880-5930	Shale, maroon/brick red w/some gypsum interbedded
5930-5990	Shale, maroon/brick red, silty, some interbedded white anhydrite and light gray limestone
5990-6020	Shale/siltstone, brick red w/some interbedded white dolomitic anhydrite
6020-6030	Limestone, light gray/tan, chalky, argillaceous, pelletoidal
6030-6040	Limestone as above w/red shale
6040-6050	Dolomite, light gray/white, chalky/sucrosic, low porosity
6050-6080	Shale, siltstone, brick red w/white anhydrite, few free coarse quartz grains
6080-6090	Sandstone, brick red, very fine grained/coarse, calcareous, low porosity, trace dolomite, pink
6090-6110	Limestone, white/light gray, dolomitic, earthy, low porosity, trace white sandstone, very fine grained, subangular, anhydritic

<u>MINNELUSA</u>

6110-6140	Dolomite, light gray, sandy/sucrosic, low porosity, hard
6140-6150	Sandstone, white, fine grained/very fine grained, subangular, abundant white clay infill, low porosity
6150-6170	Dolomite, light gray/pink, dense, low porosity
6170-6190	Sandstone, white, fine grained, very dolomitic, some white anhydrite, low/fair porosity, some white clay infill, friable, trace white chert
6190-6210	Sandstone, white, fine grained w/white dolomite interbedded and abundant white chert
6210-6250	Dolomite, white/light gray, sandy, hard w/abundant white chert
6250-6300	Dolomite, light gray/white, finely crystalline, dense, low porosity
6300-6350	Dolomite, light gray/pink, low porosity w/some lavender shale, trace clear anhydrite

Lithology - 7

6350-6390	Dolomite, pink/lavender, argillaceous, dense w/lavender/maroon shale
6390-6400	As above w/trace anhydrite, white/clear
6400-6420	Siltstone/shale, orange/bright red, dolomitic, mottled, yellow w/lavender shale and dolomite, pink/white, argillaceous
6420-6430	Shale, brick red and lavender w/dolomite, coarse crystalline, trace sandstone, white/orange, very fine grained, fair porosity
6430-6450	Dolomite, white, very sandy/coarse crystalline w/some brick red siltstone, low porosity
6450-6460	Sandstone, very fine grained and siltstone, brick red, dolomitic, argillaceous w/lavender dolomitic shale, mottled green locally
6470	Circulating Shale, orange and lavender, dolomitic

<u>6470-6556 Core #5 - recovered 88'</u>

(correct to log depths 6479-6565')

6470-6475	Claystone, brick red, subwaxy w/few small dolomite clasts

<u>MADISON</u>

6475-6481	Limestone, light gray, hard, some breccia texture
6481-6491	Limestone, dolomitic, breccia, red argillaceous matrix w/light gray clasts, very angular
6491-6510	Limestone, light gray, hard, dense w/some red shale partings, stylolite @ 6491-6495, breccia w/very angular limestone clasts @ 6496-6497', 6499', and 6501-6510' w/maroon/lavender argillaceous matrix
6510-6518	Claystone, lavender/red, dolomitic w/white anhydrite nodes and bore filling
6518-6524	Limestone, breccia, gray green and maroon argillaceous matrix, subwaxy
6524-6533	Limestone, light gray, micrite w/gray green mottled red shale partings, hard, dense, some breccia texture, very stylolitic @ 6524-6527', and 6530-6532'
6533-6546	Limestone, light gray/reddish gray, hard, dense, some intraclast and pellet grainstone in spar cement, some green shale partings, vertical fracture @ 6537-6539', 6540-6542', and 6544'; stylolite @ 6538-6540', 6542-6543', and 6545-6546'
6546-6552	Limestone, light gray/reddish gray, argillaceous, some breccia
6552-6556	Limestone, light gray, argillaceous, hard, dense, mottled, maroon/green, pelletoidal grainstone w/clear spar cement w/ some clear crystalline anhydrite, vertical fracture @ 6552-6556'

Lithology - 8

6556-6558	Shale, maroon w/some gray and lavender, mottled, subwaxy, very slightly calcareous, medium hard
	drill samples
6559-6560	Limestone, white-buff-cream, microcrystalline, no visible porosity
6560-6570	Much cement, some limestone as above
6574	Circulating 90 min. - limestone as above, much cement, trace dolomite, off-white, microcrystalline, no visible porosity, trace anhydrite, white
6574-6664	Core #6 - cut and recovered 89'
6574 -6575	Anhydrite, white w/intercalations limestone, light gray
6575 -6576½	Dolomite, tan, microcrystalline, dense
6576½-6577½	Anhydrite, white, slightly dolomitic
6577½-6580 3/4	Dolomite, brown-tan, microcrystalline, thin clay laminae up to ¼" thick, broken and fractured @ 6580¼-6580½', slightly bleeding water, low-fair porosity
6580 3/4-6582¼	Dolomite, brown-tan, dense, some anhydrite laminae
6582¼-6583¼	Dolomitic limestone, tan w/anhydrite laminae, vertical fractures, broken
6583¼-6584	Dolomitic limestone, tan w/thin laminae dark gray clay
6584 -6589	Dolomitic limestone, tan, few anhydrite lentils, low-fair porosity, few clay laminae, fracture @ 6585', wet
6589 -6590	Dolomite, gray-brown w/few blebs dolomite as above
6590	Stylolitic surface
6590 -6591	Dolomite, gray-brown
6591 -6592	Dolomite as above w/lavender laminae gray clay
6592 -6593¼	Dolomitic limestone, gray-brown, micritic, vertical fracture
6593¼-6593 3/4	Dolomitic limestone, gray-brown w/angular clasts, light brown
6593 3/4-6595	Dolomitic limestone, buff-gray-brown, micritic, dense, high angle fracture
6595 -6600	Limestone, gray-medium gray, cryptocrystalline to sublithographic, hard, vertical fracture
6600 -6608	Limestone, dolomitic, gray-brown, sucrosic-microcrystalline, few pitted, erosional ?, surfaces w/black shale laminae, bleeding water @ 6602-6619'
6608 -6612	Limestone as above, fracture
6612 -6615	Dolomitic limestone, tan-buff, microcrystalline-sucrosic, anhydrite bed 1" @ 6613 3/4'
6615 -6616	Dolomitic limestone as above, vertical fractures
6616 -6619½	Dolomite, light brown, microcrystalline-sucrosic w/crystals and nodules, anhydritic, clear
6619½	Stylolitic

Lithology - 9

6619½-6629	Limestone, brown, microcrystalline w/some coarser calcite crystals, dense, few fractures w/some polished fracture fill
6629 -6632	Limestone, brown, argillaceous w/laminae dark gray dolomitic shales, fossiliferous crinoid columnars and brachiopods
6632 -6639	Limestone, dark gray-brown, very argillaceous, fossiliferous brachiopods and crinoids
6639 -6646	Limestone, gray-brown, microcrystalline w/aragonite fossiliferous casts
6646 -6654	Limestone as above, fractured, vertical to high angle, stylolitic @ 6651' and 6652½'
6654 -6663	Limestone, gray-brown, microcrystalline, coral or sponge fossil @ 6662'
	1' missing due to broken zone loss
6660-6700	Limestone, buff-light brown, micritic to microcrystalline, dense, some pieces w/a few small pellets inbedded in micritic matrix, very low porosity
6700-6715	Limestone as above w/trace anhydrite, rose colored

<u>6715-6745 Core #7 - cut 30' and recovered 27.2'</u>

6715 -6718	Limestone, dolomitic, buff, micritic, crystals brown dolomite, few anhydrite nodules
6718 -6719	Shale, light gray-medium gray, dolomitic w/clasts and nodules of anhydrite, white
6719 -6720	Anhydrite, white, angular chunks w/shale matrix, medium gray, dolomitic
6720 -6723.5	Anhydrite, light gray-white, chicken wire pattern w/few interbeds dolomitic shale, medium gray
6723.5-6725.3	Anhydrite, white w/erosional surfaces, interbedded w/shale, medium gray, dolomitic
6725.3-6725.4	Shale, dark gray, dolomitic
6725.4-6726	Dolomite, gray-brown, microcrystalline w/crystals brown, dolomitic
6726 -6729.5	Shale, dark gray, dolomitic, subfissile
6729.5-6731.5	Anhydrite, light gray-white, chicken wire
6731.5-6733.5	Limestone, dolomitic, light brown, microcrystalline-sucrosic, abundant anhydrite intercalations, contorted bedded, bleeding water slightly, low porosity
6733.5-6735	Dolomite, gray-brown, very argillaceous, fractured
6735 -6736	Shale, dark gray, calcareous
6736 -6736.5	Clay, gray, calcareous, soft, and shale, dolomitic
6736.5-6739	Anhydrite, white
6739 -6742.2	Anhydrite, white-gray, abundant shale intercalations

Lithology - 10

6745-6775	Core #8 - recovered 30.7'
6745 -6745.3	Anhydrite, white, pure w/few inclusions dolomite, buff, dense
6745.3-6756	Anhydrite, light gray, pure, hard
6756 -6761	Anhydrite, light gray, chicken wire
6761 -6762	Anhydrite, white, fracture
6762 -6763.3	Anhydrite, gray w/shale mottling
6763.3-6766.4	Anhydrite, light gray
6766.4-6766.7	Dolomite, light brown, sucrosic, laminated finely w/thin black varves
6766.7-6768	Anhydrite, light gray w/angular to subround clasts of white anhydrite
6768 -6770	Anhydrite, light gray-white w/few dolomite laminations, buff
6770 -6771.4	Dolomite, light brown, sucrosic, anhydritic
6771.4-6772.2	Anhydrite, medium gray w/irregular inclusions of white anhydrite
6772.2-6775.7	Anhydrite, light gray, hard

drill samples

9' downhole correction
SLM - 6784' = 6775'

6780-6790	Anhydrite, white-light gray w/limestone, cream, mostly sublithographic to microcrystalline, few pieces of clastic to pelletal limestone, well cemented, very low porosity
6790-6820	Limestone, light brown-cream, mostly microcrystalline, 20% is finely fragmental, a few chips pelletal limestone, well cemented, very low porosity, 10% anhydrite, light gray-white
6820-6830	Limestone as above w/dolomite, white-blue-gray, cryptocrystalline, dense
6830-6840	Limestone and dolomite as above, trace anhydrite, white, sucrosic
6840-6850	Dolomite, blue-gray-white, cryptocrystalline, limestone, cream-brown, fragmental to microcrystalline, trace pellets and oolites, low-fair porosity
6850-6880	Limestone, cream-brown, dolomitic, finely crystalline-sucrosic, fair porosity, light yellow fluorescence, very weak cut w/dolomitic anhydrite, white-blue-gray
6880-6900	Limestone, cream-brown, slightly dolomitic, finely crystalline-sucrosic, poor-fair ? porosity w/dolomitic anhydrite, white-blue-gray, trace anhydrite, white
6900-6940	Limestone, light brown, buff, cream, micritic to sucrosic, trace porosity, dull mineral fluorescence, trace anhydrite, blue-gray
6940-6950	Limestone, light brown-buff, 50% micrite, 50% finely fragmental, trace indistinct fossil fragments, well cemented, poor porosity
6950-6960	Limestone as above, some sucrosic limestone, light brown w/ calcite clusters, some fair porosity, dull mineral fluorescence

Lithology - 11

6960-6980	Limestone, light brown, micritic to fragmental, well cemented, poor porosity, dull fluorescence, no cut
6980-7000	Limestone as above, trace anhydrite, white
7000-7010	Limestone, light brown-tan, mostly micritic to finely crystalline, trace vuggy porosity
7010-7030	Limestone as above w/5% black asphaltic staining in argillaceous zones, dull cut
7030-7050	Limestone, cream-buff, micritic to finely crystalline, very little porosity, trace anhydrite, white-rose
7050-7070	Limestone as above w/anhydrite, white-light gray, shaly

<u>7070-7128 Core #9 - recovered 54'</u>

7070 -7078	Anhydrite, white/light gray, chicken wire w/some tan dolomitic limestone chalky micrite interbedded matrix
7078 -7093½	Limestone, light gray/light brown, hard, dense w/some anhydrite nodes, algal pisolites, pellets common in spar, stylolite @ 7079½', 7082', and 7090½', sealed vertical fracture @ 7081-7082'
7093½-7099	Dolomite, brown, fair intergranular porosity, bleeding water, stylolite @ 7099'
7099 -7105	Limestone, brownish gray, dense, oncolites, algal pellets, some secondary anhydrite infill, abundant secondary spar, low porosity, hard
7105 -7109	Dolomite, brown, fair intergranular porosity, hard, bleeding water
7109 -7115	Limestone, light gray, pisolitic, hard, dense, secondary spar, sealed vertical fracture @ 7109-7110'
7115 -7121	Dolomite, brown, good intergranular porosity, few isolated white anhydrite nodes, bleeding water
7121 -7124	Limestone, gray, algal pisolites and pellets grainstone, hard, dense, very low porosity due to spar infill, stylolite @ 7121½', sealed vertical fracture @ 7122'

7128-7150	Limestone, tan, locally dolomitic w/pisolites and pellets, spar infill, low/fair porosity
7150-7180	Limestone as above w/fair/good pinpoint vuggy porosity

<u>LODGEPOLE</u>

7180-7200	Dolomite, dark gray, argillaceous, sucrosic, low porosity
7200-7260	Dolomite as above, fair intergranular porosity
7260-7290	Limestone, dark gray, dolomitic, argillaceous, low porosity, locally chalky
7290-7310	Limestone as above, becoming very chalky
7310-7340	Dolomite, gray/dark gray, sucrosic, low/fair porosity.
7340-7360	Limestone, gray, chalky, pellets, some interbedded dark gray sucrosic dolomite

Lithology - 12

7360-7370	Limestone, dark gray as above w/abundant pellets and pisolites, low porosity
7370-7422	Core #10 - recovered 51'
7370 -7374	Dolomite, dark gray, very argillaceous w/some white crystalline calcite nodes up to 2" x 2", low porosity, also some white anhydrite
7374 -7380	Limestone, dark gray, argillaceous, very fossiliferous (mostly shell casts and molds), hard, low porosity, sealed vertical fractures @ 7374-7376', and 7377-7378½'
7380 -7381	Dolomite, dark gray, argillaceous, low porosity
7381 -7385½	Limestone, dark gray, locally dolomitic, low porosity, fossiliferous, sealed vertical fracture @ 7382-7384'
7385½-7388	Dolomite, dark gray, medium/coarse crystalline, poor/fair intergranular porosity w/white anhydrite nodes @ 7386½'
7388 -7389½	Limestone, dark gray, argillaceous, hard, dense, low porosity
7389½-7391½	Dolomite, dark gray, very argillaceous w/spar calcite interbedded, hard, low porosity, sealed vertical fracture @ 7389-7391'
7391½-7399½	Limestone, dark gray, very argillaceous, very dolomitic w/ some dark gray shale interbeds, burrowed contorted bedding @ 7396-7398', carbonaceous material and stylolite @ base, sealed vertical fracture @ 7393-7395', low porosity
7399½-7400	Dolomite, dark gray, low porosity, very argillaceous w/white anhydrite, vertical fracture
7400 -7401	Limestone, dark gray, dolomitic, argillaceous
7401 -7405	Dolomite, brownish gray, sucrosic, stylolitic, poor/fair intergranular porosity, bleeding water
7405 -7421	Limestone, light gray/tan, algal pellets, some secondary calcite infill, shell casts and molds common, very stylolitic, hard, low porosity, algal pellet grainstone @ 7412-7415' w/fair porosity, sealed vertical fractures @ 7412-7414', 7416-7419', and 7420-7421', white anhydrite @ 7412'
7422-7480	Limestone, tan/light gray, pellets and pisolites in spar matrix, chalky, low porosity
7480-7490	No sample
7490-7500	Limestone, tan/gray, chalky, mostly micrite w/some pellets, low porosity
7500-7530	Dolomite, tan, sucrosic, fair porosity w/limestone, light gray/dark gray/tan, pellets and pisolites
7530-7560	Limestone, dark gray/tan w/pellets, chalky, fossil shell molds and casts, trace pink dolomite, low porosity
7560-7590	Limestone, tan/gray, subchalky, mostly micrite, low porosity

7590-7600	Limestone as above w/trace orange, red, yellow, dark gray and green calcareous shale, trace clear anhydrite, trace pink dolomite
7600-7623	**Core #11 - recovered 22½'**
7600-7604	Limestone, gray/brownish gray micrite, hard, dense w/some mottled light gray dolomite, secondary calcite rhomb crystals in mini-fractures and fossil replacement, bitumen in stylolite, low porosity, crinoid stems
7604-7610	Limestone, dark brownish gray, abundant crinoid debris, secondary clear calcite, some possible anhydrite nodes, vertical fractures @ 7604-7605', and 7607-7609'; few dark gray/black argillaceous laminae, low porosity, some horizontal fractures @ 7604', and 7608'
7610-7613	Limestone, dark gray, very argillaceous, very fine bedded (varve), hard, low porosity, sealed vertical fracture
7613-7616	Limestone, dark gray, dolomitic, crinoid stems, low porosity
7616-7622	Limestone, dark gray/brownish gray, hard w/some crinoid debris, fossil micrite, some secondary white and Fe stain, calcite, milky and tan chert common, horizontal fracture @ 7619', vertical fractures @ 7616-7618', and 7619-7622'
7623-7625	**Core #12 - recovered 2'**
7623-7625	Limestone, dark gray/dark brownish gray, slightly dolomitic, very argillaceous, abundant gray/milky chert
7625-7640	Limestone, gray, slightly dolomitic, trace glauconite, some red, green and purple shale, some white and pink calcite, gray chert common, trace bitumen, low porosi
7640-7700	**Core #13 - recovered 59'**
7640-7648	Dolomite, light tannish gray, dense, some fair vuggy porosity (low effective permeability) w/secondary white anhydrite, and white calcite rhombs infilling vugs, locally sucrosic, chert and stylolite @ 7647-7648', sealed vertical fracture @ 7646-7647'
7648-7659	Dolomite, light brownish gray, mottled w/light tan sucrosic dolomite w/anhydrite and calcite infill, low porosity, mottled, probably due to burrowing, stylolitic, low porosity

DEVONIAN

7659-7673	Marlstone, red, mottled, gray and green, few floating chert grains, coarse, subangular/subround, trace glauconite

Lithology - 14

7673-7686	Dolomite, light reddish gray, mottled, red, hard, red shale, anhydrite and calcite infilling, sealed vertical fracture @ 7673-7680', low porosity, thin bed, marly @ base
7686-7688	Dolomite, red, mottled, gray and green, shaly, stylolitic
7688-7692	Dolomite, brownish gray w/white anhydrite nodes, vertical fracture @ 7691-7693', low porosity
7692-7699	Dolomite, marly, red, mottled, gray w/interbeds of sandstone, coarse, fair sort, well rounded in dolomite matrix, low porosity

<u>7700-7760 Core #14 - recovered 59'</u>

7700-7704	Dolomite, brownish gray, very argillaceous, some calcite in-fill, thin bed, stylolitic, vertical fracture @ 7701-7702', low porosity
7704-7709	Dolomite, light gray w/large white anhydrite nodes (probable burrow infill), stylolitic, low porosity
7709-7712	Dolomite, gray, very argillaceous, thin bed, vertical fracture, low porosity
7712-7716	Shale, dark gray, hard, locally dolomitic w/some interbedded white anhydrite
7716-7726	Limestone, dolomitic, gray/dark gray, micrite, dense, low porosity, vertical fractures @ 7718-7720', and 7723-7724'
7726-7730	Dolomite, brownish gray w/white/gray anhydrite, low porosity
7730-7732	Shale, dark gray, hard, very calcareous w/interbedded white anhydrite
7732-7735	Limestone, gray, dense w/dark gray shale laminae and interbeds, low porosity
7735-7742	Dolomite, dark gray/brownish gray, very argillaceous, vertical fracture @ 7735-7737', fair intergranular porosity @ 7738-7740'
7742-7759	Shale and dolomite, gray/greenish gray w/interbedded white anhydrite, vertical fracture @ 7742-7743'

<u>7760-7820 Core #15 - recovered 60'</u>

7760-7766	Shale, greenish gray, hard, dolomitic, vertical fracture @ 7762-7764', disconformity @ 7766' w/interclasts
7766-7778	Dolomite, gray, hard, argillaceous w/some interbedded anhydrite
7778-7793	Dolomite, light gray w/dark gray shale laminae and interbeds, thin bed, bleeding water @ 7778-7779', and 7790-7791', low/fair porosity
7793-7798	Dolomite, gray, argillaceous, bleeding water, fair intergranular porosity
7798-7801	Dolomite, gray, argillaceous, low porosity
7801-7804	Dolomite, brownish gray, shattered interval, medium crystalline, fair intergranular porosity, bleeding water

Lithology - 15

7804-7815	Dolomite, brownish gray, fair intergranular porosity, bleeding water, anhydrite nodes @ 7813'
7815-7817	Shale, gray/greenish gray, slightly dolomitic, hard
7817-7820	Dolomite, light gray, finely crystalline, slightly argillaceous, low porosity, bleeding water, some secondary white anhydrite infill

7820-7865 Core #16 - recovered 38'

7820-7830	Dolomite, light gray/tan, argillaceous, large secondary white anhydrite node @ 7823', bleeding water @ 7823', stylolite @ 7821', low porosity
7830-7834	Shale, greenish gray, very dolomitic, hard w/some interbedded anhydrite
7834-7846	Dolomite, light gray, hard, argillaceous, low porosity w/some greenish gray shale interbeds, factures @ 7841-7842'
7846-7847	Shale, greenish gray, dolomitic, hard

SILURIAN INTERLAKE

7847-7849	Dolomite, cream w/gray shale laminae, low porosity, trace anhydrite, trace pyrite, fractured, few dark gray angular dolomite clasts
7849-7858	Dolomite, cream, microcrystalline, chalky, few thin stylolites, low porosity, fractured @ 7855-7858'
7865-7880	Dolomite, white/cream, chalky, low porosity
7880-7910	No samples
7910-7950	Dolomite, white, low porosity, chalky, cryptocrystalline
7950-7970	Dolomite, white, low porosity w/trace light greenish gray subwaxy shale interbedded

STONY MOUNTAIN - GUNTON MEMBER

7975	Circulating Dolomite, white w/green subwaxy shale, medium soft, splintery, dolomitic
7975-7990	Dolomite, white, cryptocrystalline w/trace green shale, low porosity
7990-8020	Dolomite as above w/some gray, green and maroon dolomitic shale, trace glauconite
8020-8050	Dolomite, gray, very argillaceous, low porosity w/dark gray shale

STONY MOUNTAIN SHALE

Lithology - 16

8050-8100	Shale and dolomite, light gray/greenish gray, trace shale

RED RIVER

8100-8110	Limestone, gray, argillaceous, low porosity
8110	Circulating Shale, gray/greenish gray, calcareous w/some brown/tan limestone, low porosity
8110-8120	Shale, very calcareous, light greenish gray, trace pyrite
8120-8150	Limestone, brown/tan, shell casts, pellets, some hairline fractures filled w/clear calcite, low porosity
8150-8170	Dolomite, tan, sucrosic, finely crystalline, fair/good intergranular porosity, some yellow fluorescence, no cut
8170-8210	Limestone, tan/brown, micrite w/few pellets, hard, low porosity, locally chalky w/trace pyrite
8210-8215	Dolomite, tan, excellent intercrystalline porosity w/some calcite infill

8215-8238 Core #17 - recovered 21'

8215-8217½	Dolomite, cream/light gray, cryptocrystalline w/few gray shale laminae, small disconnected vugs to ½"
8217½-8220	Dolomite, gray, sucrosic, fair intercrystalline porosity w/dark gray argillaceous laminae
8220 -8230	Dolomite as above, low porosity, micrite
8230 -8232	Dolomite, limy, gray, micrite w/gray shale laminae, low porosity, shattered interval, some fractures appear open
8232 -8236	Dolomite, gray, low porosity, vertical fractures
8238-8240	Very poor samples - nearly all cavings
8240-8270	Limestone, brown/tan, cryptocrystalline, dolomitic locally, low/fair porosity w/trace dark gray argillaceous limestone
8270-8320	Dolomite, tan, sucrosic, some dead oil stain, yellow fluorescence, no cut, fair/good intercrystalline porosity, finely crystalline
8320-8370	Limestone, buff/brown, micrite w/gray argillaceous laminae, low porosity
8370-8430	Dolomite and limestone, brown/buff, finely crystalline, poor-fair porosity
8430-8450	Limestone, tan/brown w/some dolomite as above
8450-8460	No sample
8460-8560	Limestone, brown/gray/tan, pellets, calcite infill, low porosity

8560-8570	Limestone as above w/gray green subwaxy shale, pyritic

ROUGHLOCK SANDSTONE

8570-8620	Sandstone, white, very fine grained, subangular/well rounded, friable, fair/good porosity, siliceous, pyritic, some interbedded green shale

ICEBOX SHALE

8620-8668	Shale, green/gray green, splintery, subwaxy, noncalcareous

WINNIPEG SANDSTONE

8668	Circulating Shale as above w/sandstone, white, very fine grained, subangular/well rounded, pyritic, well sorted, hard, slightly calcareous, low porosity, very siliceous (secondary)

DEADWOOD

8670-8700	Limestone, tan/light gray, very chalky, fragmental w/interbedded gray green shale, splintery/blocky, subwaxy, low porosity
8700-8720	Sandstone, white/cream, very fine grained, very calcareous, subrounded, clay infill, glauconitic limestone in part
8720-8790	Limestone, white/cream, sandy, glauconitic, pyritic, fossiliferous, locally chalky, locally translucent, low porosity
8790-8800	Limestone, white/gray, sandy, glauconitic w/interbedded green gray shale, low porosity
8800-8840	Limestone as above w/few free well rounded, coarse quartz grains, some shale as above interbedded, low porosity
8840-8880	Limestone, white, chalky, argillaceous, glauconitic, low porosity
8880-8930	Limestone as above w/gray green shale interbedded, waxy, splintery, low porosity
8930-8990	Shale, green/gray green, splintery, waxy w/some light gray limestone, chalky, glauconitic
8990-9010	Shale, green, splintery, trace maroon shale w/some yellow limestone
9010-9100	Shale, green/gray green, mottled, brown, subwaxy w/few interbeds limestone, white, sandy, glauconitic, chalky, low porosity
9100-9150	Shale, gray green, slightly calcareous, some subwaxy, some limestone as above, some sandstone, light gray, very fine grained, glauconitic ?, tite, no fluorescence or cut, micaceous

Lithology - 18

9150-9240	Shale, gray-green, slightly calcareous, subwaxy in part, trace limestone as above, some interbedded sandstone, silty, light gray, very fine grained, round, micaceous, glauconitic ?, very low porosity, no fluorescence
	lag time incorrect

FLATHEAD

9240-9250	As above, trace sandstone, white-clear, coarse to fine w/ large, free, round grains, poor sorting, subround, abundant secondary quartz cement, poor-fair porosity
9250-9260	As above, increasing sandstone, clear-white, fine-coarse grained, poor sorting, subangular-subround, abundant secondary quartz cement, some large free quartz grains, poor porosity, no fluorescence
9260-9270	Some sandstone as above, some w/red-brown flattened hematite ?, pellets, and iron stained zones
9270-9280	trip for bit followed by water flow - samples lost
9280-9300	Abundant green shale cavings ?, some sandstone, white-clear, slightly calcareous, fine-medium grained, few coarse grains, subangular, some clear quartz pebbles, quartz cement, fair porosity, trace calcareous pyritic sandstone

PRECAMBRIAN

9300-9320	Shale as above w/sandstone, white-clear-rusty, medium-coarse grained w/granite pebbles ?, subangular-angular, trace pink feldspar, abundant quartz cement, fair ? porosity
9320-9340	No recovery of samples
9340-9350	Sandstone, coarse, clear quartz and granite, clear quartz, feldspar, pink and biotite
9350-9375	Quartz, clear-white, feldspars, salmon-pink, and biotite, Precambrian granite

9375-9388 Core #18 - cut 13' and recovered 11'

9375 -9380	Granite, pinkish-salmon, numerous horizontal fractures, core came out in 1-4" slabs
9380 -9382½	Granite, coarse feldspar phenocrysts, fairly solid
9382½-9386	Granite, vertical fractures

Lithology - 19

<u>9388-9394</u>	<u>Core #19 - recovered 6'</u>
9388-9394	Granite, biotite and hornblende abundant, horizontal fractures, poker chips 1"-3" thick

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ________ Page 1 of 10

Well MADISON NO. 2 Cores ________ File RP-2-5292

Field WILDCAT Drilling Fluid ________ Date Report 2-4-77

County ________ State MONTANA Elevation ________ Analysts RM

Location ________ Remarks ________

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	Grain Density	REMARKS
1	4345.0	47	6.5	22.4			2.65	NEWCASTLE SANDSTONE
2	4347.0	32		21.2				
3	4349.0	15	2.0	19.4				
4	4351.5-53.5			WHOLE CORE ANALYSIS				
5	4356.0	53		21.1				
6	4359.0	0.28	0.14	9.1			2.65	
7	4361.0	129		22.3				
8	4364.0	21		19.0				
9	4367.5	48	3.3	19.3				

NOTE:
(*) REFER TO ATTACHED LETTER
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 2 of ______
Well MADISON NO. 2 Cores ______ File RP-2-5292
Field WILDCAT Drilling Fluid ______ Date Report 3-23-77
County ______ State MONTANA Elevation ______ Analysts RM
Location ______ Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	Grain Density	REMARKS
10	4881.0						2.67	DAKOTA SANDSTONE (LAKOTA
11	4890.0	421	58	16.2			2.82	SANDSTONE)
12	4893.0	3400	223	23.3			2.63	
13	4896.0	4600	2300	25.0				
14	4899.0	4000	2100	24.1			2.63	
15	4900-00.5				WHOLE CORE ANALYSIS			
16	6471.1						2.76	MINNELUSA
17	6474.4						2.81	
18	6475.0						2.78	
19	6476.8		<0.01				2.71	
20	6480.5						2.72	
21	6483.0						2.68	
22	6485.5			3.7			2.71	MADISON (CHARLES)
23	6490.4	0.06		4.0			2.67	
24	6491.0						2.70	
25	6494.5						2.82	
26	6498.9			1.2			2.72	
27	6501.0						2.79	
28	6507.6			0.6			2.70	
29	6508.7			2.2			2.71	
30	6510.2						2.84	
31	6511.9						2.77	
32	6514.9			8.9			2.82	
33	6515.4	0.02		17.1			2.82	
34	6516.8	0.02		11.3			2.81	
35	6520.4						2.73	
36	6526.5	<0.01	<0.01	0.4			2.70	
37	6531.5						2.70	
38	6533.3						2.70	
39	6539.4			0.8			2.70	
40	6545.4						2.71	
41	6547.5	0.02		1.2			2.70	
42	6549.5			1.1			2.70	
43	6551.4						2.72	
44	6554.0	0.02		11.4			2.83	
45	6556.2			8.8			2.80	

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 3 of ______
Well MADISON NO. 2 Cores ______ File RP-2-5292
Field WILDCAT Drilling Fluid ______ Date Report 4-11-77
County ______ State MONTANA Elevation ______ Analysts RM
Location ______ Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	TOTAL WATER % PORE	Grain Density	REMARKS
46	6574.7						2.89	MADISON (CHARLES)
47	6575.3	0.01		7.4				
48	6576.4			3.6			2.87	
49	6577.5			6.6			2.84	
50	6578.7	0.03		4.6				
51	6579.2	0.22	0.34	11.8			2.80	
52	6583.6	0.44	0.03	15.4			2.80	
53	6585.8						2.77	
54	6586-87			WHOLE CORE ANALYSIS				
55	6587.7	0.15		12.8			2.81	
56	6591.5						2.77	
57	6594.5	<0.01		2.6				
58	6602.7	0.13		9.5			2.81	
59	6604.5	0.53		13.3				
60	6607.6	0.60	0.63	15.8			2.80	
61	6610.3	1.0	1.1	18.8			2.79	
62	6614.5	5.0	5.9	24.0			2.80	
63	6616-17.5			WHOLE CORE ANALYSIS				
64	6620.0			4.2			2.76	
65	6622.1			2.7			2.73	
66	6624.4	<0.01		2.4			2.71	
67	6624.6	<0.01		5.5			2.63	
68	6626.5			2.6			2.71	
69	6629.3			2.3			2.70	
70	6632.8			1.3			2.69	
71	6635.8			1.1			2.69	
72	6637.7			1.4			2.70	
73	6640.5	<0.01		2.7			2.69	MADISON (MISSION CANYON)
74	6644.5			2.2				
75	6644.8	<0.01	<0.01	4.3			2.69	
76	6646.5	<0.01	<0.01	4.4			2.68	
77	6649.5	0.01		2.3				
78	6651.9	<0.01	<0.01	2.3			2.68	
79	6653.9	0.01	<0.01	2.4				
80	6654.2	0.02	0.01	2.8				
81	6655.6	<0.01		3.0				
82	6657.7	0.32		9.4				
83	6657.9	0.01		4.7				

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

CL-811-B

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 4 of ______

Well MADISON NO. 2 Cores ______ File RP-2-5292

Field WILDCAT Drilling Fluid ______ Date Report 4-11-77

County ______ State MONTANA Elevation ______ Analysts RM

Location ______ Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	Grain Density	REMARKS
84	6658.8	<0.01	1.6*	4.1			2.68	MADISON (MISSION CANYON)
85	6659.6	0.01		4.2				
86	6660.3	0.01		3.7				
87	6662.0	0.01		3.5				

*VERTICAL FRACTURE IN PERMEABILITY PLUG

NOTE:
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(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 5 of ______
Well MADISON NO. 2 Cores ______ File RP-2-5292
Field WILDCAT Drilling Fluid ______ Date Report 5-25-77
County ______ State MONTANA Elevation ______ Analysts RG
Location ______ Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	Grain Density	REMARKS
88	6715.0			1.6			2.70	MADISON (MISSION CANYON)
89	6718.8						2.83	
90	6720.8			0.4			2.95	
91	6723.8						2.96	
92	6725.7						2.89	
93	6727.3	2.0	1.7	13.7			2.79	
94	6729.0	6.9	7.1	15.9			2.80	
95	6729.5						2.92	
96	6731.4						2.95	
97	6731.4-33.9			WHOLE CORE ANALYSIS				
98	6734.1			2.9				
99	6735.5			0.7				
100	6736.8			0.6				
101	6738.0			0.3				
102	6745.1			0.8			2.67	
103	6747.0	0.01		0.3				
104	6748.7	0.01		0.4				
105	6752.4			0.7				
106	6756.0						2.87	
107	6760.2			0.3			2.86	
108	6762.1	0.01		2.3				
109	6763.2	0.01		2.2			2.85	
110	6766.6	0.22		3.3				
111	6766.9			5.5				
112	6769.9						2.73	
113	6771.4			6.0				
114	6772.0			1.3			2.90	
115	6773.1						2.94	
116	7070.3			0.6				
117	7071.7			0.5				
118	7077.0			2.6				
119	7077.9			2.8				
120	7080.6	0.01		2.0				
121	7080.9	0.01	0.01					
122	7085.1	0.01		4.4				
123	7087.4	0.01		3.9				

NOTE
(*) REFER TO ATTACHED LETTER
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

CL-811-S

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______
Well MADISON NO. 2 Cores ______ File RP-2-5292
Field WILDCAT Drilling Fluid ______ Date Report 5-25-77
County ______ State MONTANA Elevation ______ Analysts RG
Location ______ Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS		POROSITY PERCENT	RESIDUAL SATURATION		Grain Density	REMARKS
		HORIZONTAL (K_A)	VERTICAL		OIL % VOLUME % PORE	TOTAL WATER % PORE		
124	7087.7	0.01		4.4				MADISON (MISSION CANYON)
125	7089.6	0.02		4.0				
126	7092.7	0.01						
127	7094.1	13	9.2	17.1				
128	7094.7			7.8				
129	7097.0			18.0				
130	7097.2			16.3				
131	7098.5	0.49		11.4				
132	7101.5			4.8				
133	7103.4			2.5				
134	7105.8	0.20		9.5				
135	7106.0	1.8	0.65	13.2				
136	7108.2	0.03	1.1	5.2			2.78	
137	7110.4	0.01		2.9				
138	7115.1	0.09		4.2				
139	7117.2	17	18	18.7			2.83	
140	7119-20			WHOLE CORE ANALYSIS				
141	7120.2	13		14.7				
142	7120.8	3.2		11.3				
143	7370.7	0.02		7.7				MADISON (LODGEPOLE)
144	7370.9			1.1				
145	7371.9			3.7				
146	7373.0	0.03		8.0			2.78	
147	7377.5			1.5				
148	7378.6	0.02		4.8				
149	7378.8	0.01		2.8				
150	7382.4			2.7				
151	7382.7	0.01		1.7				
152	7384.6	*	*	*			*	
153	7386.4						2.81	
154	7386.8	0.02		6.2				
155	7396.0						2.73	
156	7397.3			18.2				
157	7399.9	0.09		8.6				

*UNSUITABLE FOR ANALYSIS

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 7 of ______

Well MADISON NO. 2 Cores ______ File RP-2-5292

Field WILDCAT Drilling Fluid ______ Date Report 5-25-77

County ______ State MONTANA Elevation ______ Analysts RG

Location ______ Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	Grain Density	REMARKS
158	7402.0			5.8				MADISON (LODGEPOLE)
159	7402-03			WHOLE CORE ANALYSIS				
160	7406.6						2.74	
161	7408.7	0.01	0.01	1.9				
162	7409.5	*	*	*			*	
163	7411.2	0.01		3.6				
164	7413.7	0.13		7.0				
165	7414.8			4.3				
166	7601.7			2.4			2.70	
167	7602.1			1.4				
168	7603.8	0.01		0.3				
169	7605.1						2.71	
170	7610.0	0.03		0.3				
171	7611.6			1.4				
172	7615.8			0.6				
173	7618.0			1.0				
174	7621.6			4.1				
175	7623.3			1.4				
176	7640.7	0.04		8.8				
177	7641.7						2.79	
178	7642.3			2.2				
179	7643.0			1.3				
180	7643.2-44.7			WHOLE CORE ANALYSIS				
181	7645.0			1.6				
182	7646.4	0.01		4.5				
183	7651.1	0.02		3.3				
184	7653.1			6.0				
185	7654.9	0.08		5.5				
186	7658.0	0.01		1.5				
187	7658.6			1.2				
188	7659.7	0.01		9.2				
189	7660.8	0.01		5.5				
190	7661.8	0.01		5.6				
191	7662.4			1.3				DEVONIAN (THREE FORKS - JEFFERSON)
192	7665.5	0.01		5.2				
193	7666.1						2.74	

*UNSUITABLE FOR ANALYSIS

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

CL-911-8

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 8 of ______
Well MADISON NO. 2 Cores ______ File RP-2-5292
Field WILDCAT Drilling Fluid ______ Date Report 5-25-77
County ______ State MONTANA Elevation ______ Analysts RG
Location ______ Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS		POROSITY PERCENT	RESIDUAL SATURATION			Grain Density	REMARKS
		HORIZONTAL (K_A)	VERTICAL		OIL % VOLUME	% PORE	TOTAL WATER % PORE		
194	7668.0			7.0					DEVONIAN (THREE FORKS - JEFFERSON)
195	7670.2	0.03		8.6					
196	7672.2	0.16		10.9					
197	7673.5			3.1					
198	7674.0							2.82	
199	7675.6							2.82	
200	7679.0	0.01		3.2					
201	7682.1			4.5					
202	7685.8	0.55		3.7					
203	7688.4	0.01		3.2					
204	7689.6			3.1					
205	7691.4			2.8					
206	7691.8			5.7					
207	7693.8	0.01	0.01	6.0					
208	7696.0							2.72	
209	7697.7	0.02		6.8					
210	7698.6			2.3					
211	7700.1			0.7					
212	7701.7			3.4					
213	7704.3	0.36		6.0					
214	7706.2	0.01		6.0					
215	7709.0	0.13	0.16	11.5				2.81	
216	7709.3			11.2					
217	7709.5			8.4					
218	7710.4	0.02		5.0					
219	7712.1	1.3		8.3					
220	7713.0							2.66	
221	7714.2							2.85	
222	7714.8			8.5					
223	7717.6			0.9					
224	7717.9	0.01	0.01	1.6					
225	7721.9			4.6					
226	7722.7	0.01		1.3					
227	7726.9	0.02	0.02	10.6				2.80	
228	7727.5	1.9		5.2					
229	7728.7			2.4					
230	7730.0			2.7					

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS

CL-911-B

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 9 of ______

Well MADISON NO. 2 Cores ______ File RP-2-5292

Field WILDCAT Drilling Fluid ______ Date Report 5-25-77

County ______ State MONTANA Elevation ______ Analysts RG

Location ______ Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME	RESIDUAL SATURATION OIL % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	Grain Density	REMARKS
231	7730.5							2.65	DEVONIAN (THREE FORKS - JEFFERSON)
232	7731.5			0.7					
233	7737.4			3.7					
234	7738.5	0.16		6.8					
235	7739.6			4.0					
236	7740.5	0.02		3.2					
237	7742.1			3.6				2.84	
238	7743.6	0.10		6.0					
239	7744.6			5.1					
240	7746.9	*	*	*				*	
241	7747.9	0.01		5.3					
242	7749.5	15M		5.2					
243	7751.9			0.9					
244	7753.4	*	*	*				*	
245	7754.0			1.0					
246	7758.5							2.79	
247	7759.1	0.01		0.8					
248	7765.1			4.4					
249	7766.2	0.06		5.2					
250	7768.6			3.5					
251	7772.8			1.1				2.90	
252	7775.2			9.2					
253	7777.8	0.01		6.6					
254	7778.3	0.36	0.34	15.4					
255	7780.9	0.01		8.1					
256	7782.0	0.01		0.6					
257	7785.8	0.09	0.02	10.9					
258	7786.3	0.02	0.02	11.6				2.81	
259	7790.8	1.3	0.54	18.4				2.82	
260	7791.5			6.0					
261	7795.0	33	46	21.3				2.79	
262	7796.6	71	21	22.3				2.80	
263	7797.9	5.3	0.07	14.2				2.78	

*UNSUITABLE FOR ANALYSIS

*UNSUITABLE FOR ANALYSIS
M = SAMPLE MOUNTED IN SEALING WAX

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

L-811

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ________ Page 10 of ____

Well MADISON NO. 2 Cores ________ File RP-2-5292

Field WILDCAT Drilling Fluid ________ Date Report 6-24-77

County ________ State MONTANA Elevation ________ Analysts RM

Location ________ Remarks ________

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	Grain Density	REMARKS
264	7800.9	0.10	0.06	6.4				
265	7807.3	14	22	10.4			2.80	
266	7808.6-09.7			WHOLE CORE ANALYSIS				
267	7810.0	170	143	24.3			2.82	
268	7810.4	3.8	1.7	13.4			2.79	
269	7811.1	0.06		10.9				
270	7812.3	3.7	4.8	14.5			2.85	
271	7814.7	1.5	2.3	11.6				
272	7818.3	0.71	0.92	10.1			2.82	
273	7822.0	0.01		7.1				
274	7824.2	0.07		8.4			2.71	
275	7827.5	4.1	2.3	24.0				
276	7829.4	0.03		11.8				
277	7835.8	0.11	0.01	14.2				
278	7836.8	0.02		9.0				
279	7837.5			9.4				
280	7842.5	31	0.37	10.7				
281	7844.1			1.7				
282	7847.5	8.6		16.6				SILURIAN (INTERLAKE)
283	7849.8	0.04	VF	7.4			2.85	
284	7851.9	0.03		6.8				
285	7854.2	0.06		6.6				
286	8217.5			14.7				RED RIVER
287	8217.7	5.3	4.6	21.9				
288	8219.0	1.8		12.7				
289	8220.2	135	128	23.8			2.81	
290	8222.7	33	31	21.7			2.81	
291	8224.2	31	33	22.3				
292	8227.7	134	112	28.1			2.81	
293	8234.0	167	89	28.7			2.82	

VF = VERTICAL FRACTURE

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 1 of 1
Well MADISON NO. 2 Cores ______ File RP-4-3946
Field WILDCAT Drilling Fluid ______ Date Report 6-29-77
County ______ State MONTANA Elevation ______ Analysts KB
Location ______ Remarks WHOLE CORE ANALYSIS

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX.	PERMEABILITY MILLIDARCYS 90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	VERT. PERMS.	Grain Density	REMARKS
4	4351.5-53.5	1.6	1.4	12.0	0.0	52.3	0.06	2.84	NEWCASTLE SANDSTONE
15	4900.0-00.5	54	53	18.5	0.0	*	9.8	2.88	MINNELUSA
54	6586.0-87.0	0.16	#0.08	3.2	0.0	29.3	<0.01	2.83	MADISON (CHARLES)
63	6616.0-17.5	38	37	24.8	0.0	63.5	22	2.88	MADISON (CHARLES)
97	6731.4-33.9	1677	1341	26.4	0.0	39.9	291	2.68	MADISON (MISSION CANYON)
140	7119.0-20.0	3.6	3.1	15.0	0.0	68.2	0.31	2.88	MADISON (MISSION CANYON)
159	7402.0-03.0	1.8	1.8	24.5	0.0	*	0.14	2.86	MADISON (LODGEPOLE)
180	7643.2-44.7	56	55	24.0	0.0	42.9	12	2.68	MADISON (LODGEPOLE)
266	7808.6-09.7	0.14	0.08	7.7	0.0	*	<0.01	2.87	DEVONIAN (THREE FORKS-JEFFERSON)

*SAMPLE DRIED OUT

#HORIZONTAL FRACTURE

NOTE:
(*) REFER TO ATTACHED LETTER
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS.

Hydrologic testing

Seventeen conventional drill-stem tests and packer-swabbing tests were made in the open hole (table 2). Thirteen of these tests give clues to pressure heads of water in the intervals tested, but in the other four tests pressure heads were not obtained because of tool malfunction, ruptured packers, or bypass around lower packers. Also, numerical values of pressure heads in 6 of the 13 tests are questionable because of tool malfunction, very low permeability, or bypass around lower packers. Flowing water was obtained during seven of the tests, but the rates of flow from two of them are not representative of the zone tested because of bypass around lower packers.

Intervals for testing with packers were selected after preliminary interpretation of geophysical logs and examination of cores. Primary considerations were the presence of interstitial and (or) fracture porosity, suitable hole diameter, and a representation of each of the major rock types and formations penetrated in the hole. The intervals tested (6,593-9,394 ft below Kelly bushing) covered approximately 60 percent of the Paleozoic section below the 9-5/8-in casing.

Three types of inflatable packer tools were used during the testing. The first four tests were made using conventional straddle drill-stem testing tools on 4-1/2-in drill pipe (fig. 7). Tests 5 and 17 were made using dual seal production-injection packers on 2-7/8-in EUE 8-round tubing (fig. 8), and the remaining tests were made using a modified version of a dual-seal straddle treating and testing tool on 2-7/8-in EUE 8-round tubing (fig. 9). The straddle treating and testing tool was used for most tests because drilling mud and muddy water entering the ports of the tool from the interval isolated by packers could be removed from the tubing by swabbing. Lowering the head on the interval by swabbing often induced water to flow to the surface. After collecting water samples from producing intervals, the packers were deflated and the tool reset to test other intervals, higher or lower in the hole, without making a trip out of the hole.

After completing all packer tests, and spotting cement plugs from 9,378-9,084 ft and 8,884-8,422 ft below land surface, a well head (fig. 5) was installed. Drilling mud was removed from the hole and the well began to flow. It flowed about 44 gal/min through a 2-in valve in the well head with about 3 lb/in^2 back pressure. Measured at the well head, the shut-in pressure was 333 lb/in^2. The temperature of water was about 48°C.

Table 2 summarizes the drill-stem and packer-swabbing tests made in Madison test well 2 and indicates the test data that are included in this report.

Table 2.--Summary of drill-stem-test data

[Kelley bushing (KB) is 16 ft above land surface (LS) and 2,809 ft above sea level. A constant of 2.307 was used to convert shut-in pressure to feet of head. SIP_1 Initial shut-in pressure. SIP_2 Second shut-in pressure.]

Test	Formation	Interval (ft below KB)	Shut-in pressure (lb/in_2)	Depth to pressure recorder (ft below KB)	Discharge or flow (gal/min)	Remarks
1	Newcastle Sandstone	4,300-4,680	1,540	4,270	---------	Bottom-hole temperature (BHT) 129° F (54°C). Water level (head) 701 ft below LS.
2	Minnelusa----------	6,138-6,248	--------------	6,143	---------	BHT 152°F (67°C). Packer seat failed.
*3	--------do---------	6,134-6,244	2,956	6,139	---------	BHT 165°F (74°C). Head 696 ft above LS.
4	Lakota Sandstone---	4,898-4,916	1,820	4,903	---------	BHT 127°F (53°C). Head 688 ft below LS.
5	Precambrian--------	9,300-9,394	--------------	9,310	---------	Packer failed.
6a	Flathead Sandstone (gas show)	9,238-9,262	4,149 (?)	9,255	---------	Interval has very low permeability.
7	Flathead Sandstone and Precambrian	9,238-9,394	--------------	9,255	---------	Interval has very low permeability.
8	Red River	8,115-8,335	3,899 (?)	8,135	10 to 0	Head calculation not valid because of bypass around lower packer after about 150 min of flow.
9	--------do---------	8,030-8,250	--------------	--------------	---------	Lower packer ruptured.
*10	--------do---------	8,115-8,355	SIP_1 3,849 SIP_2 3,848 SIP_1 315 SIP_2 326	8,125 8,125 2 ft above KB 2 ft above KB	18 to 13	Temperature of fluid at surface 114°F (46°C). Head based on down-hole pressure gauge, 768-771 ft above LS. Head based on surface pressure gauge, 745-770 ft above LS.
*11	Devonian (undifferentiated) and Interlake	7,775-8,015	3,752 (?) SIP_1 312 SIP_2 317	7,785 2 ft above KB 2 ft above KB	10 to 8	Temperature of fluid at surface 103°F (39°C). Head based on down-hole pressure gauge, 887 ft above LS. Head based on surface pressure gauge, 738-749 ft above LS.
12	Madison (Charles)	6,449-6,689	3,292 (?)	6,450	--------	Interval tested twice; no effective permeability.

Table 2.--Summary of drill-stem-test data--Continued

[Kelley bushing (KB) is 16 ft above land surface (LS) and 2,809 ft above sea level. A constant of 2.307 was used to convert shut-in pressure to feet of head. SIP_1 Initial shut-in pressure. SIP_2 Second shut-in pressure.]

Test	Formation	Interval (ft below KB)	Shut-in pressure (lb/in^2)	Depth to pressure recorder (ft below KB)	Discharge or flow (gal/min)	Remarks
*13	Madison (Mission Canyon)	6,814-7,054	3,303 340	6,824 2 ft above KB	5	Temperature of fluid at surface 93°F (34°C). Head based on down-hole pressure gauge, 812 ft above LS. Head based on surface pressure gauge, 802 ft above LS.
*14a	Madison (lower part of Mission Canyon and upper part of Lodgepole)	7,064-7,304	3,421 340	7,075 2 ft above KB	9	Temperature of fluid at surface 106°F (41°C). Head based on down-hole pressure gauge, 833 ft above LS. Head based on surface pressure gauge, 802 ft above LS.
15	Madison (Lodgepole)	7,305-7,545	3,568 (?)	7,325 (?)	--------	Head based on down-hole pressure chart, 922 ft above LS.
16	Madison (basal part of Lodgepole) and upper part of Devonian	7,525-7,765	3,575 (?)	7,536	25 to 0	Bypass around lower packer. Reset packers 10 ft higher and tested; had bypass around lower packer again.
*17	Winnipeg Sandstone to Precambrian	8,520-9,394	4,038 317	8,535 2 ft above KB	50	Temperature of fluid at surface 153°F (67°C). Head based on down-hole pressure gauge, 797 ft above LS. Head based on surface pressure gauge, 749 ft above LS.

* Original drill-stem-test data included in report.
(?) Numerical value is of questionable reliability.

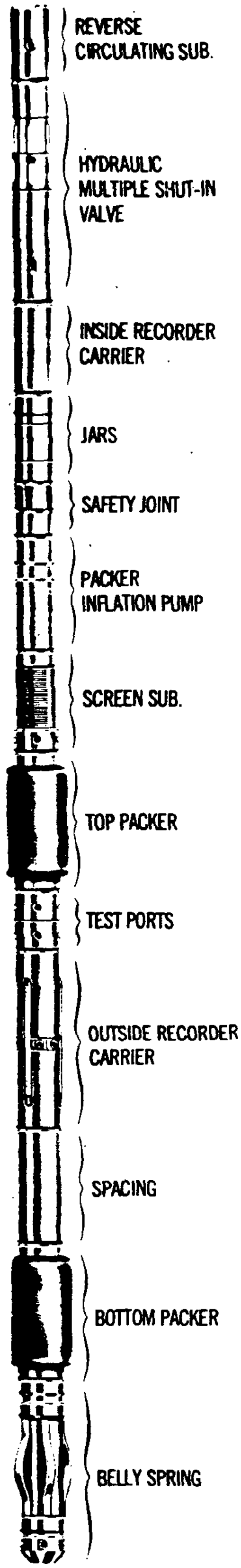


Figure 7.--Inflatable straddle packer tool for conventional drill-stem tests. (Courtesy Lynes, Inc., Houston, Texas)

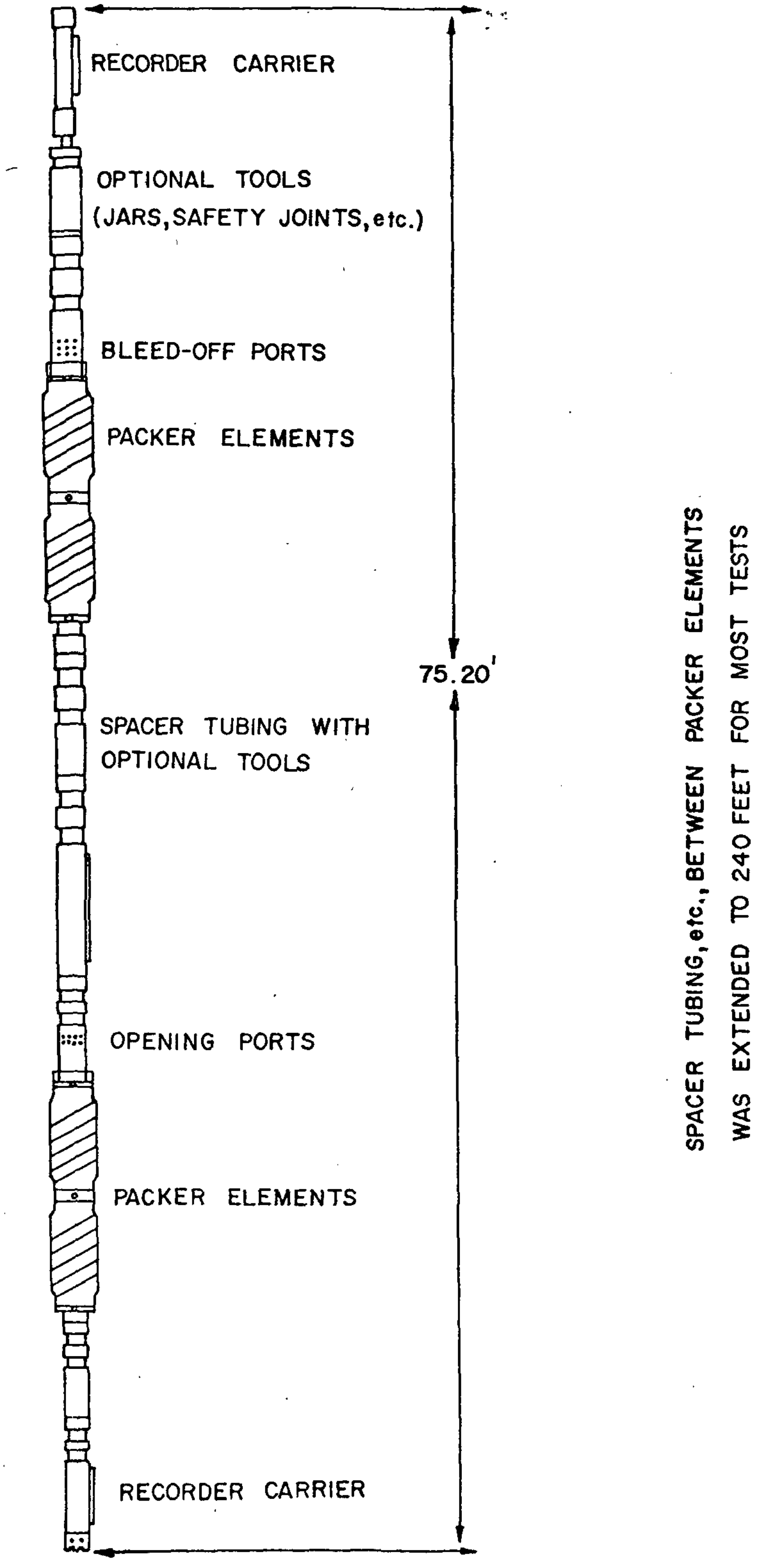


Figure 8.--Dual seal inflatable straddle packer tool used on tubing.
(Courtesy Lynes, Inc., Houston, Texas)

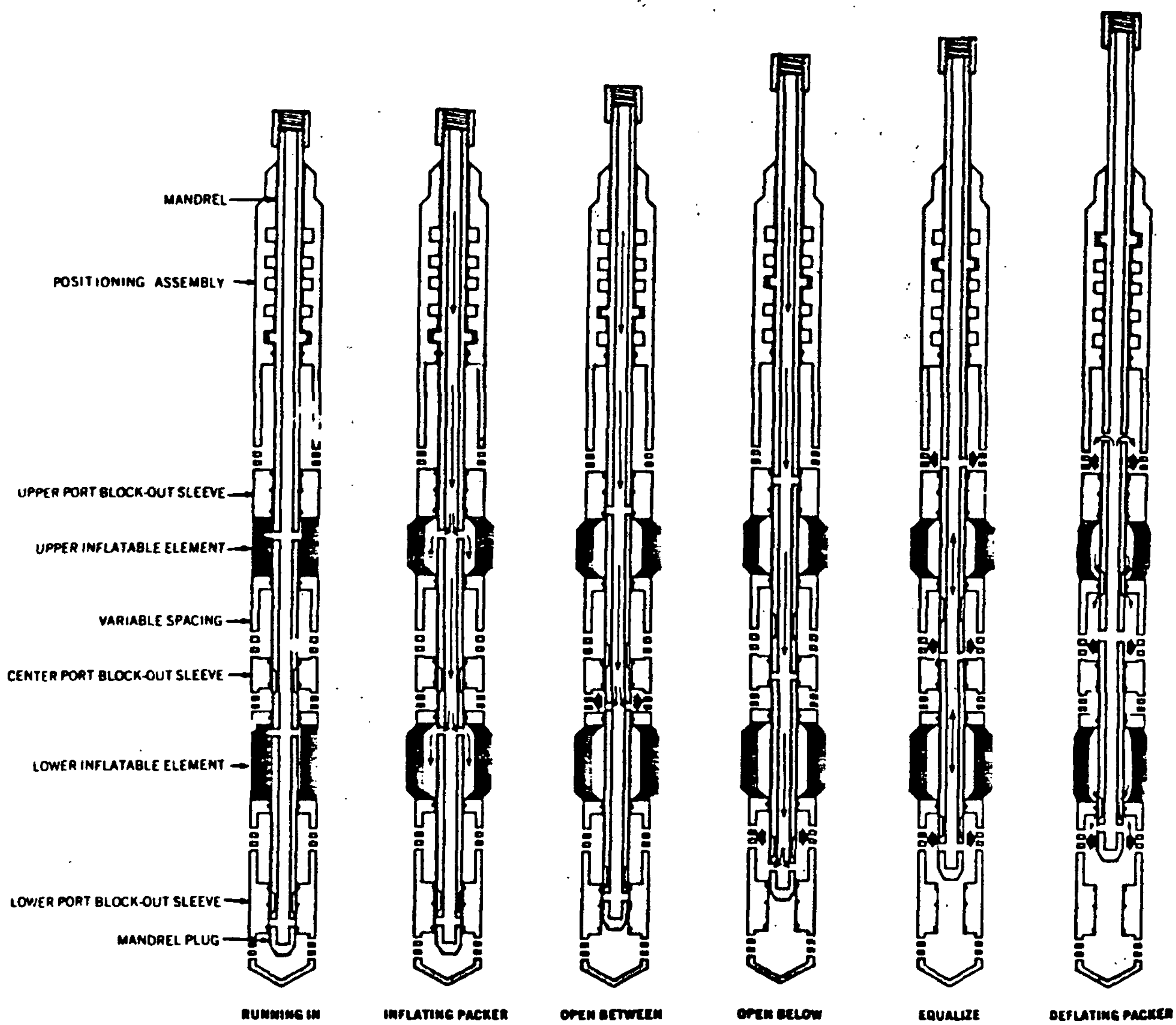


Figure 9.--Inflatable straddle packer used in open hole or casing. (Courtesy Lynes, Inc., Houston, Texas)

Phone
522-1206 Area 303

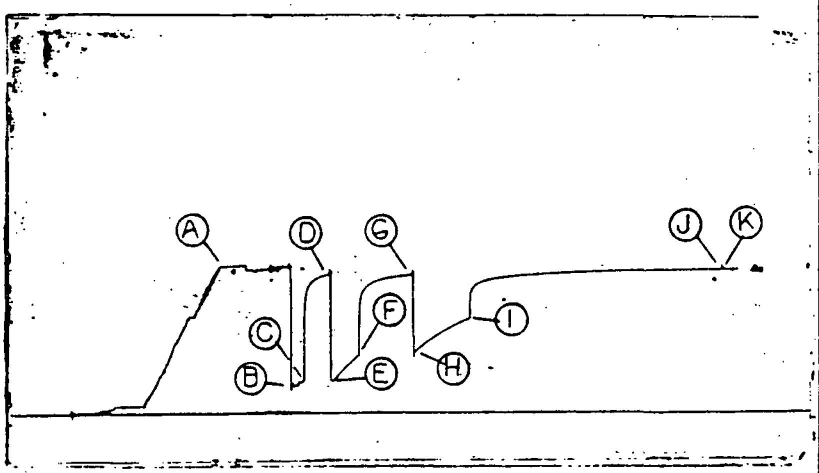
LYNES, INC.

Box 712
Sterling, Colo. 80751

Operator U.S.G.S.
Address Sec Distribution
Well Name and No. Madison #2
Ticket No. 3219
Date 1-23-77
DST No. 3
No. Final Copies 6

Contractor	Anderson Drlg. Co.	Top Choke	¼"	Flow No. 1	15 Min.
Rig No.	8	Bottom Choke	9/16"	Shut-in No. 1	30 Min.
Spot	SE-SE	Size Hole	8½"	Flow No. 2	30 Min.
Sec.	18	Size Rat Hole	--	Shut-in No. 2	60 Min.
Twp.	1 N	Size & Wt. D. P.	4½" 16.60	Flow No. 3	60 Min.
Rng.	54 E	Size Wt. Pipe	--	Shut-in No. 3	270 Min.
Field	Wildcat	I. D. of D. C.	2¼"		
County	Custer	Length of D. C.	361'	Bottom Hole Temp.	165°F
State	Montana	Total Depth	6567'		
Elevation	2809' "K.B."	Interval Tested	6134-6244'	Mud Weight	9.3
Formation	Minnelusa	Type of Test	Inflate Straddle	Gravity	--
				Viscosity	--

Tool opened @ 11:10 PM.



Outside Recorder

PRD Make Kuster K-3

No. 6381 Cap. 8000 @ 6139'

Press		Corrected
Initial Hydrostatic	A	2983
Final Hydrostatic	K	2960
Initial Flow	B	568
Final Initial Flow	C	693
Initial Shut-in	D	2820
Second Initial Flow	E	689
Second Final Flow	F	1207
Second Shut-in	G	2812
Third Initial Flow	H	1282
Third Final Flow	I	1950
Third Shut-in	J	2903

Our Tester: Paul Robbins

Witnessed By: Don Brown

Did Well Flow – Gas No Oil No Water No

RECOVERY IN PIPE: 4200' Saltwater = 56.28 bbl.

REMARKS:

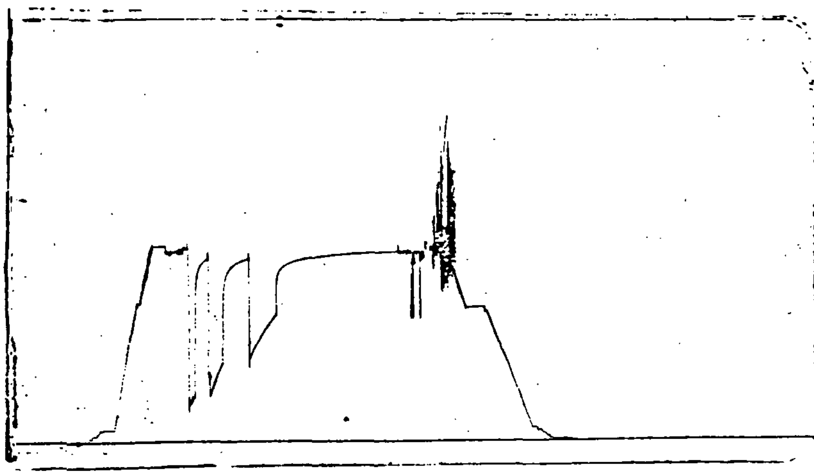
1st Flow- Tool opened with fair blow, increased to strong blow after 3 minutes and remained thru flow period.

2nd Flow- Tool opened with fair flow, increased to strong blow after 3 minutes and remained thru flow period.

3rd Flow- Tool opened with fair blow, increased to strong blow after 3 minutes and remained thru flow period. Flow gauged at 10 psig. on ¼" choke.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison#2 DST No. 3

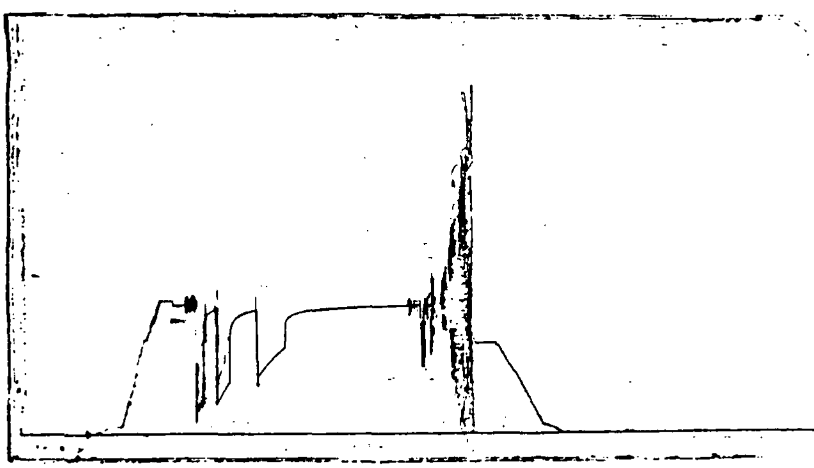


Outside Recorder

PRD Make Kuster K-3

No. 8682 Cap. 6200 @ 6139'

Press		Corrected
Initial Hydrostatic	A	2977
Final Hydrostatic	K	2956
Initial Flow	B	583
Final Initial Flow	C	711
Initial Shut-in	D	2827
Second Initial Flow	E	685
Second Final Flow	F	1222
Second Shut-in	G	2820
Third Initial Flow	H	1287
Third Final Flow	I	1959
Third Shut-in	J	2905
Pressure Below Bottom Packer Bled To		



Inside Recorder

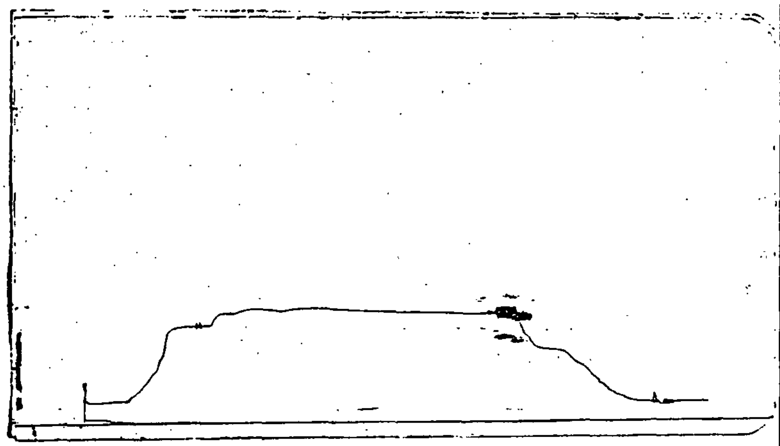
PRD Make Kuster K-3

No. 9064 Cap. 9000 @ 6106'

Press		Corrected
Initial Hydrostatic	A	2980
Final Hydrostatic	K	2954
Initial Flow	B	561
Final Initial Flow	C	691
Initial Shut-in	D	2815
Second Initial Flow	E	688
Second Final Flow	F	1195
Second Shut-in	G	2811
Third Initial Flow	H	1281
Third Final Flow	I	1951
Third Shut-in	J	2911
Pressure Below Bottom Packer Bled To		

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison #2 DST No. 3



PRD Make Kuster K-3T
No. 12355 Cap 35-249 @ 6139'

Press		Corrected
Initial Hydrostatic	A	
Final Hydrostatic	K	
Initial Flow	B	
Final Initial Flow	C	
Initial Shut-in	D	
Second Initial Flow	E	
Second Final Flow	F	
Second Shut-in	G	
Third Initial Flow	H	
Third Final Flow	I	
Third Shut-in	J	
Maximum temperature =		165°F
Pressure Below Bottom Packer Bled To		

PRD Make
No. Cap. @

Press		Corrected
Initial Hydrostatic	A	
Final Hydrostatic	K	
Initial Flow	B	
Final Initial Flow	C	
Initial Shut-in	D	
Second Initial Flow	E	
Second Final Flow	F	
Second Shut-in	G	
Third Initial Flow	H	
Third Final Flow	I	
Third Shut-in	J	
Pressure Below Bottom Packer Bled To		

Form 3

LYNES, INC.

Fluid Sample Report

Date 1-23-77 Ticket No. 3219

Company U.S.G.S.

Well Name & No. Madison #2 DST No. 3

County Custer State Montana

Sampler No. -- Test Interval 6134-6244'

Pressure in Sampler 35 PSIG BHT 165 °F

Total Volume of Sampler: 3000 cc.

Total Volume of Sample: 3000 cc.

Oil: None cc.

Water: None cc.

Mud: 3000 cc.

Gas: None cu. ft.

Other: None

Resistivity

Water: ______ @ ______ of Chloride Content ______ ppm.

Mud Pit Sample ______ @ ______ of Chloride Content ______ ppm.

Gas/Oil Ratio ______ Gravity ______ °API @ ______ °F

Where was sample drained On Location

Remarks: Tool was open momentarily unsetting packer, causing sampler to fill with mud.

Form 5

LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

BOX 712
STERLING, COLORADO 80751
PHONE 303-522-1206

Comments relative to the analysis of the pressure chart from DST #3 Interval: 6134-6244', in the U.S.G.S., Madison #2, SE SE Sec. 18, T1N-R54E, Custer County, Montana:

For purposes of this analysis, the following reservoir and fluid properties and test parameters have been used:

BHT = 165° F, μ = 1.0 cp., t = 105 minutes, h = 10 feet (estimated).

1. Extrapolation of the Initial Shut-in pressure build-up curve indicates a maximum reservoir pressure of 2943 psi at the recorder depth of 6139 feet. Extrapolation of the Second Shut-in pressure build-up curve indicates a maximum reservoir pressure of 2917.9 psi. Extrapolation of the Final Shut-in pressure build-up curve indicates a maximum reservoir pressure of 2955.8 psi. The difference between the three extrapolated pressures is considered insignificant and is indicated to be due to the use of insufficient time for the First and Second Shut-in periods. Numerical values for the various reservoir properties shown below and on the summary pages have been calculated independently in (1) analysis of the Second Shut-in pressure build-up curve and (2) analysis of the Final Shut-in pressure build-up curve. The results described below are based upon the analysis of the Final Shut-in pressure build-up curve and comparison of these results can be made by referring to the summary page which shows the calculated results which are based on the analysis of the Second Shut-in pressure build-up curve.

2. The calculated Average Production Rate which was used in this analysis, 771.8 BPD, is based upon the total fluid recovery of 56.28 barrels and the total flowing time of 105 minutes.

3. The calculated Damage Ratio of 0.5 indicates that no significant well-bore damage was present at the time of this formation test.

U.S.G.S., Madison #2
Interval: 6134-6244', (DST #3)

Comments - Page 2

4. The calculated Effective Transmissibility of 339.2 md.-ft./cp. indicates an Average Permeability to the produced fluid of 33.92 md. for the estimated 10 feet of effective porosity within the total 110 feet of interval tested.

5. The Radius of Investigation of this test is indicated by the relationship, $b \approx \sqrt{k t_o}$, to be about 60 feet.

6. The evaluation criteria used in the Drill-Stem-Test Analysis System indicate that the results obtained in this analysis should be reliable within reasonable limits relative to the assumptions which have been made.

Roger L. Hoeger
Roger L. Hoeger
Consultant for Lynes, Inc.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison #2 DST No. 3

Recorder No. 6381 @ 6139'

FIRST SHUT IN PRESSUR:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	693
3.0	6.0000	2430
6.0	3.5000	2584
9.0	2.6667	2654
12.0	2.2500	2705
15.0	2.0000	2738
18.0	1.8333	2762
21.0	1.7143	2782
24.0	1.6250	2799
27.0	1.5556	2812
30.0	1.5000	2820

EXTRAPLN OF FIRST SHUT IN : 2943 .0

Form 2

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison #2 DST No. 3

Recorder No. 6381 @ 6139'

SECOND SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	1207
6.0	8.5000	2513
12.0	4.7500	2621
18.0	3.5000	2678
24.0	2.8750	2715
30.0	2.5000	2745
36.0	2.2500	2762
42.0	2.0714	2779
48.0	1.9375	2792
54.0	1.8333	2805
60.0	1.7500	2812

EXTRAPLN OF SECOND SHUT IN : 2917.9

CALCULATIONS: SECOND SHUT IN

EXTRAP PRESS(PSIG)...........	2917.9
NO OF PTS ENTERD...........	11.0
NO OF PTS U ED.............	4.0
RMS DEVIATION(PSI).........	0.003
TOTL FLO TIM(MIN)..........	45.0
AVE PROD RATE(BBLS/DAY)........	771.8
TRANSMISS(MD-FT/CP)...........	287.9
IN SITU CAP(MD-FT)............	287.9
AVE EFFECT PERM(MD)...........	28.79
PROD INDX(BBLS/DAY-PSI).......	0.451
DAMAGE RATIO..................	0.7
PROD INDX-DAMAGE(BBLS/DAY-PSI)	0.324
RAD OF INVEST(FT).............	36.0
DRAWDOWN(PERCENT).............	0.1
POTENMETRC SURF(FT)...........	3403.9

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison #2 DST No. 3

Recorder No. 6381 @ 6139'

THIRD SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	1950
27.0	4.8889	2738
54.0	2.9444	2795
81.0	2.2962	2826
108.0	1.9722	2849
135.0	1.7778	2862
162.0	1.6481	2876
189.0	1.5556	2883
216.0	1.4861	2893
243.0	1.4321	2899
270.0	1.3889	2903

Extrapln of Third Shut in ; 2955.8 M: 369.9

RESERVOIR PARAMETERS:

COLLAR RECOV	361.000	PIPE RECOV	3839.000	INT FLO TIM	15.000
FINL FLO TIM	60.000	MUD EXPANS	1.000	BTM HOL TMP	164.000
API GRAVITY	10.000	SPEC GRAVTY	1.000	VISCOSITY	1.000
PAY THICKNES	10.000	SUBSEA DPTH	-3330.000	WATR GRADNT	0.433

CALCULATIONS: THIRD SHUT IN

EXTRAP PRESS(PSIG)............	2955.8
NO OF PTS ENTERED..........	11.0
NO OF PTS USED.............	4.0
RMS DEVIATION(PSI).........	0.003
TOTL FLO TIM(MIN)..........	105.0
AVE PROD RATE(BBLS/DAY).......	771.8
TRANSMISS(MD-FT/CP)...........	339.2
IN SITU CAP(MD-FT)............	339.2
AVE EFFECT PERM(MD)...........	33.92
PROD INDX(BBLS/DAY-PSI).......	0.767
DAMAGE RATIO..................	0.5
PROD INDX-DAMAGE(BBLS/DAY-PSI)	0.382
RAD OF INVEST(FT).............	59.7
DRAWDOWN(PERCENT).............	0.0
POTENMETRC SURF(FT)...........	3496.3

Form 2

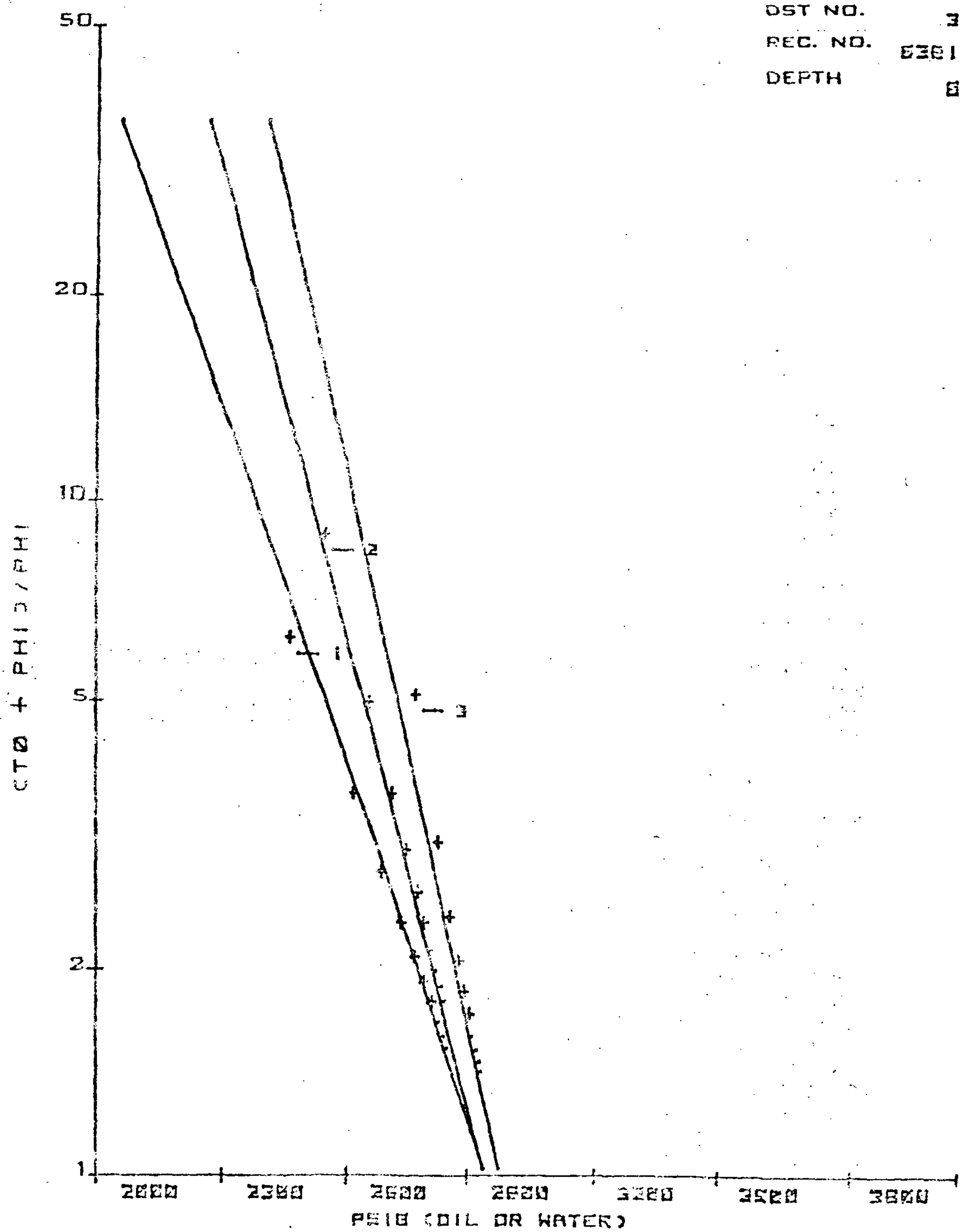
LYNES UNITED SERVICES LTD.

WELL: MADISON 2 J R K OIL CO. LOCN: DATE: 01-23-77

DST NO. 3

REC. NO. 6381

DEPTH 8



PRESSURE EXTRAPOLATION PLOT

FORM 236 12-76

Phone
522-1206 Area 303

LYNES, INC.

Box 712
Sterling, Colo.

Operator United States Geological Survey
Box 25046, Denver Federal Center, Stop 412
Address Lakewood, Colorado 80225
Well Name and No. Madison Test Well #2 Test #10
Type Tool Straddle Treating & Testing Tool
Date 4-12-77
Ticket No. 6658

Spot	--	Csg. Size & Grade	9 5/8"
Sec.	18	Tubing Size	2 7/8"
Twp.	1 N	Tool Depth	8115-8355'
Rng.	54 E	On Location @	4-12-77 4:30 AM.
Field	Wildcat	Off Location @	4-15-77 7:35 AM.
County	Custer	Lynes Rep.	Paul Robbins
State	Montana	Well Owners Rep.	Ellwood Bennett

Tool Description Straddle Treating & Testing Tool

Top Packer: 7½" X 132" Bottom Packer: 7½" X 132"

Test #10

Summary:

4-12-77

5:05 AM. Moved tool to blank position and bled off pressure, then swabbed down 2500' of fluid.

8:55 AM. Moved tool to between position. Tool opened with a strong blow with fluid to surface in 8 minutes, let test flow over night.

4-13-77

10:43 AM. Shut-in on surface.

1:30 PM. Reopened tool.

3:35 PM. Shut-in on surface.

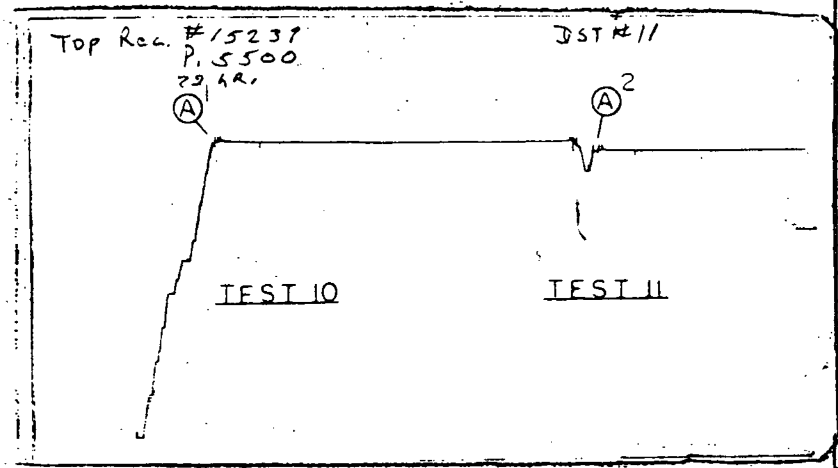
5:20 PM. Reopened tool.

6:05 PM. Moved tool to blank position and pressured tubing to 800 psig.

6:25 PM. Moved tool to inflate position, bled off pressure and released packers.

LYNES, INC.

Operator U.S. Geological Survey Lease & No. Madison Test Well #2 DST No. 10

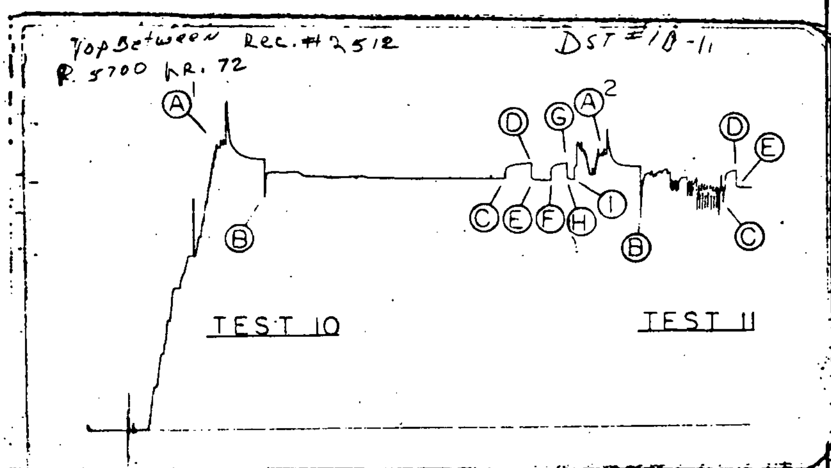


Above Interval

PRD Make Kuster K-3

No. 15239 Cap. 5500 @

Press		Corrected
Initial Hydrostatic	A	4108
Final Hydrostatic	K	
Initial Flow	B	
Final Initial Flow	C	
Initial Shut-in	D	
Second Initial Flow	E	
Second Final Flow	F	
Second Shut-in	G	
Third Initial Flow	H	
Third Final Flow	I	
Third Shut-in	J	
Pressure Below Bottom Packer Bled To		



PRD Make Kuster K-3

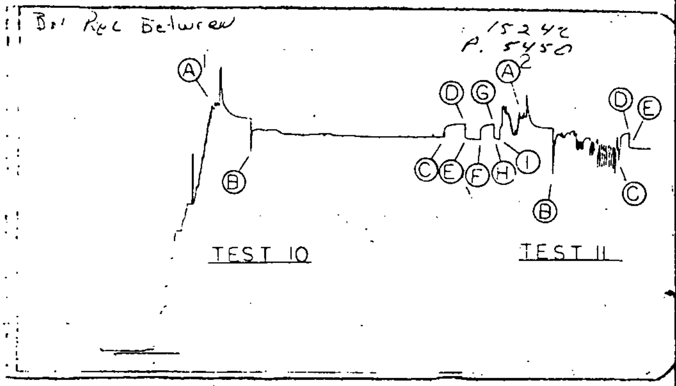
No. 2512 Cap. 5700 @ 8125'

Press		Corrected
Initial Hydrostatic	A	4130
Final Hydrostatic	K	--
Initial Flow	B	3337
Final Initial Flow	C	3584
Initial Shut-in	D	3808
Second Initial Flow	E	3575
Second Final Flow	F	3553
Second Shut-in	G	3800
Third Initial Flow	H	3579
Third Final Flow	I	3555
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

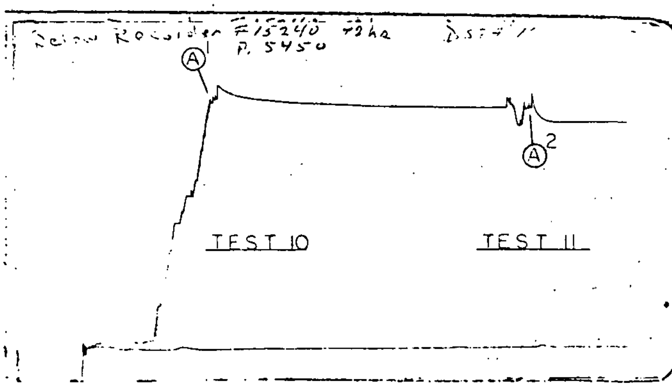
LYNES, INC.

Operator U.S. Geological Survey Lease & No. Madison Test Well #2 DST No. 10



PRD Make Kuster K-3
No. 15242 Cap. 5450 @ --

Press		Corrected
Initial Hydrostatic	A	4131
Final Hydrostatic	K	--
Initial Flow	B	3338
Final Initial Flow	C	3587
Initial Shut-in	D	3816
Second Initial Flow	E	3578
Second Final Flow	F	3553
Second Shut-in	G	3812
Third Initial Flow	H	3583
Third Final Flow	I	3560
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



Below Interval
PRD Make Kuster K-3
No. 15240 Cap. 5450 @ --

Press		Corrected
Initial Hydrostatic	A	4240
Final Hydrostatic	K	
Initial Flow	B	
Final Initial Flow	C	
Initial Shut-in	D	
Second Initial Flow	E	
Second Final Flow	F	
Second Shut-in	G	
Third Initial Flow	H	
Third Final Flow	I	
Third Shut-in	J	
Pressure Below Bottom Packer Bled To		

Form 3

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Denver, Colorado 80222
(303) 759 - 4491

Drill-Stem-Test Pressure Analysis Report

LOCATION: T1N-R54E, Section 18	TIME OPEN: Initial: 1548 mins. Final: 125 mins.	FILE NUMBER: Special
COUNTY AND STATE: MONTANA, CUSTER	INITIAL SHUT-IN TIME: 167 minutes	I. D. NUMBER: L-6658
COMPANY: U.S. Geological Survey	FINAL SHUT-IN TIME: 105 minutes	DATE COMPUTED: 6/8/77
LEASE AND WELL NUMBER: Madison Test Well #2	TEST NUMBER: 10	DATE TESTED: 4/12/77
FORMATION TESTED: Red River	INTERVAL TESTED (Feet): 8115-8355	ELEVATION (Feet): KB 2809

RECOVERY: Fluid to surface in 8 minutes of First Flow; reported flow rate range: 13.8 gpm - 18.5 gpm.

HOLE, TOOL AND RECOVERY DATA

DRILL-PIPE CAPACITY (Barrels per foot)	Test tool run	FEET OF MUD		MUD PERCENTAGE %	
DRILL-COLLAR CAPACITY (Barrels per foot)	on 2-7/8"	FEET OF WATER		WATER PERCENTAGE %	
DRILL-COLLAR FOOTAGE (Feet)	tubing.	FEET OF OTHER		OTHER PERCENTAGE %	
HOLE DIAMETER (Inches)	9.625	FEET OF OIL		OIL PERCENTAGE %	
PIPE FOOTAGE EQUIVALENT TO ANNULUS (Feet)	---	FEET OF CUSHION		FORMATION RECOVERY PERCENTAGE %	
INTERVAL THICKNESS (Feet)	240.	TOTAL RECOVERY (Feet)	Flowed water	AVERAGE PRODUCTION RATE (Barrels per day)	538.8
MUD WEIGHT (Pounds per gallon)	---	CAPACITY OF ANNULUS (Barrels)	---		
EFFECTIVE FLOWING TIME (Minutes)	1673.	GROSS RECOVERY VOLUME (Barrels)	---	RECOVERY LESS THAN ANNULAR VOLUME, (X)	☐

GAUGE SUMMARY

	RECORDER NUMBER	DEPTH	DATUM
A	2512	8125'	-5316'
B (Surface Recorder)		2' above K.B.	+2811'

KEY POINT SUMMARY

	A	B
First Flow		
INITIAL FLOWING PRESSURE (psig)	3337.	---
FINAL FLOWING PRESSURE (psig)	3584.	---
Second Flow		
INITIAL FLOWING PRESSURE (psig)	3575.	---
FINAL FLOWING PRESSURE (psig)	3553.	---
INITIAL SHUT-IN PRESSURE (psig)	3808.	287.
FINAL SHUT-IN PRESSURE (psig)	3800.	286.5
INITIAL HYDROSTATIC MUD PRESSURE (psig)	4130.	---
FINAL HYDROSTATIC MUD PRESSURE (psig)	---	---

EXTRAPOLATION SUMMARY

	A	B
INITIAL (t+θ)/θ CALCULATED FROM MEASURED DATA	10.27	10.27
NUMBER OF POINTS USED FOR INITIAL CURVE-FIT	5.	8.
SLOPE OF INITIAL BUILD-UP CURVE (psi/cycle)	---	---
INITIAL EXTRAPOLATED PRESSURE (psig)	3849.	315.
FINAL (t+θ)/θ CALCULATED FROM MEASURED DATA	16.93	17.40
NUMBER OF POINTS USED FOR FINAL CURVE-FIT	6.	9.
SLOPE OF FINAL BUILD-UP CURVE (psi/cycle)	38.	31.
FINAL EXTRAPOLATED PRESSURE (psig)	3848.	326.

* Conversion Constant of 2.30 ft./psi used to calculate P.S. Elevation.

SUMMARY OF RESULTS

	A	B
EFFECTIVE TRANSMISSIBILITY, kh/μ (md ft per cp)	2305.5	---
INDICATED AVERAGE PERMEABILITY, k/μ (md/cp)	230.6 (for est. 10' effect. φ)	
PRODUCTIVITY INDEX (Barrels per day per psi)	1.83	---
DAMAGE RATIO	1.61	---
FLOWING PRESSURE COMPARISON %	---	---
INITIAL POTENTIOMETRIC SURFACE (feet)	*3537.	*3536.
Ft. of Head above K.B.	728.	727.
FINAL POTENTIOMETRIC SURFACE (feet)	*3534.	*3561.
Ft. of Head above K.B.	725.	752.

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Comments relative to the analysis of the pressure chart from DST #10, Interval: 8115-8355', in the U.S. Geological Survey, Madison Test Well #2, Section 18, T1N-R54E, Custer County, Montana:

1. Extrapolation of the Initial Shut-in pressure build-up curve indicates a maximum reservoir pressure of 3849 psi at the recorder depth of 8125 feet. Extrapolation of the Final Shut-in pressure build-up curve indicates a maximum reservoir pressure of 3848 psi. These extrapolated pressures are equivalent to potentiometric surface elevations of +3537 feet and +3534 feet, respectively, based on the conversion constant of 2.30 ft./psi. These potentiometric surface elevations indicate a head of water above the elevation of the Kelly Bushing (+2809') of 728 feet and 725 feet, respectively.

   Extrapolation plots, using the Horner method, have been made of the shut-in pressure build-up data which were obtained by the surface pressure recorder located 2' above the K.B. The results of these extrapolations are shown on the summary page and, when converted to potentiometric surface elevations, compare very closely with those determined by the analysis of the pressure build-up data recorded by the down-hole pressure instrument.

2. The calculated Average Production Rate which was used in this analysis, 538.8 BPD, is based upon the reported flow rates which were gauged throughout the flowing periods used in this test. This average production rate has been used in the basic Horner equation, along with the measured slope of the extrapolation plot for the Final Shut-in pressure build-up curve, 38 psi/log cycle, as a means of calculating numerical values for the various reservoir properties shown below and on the summary page.

3. The calculated Damage Ratio of 1.61 indicates that slight well-bore damage was present at the time of this formation test; however, in view of the volume-rate of production which occurred, this indicated well-bore damage may be due to the choke effect of the test tool rather than formation damage.

4. The calculated Effective Transmissibility of 2305.5 md.-ft./cp. indicates an Average Permeability of 230.6 md./cp. for the estimated 10 feet of effective porosity within the total 240 feet of interval tested.

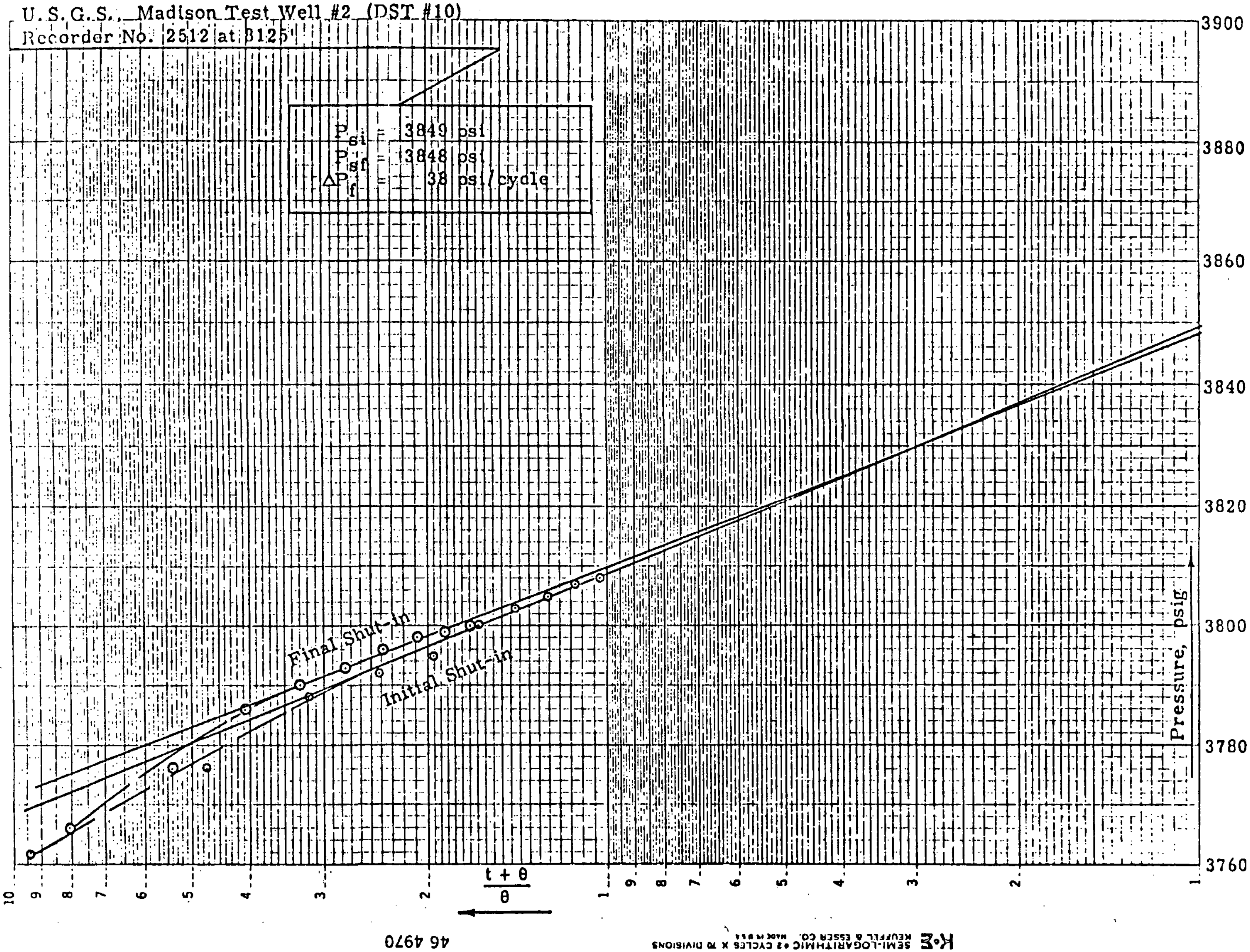
5. The evaluation criteria used in the Drill-Stem-Test Analysis System indicate that the results obtained in this analysis should be reliable within reasonable limits relative to the assumptions which have been made.

PRESSURE BUILD-UP CURVE INCREMENTAL-READING DATA

Company: U.S. Geological Survey
Well Name & No.: Madison Test Well #2
Location: Sec. 18, T1N-R54E, Custer County, Montana
DST No.: 10 Test Interval: 8115-8355' Formation Tested: Red River

Recorder No.: 2512 Recorder Depth: 8125 feet.

INITIAL SHUT-IN				FINAL SHUT-IN			
Initial Flow Time, t = 1548				Total Flow Time, t = 1673			
θ	t + θ	(t + θ)/θ	Pressure (p.s.i.)	θ	t + θ	(t + θ)/θ	Pressure (p.s.i.)
16.7	1564.7	93.69	3762	10.5	1683.5	160.33	3750
33.4	1581.4	47.35	3776	21.0	1694.0	80.67	3766
50.1	1598.1	31.90	3788	31.5	1704.5	54.11	3776
66.8	1614.8	24.17	3792	42.0	1715.0	40.83	3786
83.5	1631.5	19.54	3795	52.5	1725.5	32.87	3790
100.2	1648.2	16.45	3800	63.0	1736.0	27.56	3793
116.9	1664.9	14.24	3803	73.5	1746.5	23.76	3796
133.6	1681.6	12.59	3805	84.0	1757.0	20.92	3798
150.3	1698.3	11.30	3807	94.5	1767.5	18.70	3799
167.0	1715.0	10.27	3808	105.0	1778.0	16.93	3800


U.S.G.S., Madison Test Well #2 (DST #10)
Recorder No. 2512 at 3125'
P_{si} = 3849 psi
P_{sf} = 3848 psi
ΔP_f = 38 psi/cycle
Final Shut-in
Initial Shut-in
Pressure, psig
$\frac{t + \theta}{\theta}$
3900
3880
3860
3840
3820
3800
3780
3760
10
9
8
7
6
5
4
3
2
1
46 4970
K+E SEMI-LOGARITHMIC 2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

PRESSURE BUILD-UP CURVE INCREMENTAL-READING DATA

Company U.S.G.S.

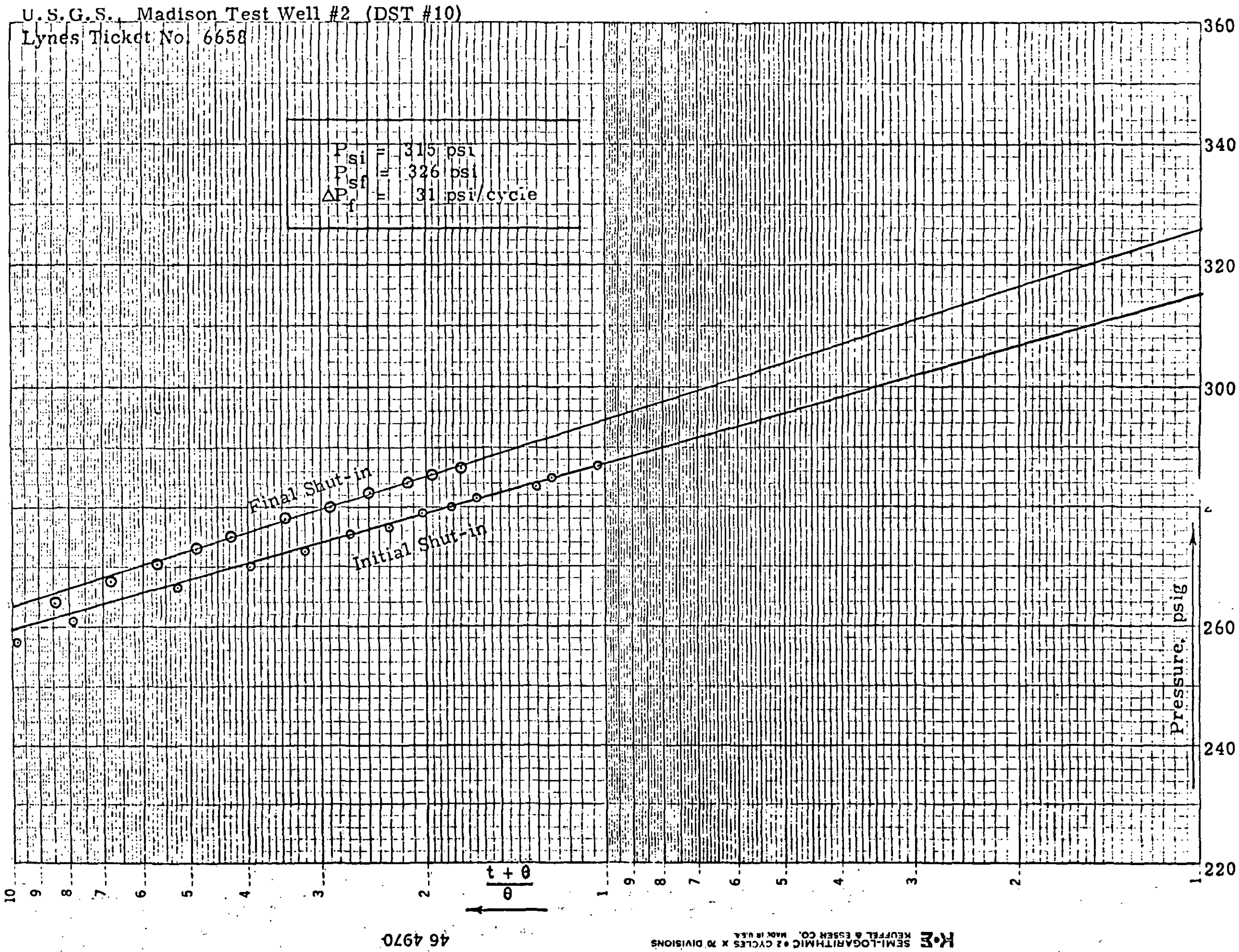
Well Name & No. Madison Test Well #2

Location Sec. 18, T1N-R54E, Custer County, Montana

DST No. 10 Test Interval: 8115-8355' Formation Tested: Red River

Recorder No. ____________ Recorder Depth ________________ feet.

INITIAL SHUT-IN				FINAL SHUT-IN			
Initial Flow Time, t = 1548				Total Flow Time, t = 1673			
θ	t + θ	(t + θ)/θ	Pressure (p.s.i.)	θ	t + θ	(t + θ)/θ	Pressure (p.s.i.)
5	1553	310.60	239.0	5	1678	335.60	238.0
10	1558	155.80	250.0	10	1683	168.30	251.5
16	1564	97.75	257.5	14	1687	120.50	258.0
20	1568	78.40	261.0	20	1693	84.65	264.0
30	1578	52.60	266.5	25	1698	67.92	267.5
40	1588	39.70	270.0	30	1703	56.77	270.5
50	1598	31.96	272.5	35	1708	48.80	273.0
60	1608	26.80	275.5	40	1713	42.83	275.0
70	1618	23.11	276.5	50	1723	34.46	278.0
80	1628	20.35	279.0	60	1733	28.88	280.0
90	1638	18.20	280.0	70	1743	24.90	282.5
100	1648	16.48	281.5	82	1755	21.40	284.0
120	1668	13.07	283.5	90	1763	19.59	285.5
137	1685	12.30	285.0	102	1775	17.40	286.5
167	1715	10.27	287.0				



U.S.G.S., Madison Test Well #2 (DST #10)
Lynes Ticket No. 6658
P_{si} = 315 psi
P_{sf} = 326 psi
ΔP_f = 31 psi/cycle
Final Shut-in
Initial Shut-in
Pressure, psig
360
340
320
300
260
240
220
10
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
1
$\frac{t + \theta}{\theta}$
46 4970
K&E SEMI-LOGARITHMIC 2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

Phone
522-1206 Area 303

LYNES, INC.

Box 712
Sterling, Colo.

Operator: United States Geological Survey
Address: Box 25046, Denver Federal Center, Stop 412
Lakewood, Colorado 80225
Well Name and No.: Madison Test Well #2 Test #11
Type Tool: Straddle Treating & Testing Tool
Date: 4-13-77
Ticket No.: 6658

Spot	--	Csg. Size & Grade	9 5/8"
Sec.	18	Tubing Size	2 7/8"
Twp.	1 N	Tool Depth	7775-8015'
Rng.	54 E	On Location @	4-12-77 4:30 AM.
Field	Wildcat	Off Location @	4-15-77 7:35 AM.
County	Custer	Lynes Rep.	Paul Robbins
State	Montana	Well Owners Rep.	Ellwood Bennett

Tool Description: Straddle Treating & Testing Tool

Top Packer: 7½" X 132" Bottom Packer: 7½" X 132"

Test #11

Summary:

4-13-77

10:00 PM. Pressured tool to 2500 psig. and moved to blank position. Bled off pressure then swabbed down 1000' of fluid.

4-14-77

1:07 AM. Moved tool to between position. Tool opened with weak blow, increased to strong blow after 1 minute. Fluid to surface in 22 minutes.

10:11 AM. Shut-in at surface.

11:21 AM. Opened tool and let test flow until samples cleared up. Clock ran out at 12:44 PM.

5:37 PM. Shut-in at surface.

8:37 PM. Opened tool.

10:05 PM. Moved tool to equalize position and let set 45 minutes.

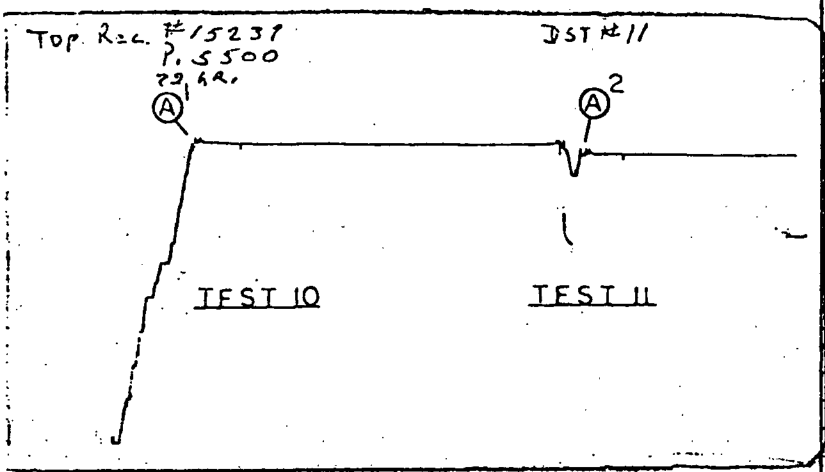
10:50 PM. Moved tool to come out position. Had weight increase of 10,000 psig. indicating equalization was incomplete. Worked tubing to free, and started out of hole.

4-15-77

2:35 AM. Out of hole.

LYNES, INC.

Operator U.S. Geological Survey Lease & No. Madison Test Well #2 DST No. 11

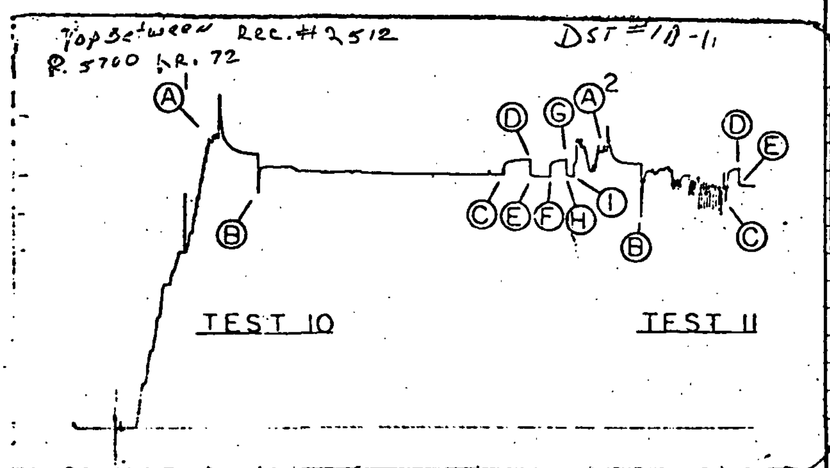


Above Interval

PRD Make Kuster K-3

No. 15239 Cap. 5500 @ --

Press		Corrected
Initial Hydrostatic	A	3901
Final Hydrostatic	K	--
Initial Flow	B	--
Final Initial Flow	C	--
Initial Shut-in	D	--
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



PRD Make Kuster K-3

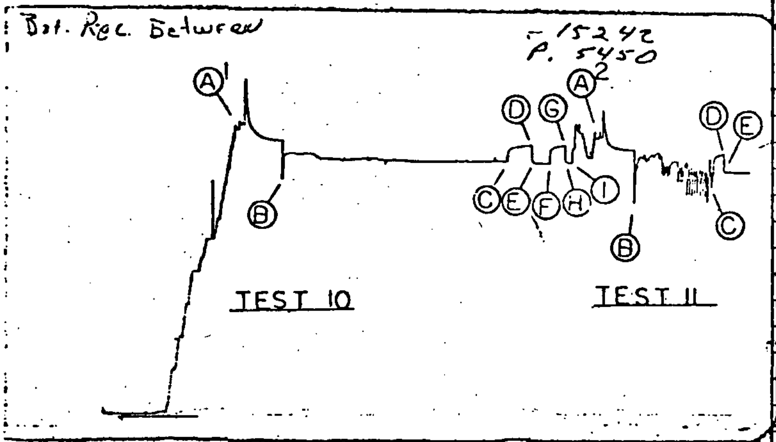
No. 2512 Cap. 5700 @ 7785'

Press		Corrected
Initial Hydrostatic	A	3925
Final Hydrostatic	K	--
Initial Flow	B	2983
Final Initial Flow	C	3406
Initial Shut-in	D	3678
Second Initial Flow	E	3421
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

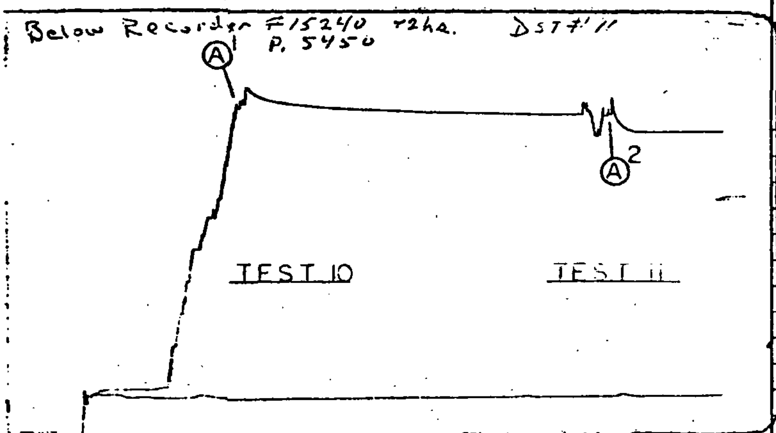
LYNES, INC.

Operator U.S. Geological Survey Lease & No. Madison Test Well #2 DST No. 11



PRD Make Kuster K-3
No. 15242 Cap. 5450 @ --

Press		Corrected
Initial Hydrostatic	A	3925
Final Hydrostatic	K	--
Initial Flow	B	2989
Final Initial Flow	C	3413
Initial Shut-in	D	3683
Second Initial Flow	E	3422
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



Below Interval

PRD Make Kuster K-3
No. 15240 Cap. 5450 @ --

Press		Corrected
Initial Hydrostatic	A	4043
Final Hydrostatic	K	--
Initial Flow	B	--
Final Initial Flow	C	--
Initial Shut-in	D	--
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

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Denver, Colorado 80222
(303) 759-4491

Drill-Stem-Test Pressure Analysis Report

LOCATION: T1N-R54E, Section 18	TIME OPEN: Initial: 544 Mins. Final: 376 Mins.	FILE NUMBER: Special
COUNTY AND STATE: MONTANA, CUSTER	INITIAL SHUT-IN TIME: 70 Minutes	I. D. NUMBER: L-6658
COMPANY: U.S. Geological Survey	FINAL SHUT-IN TIME: 180 Minutes	DATE COMPUTED: 6/6/77
LEASE AND WELL NUMBER: Madison Test Well #2	TEST NUMBER: 11	DATE TESTED: 4/13/77
FORMATION TESTED: Devonian & Silurian	INTERVAL TESTED (Feet): 7775-8015	ELEVATION (Feet): KB 2809

RECOVERY: Fluid to surface in 22 minutes of First Flow Period. Flowed at rate of 8 to 10 gallons per minute.

HOLE, TOOL AND RECOVERY DATA

DRILL-PIPE CAPACITY (Barrels per foot)	Test tool run	FEET OF MUD		MUD PERCENTAGE %	
DRILL-COLLAR CAPACITY (Barrels per foot)	on 2-7/8"	FEET OF WATER		WATER PERCENTAGE %	
DRILL-COLLAR FOOTAGE (Feet)	tubing.	FEET OF OTHER		OTHER PERCENTAGE %	
HOLE DIAMETER (Inches)	9.625	FEET OF OIL		OIL PERCENTAGE %	
PIPE FOOTAGE EQUIVALENT TO ANNULUS (Feet)	---	FEET OF CUSHION		FORMATION RECOVERY PERCENTAGE %	
INTERVAL THICKNESS (Feet)	240.	TOTAL RECOVERY (Feet)	Flowed water	AVERAGE PRODUCTION RATE (Barrels per day)	301.5
MUD WEIGHT (Pounds per gallon)	---	CAPACITY OF ANNULUS (Barrels)	---		
EFFECTIVE FLOWING TIME (Minutes)	920.	GROSS RECOVERY VOLUME (Barrels)	---	RECOVERY LESS THAN ANNULAR VOLUME, (X)	☐

GAUGE SUMMARY

A

RECORDER NUMBER	DEPTH:	DATUM:
2512	7785'	-4976'

B- Surface Recorder

RECORDER NUMBER	DEPTH:	DATUM:
	2' above K.B.	+2811'

KEY POINT SUMMARY

	A	B
First Flow		
INITIAL FLOWING PRESSURE (psig)	2983.	---
FINAL FLOWING PRESSURE (psig)	3406.	---
Second Flow		
INITIAL FLOWING PRESSURE (psig)	3421.	---
FINAL FLOWING PRESSURE (psig)	---	---
INITIAL SHUT-IN PRESSURE (psig)	3678.	270.5
FINAL SHUT-IN PRESSURE (psig)	** None	300.
INITIAL HYDROSTATIC MUD PRESSURE (psig)	3925.	---
FINAL HYDROSTATIC MUD PRESSURE (psig)	---	---

** Chart time expired.

EXTRAPOLATION SUMMARY

	A	B
INITIAL (t+θ)/θ CALCULATED FROM MEASURED DATA	8.77	8.77
NUMBER OF POINTS USED FOR INITIAL CURVE-FIT	4.	9.
SLOPE OF INITIAL BUILD-UP CURVE (psi/cycle)	78.5	42.
INITIAL EXTRAPOLATED PRESSURE (psig)	3752.	311.
FINAL (t+θ)/θ CALCULATED FROM MEASURED DATA	---	6.11
NUMBER OF POINTS USED FOR FINAL CURVE-FIT	---	8.
SLOPE OF FINAL BUILD-UP CURVE (psi/cycle)	---	24.
FINAL EXTRAPOLATED PRESSURE (psig)	---	319.

* Conversion Constant of 2.30 ft./psi used to calculate P.S. Elevation.

SUMMARY OF RESULTS

	A	B
EFFECTIVE TRANSMISSIBILITY, kh/μ (md ft per cp)	624.4	---
INDICATED AVERAGE PERMEABILITY, k/μ (md/cp)	62.4 (for 10' effect. ϕ)	
PRODUCTIVITY INDEX (Barrels per day per psi)	0.87	---
DAMAGE RATIO	0.8	---
FLOWING PRESSURE COMPARISON %	---	---
INITIAL POTENTIOMETRIC SURFACE (feet)	*3654.	*3526.
Ft. of Head above K.B.	845.	717.
FINAL POTENTIOMETRIC SURFACE (feet)	---	*3545.
Ft. of Head above K.B.	---	736.

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Comments relative to the analysis of the pressure chart from DST #11, Interval: 7775-8015', in the U.S. Geological Survey, Madison Test Well #2, Section 18, T1N-R54E, Custer County, Montana:

1. Extrapolation of the Initial Shut-in pressure build-up curve indicates a maximum reservoir pressure of 3752 psi at the recorder depth of 7785 feet. The chart time expired shortly after opening the tool for the Second Flow period. Consequently, a Final Shut-in pressure build-up curve was not recorded during this test. The indicated maximum reservoir pressure is equivalent to a potentiometric surface elevation of 3654' above sea level, based upon the conversion constant of 2.30 ft./psi. This potentiometric surface elevation in turn indicates a head of water above the K.B. (+2809') of 845 feet.

   Extrapolation plots, using the Horner method, for the shut-in pressure build-up data that were recorded by the surface recorder during this test indicate the following: extrapolated Initial Shut-in pressure, 311 psi and extrapolated Final Shut-in pressure, 319 psi. These extrapolated surface pressures convert to potentiometric surface elevations of +3526' and +3545' on the basis of the conversion constant of 2.30 ft./psi. These potentiometric surface elevations indicate the following head elevations above K.B.: 717' for the Initial Shut-in and 736' for the Final Shut-in.

   There is considerable difference between the calculated results which were obtained by analysis of the subsurface pressure recorder data and the surface pressure recorder data. The cause of this difference has not been discernible by the writer.

2. The calculated Average Production Rate which was used in this analysis, 301.5 BPD is based upon the reported flow rates which were measured during the flowing periods used in this test. This average production rate and the measured slope of the extrapolation plot for the Initial Shut-in pressure build-up curve, 78.5 psi/log cycle, have been used in the basic Horner equation to calculate numerical values for the various reservoir properties shown below and on the summary page.

3. The calculated Damage Ratio of 0.8 indicates that no significant well-bore damage was present at the time of this formation test.

4. The calculated Effective Transmissibility of 624.4 md.-ft./cp. indicates an Average Permeability of 62.4 md./cp. for the estimated 10 feet of effective porosity within the total 240 feet of interval tested.

5. The evaluation criteria used in the DST Analysis System indicate that the results obtained in this analysis should be reliable within reasonable limits relative to the assumptions which have been made.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 11

Recorder #2512 @ 7785'

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	3406
7.0	78.7143	3615
14.0	39.8571	3635
21.0	26.9048	3647
28.0	20.4286	3654
35.0	16.5429	3659
42.0	13.9524	3663
49.0	12.1020	3667
56.0	10.7143	3671
63.0	9.6349	3675
70.0	8.7714	3678

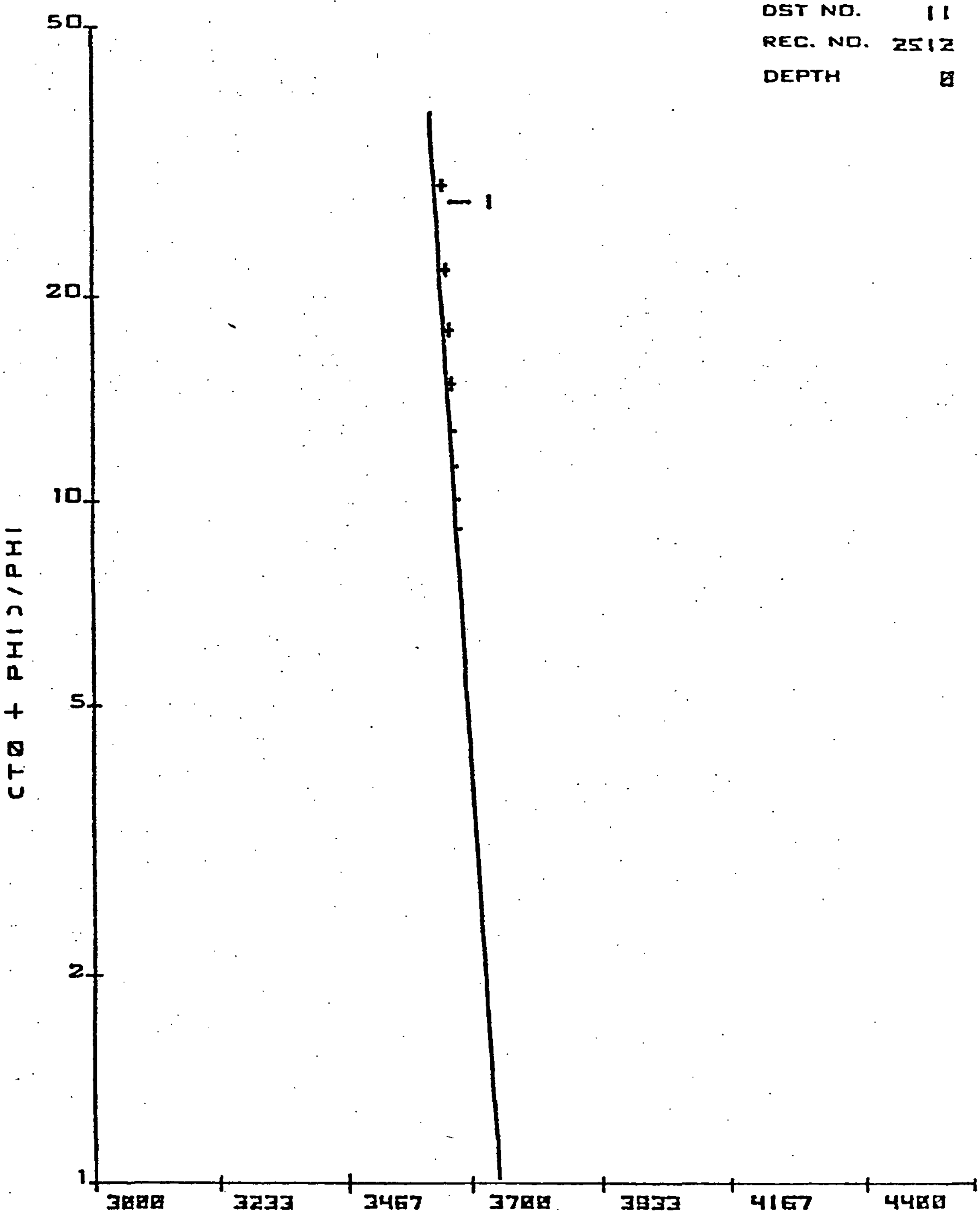
EXTRAPLN OF FIRST SHUT IN : 3752.0 M : 78.5

Form 2

LYNES UNITED SERVICES LTD.

WELL: MADISON 2 USGS LOCN: DATE: 8-14-77

DST NO. 11
REC. NO. 2512
DEPTH 0



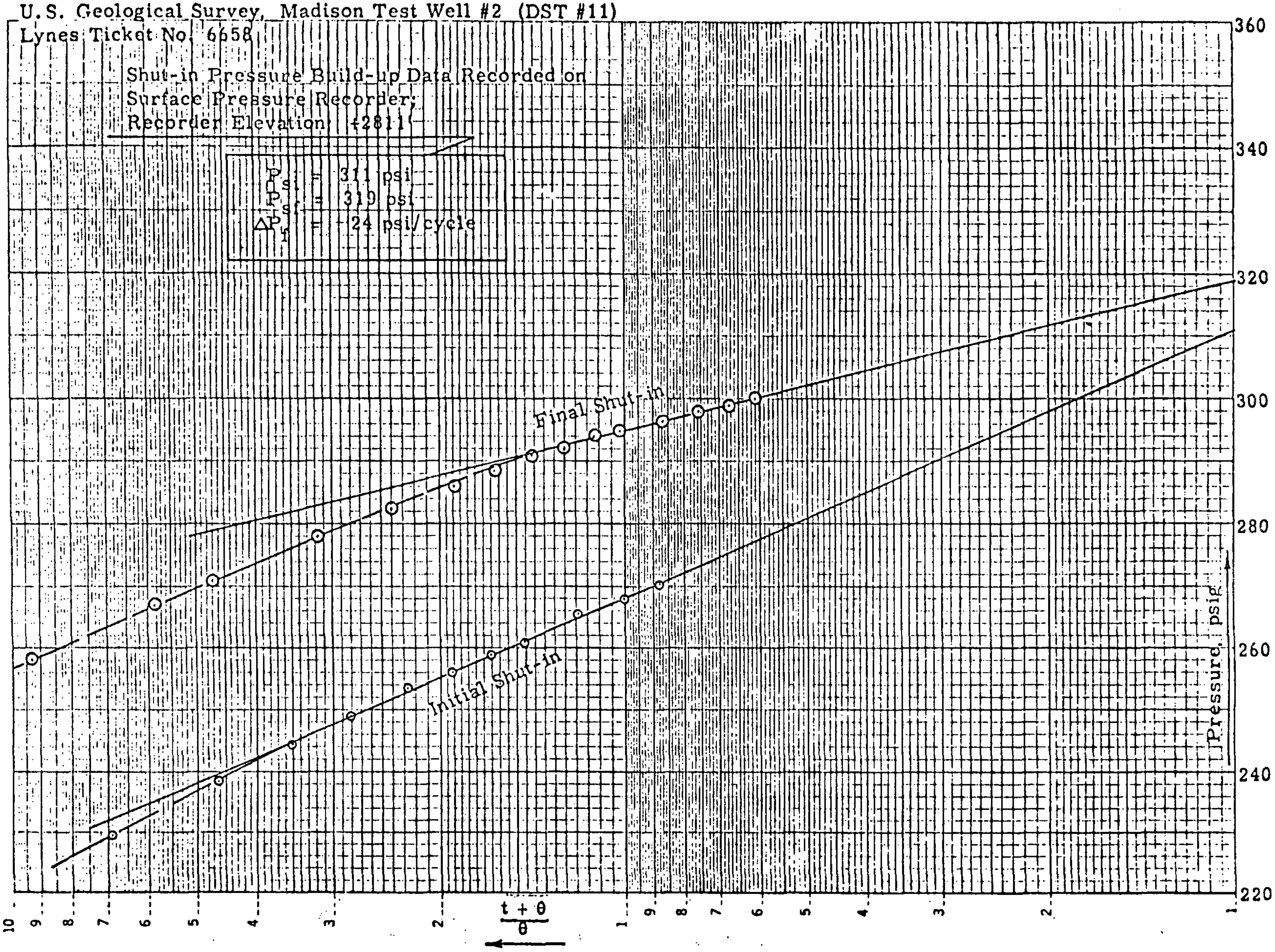
PRESSURE EXTRAPOLATION PLOT

FORM 256 12-76

PRESSURE BUILD-UP CURVE INCREMENTAL-READING DATA

Company U.S. Geological Survey
Well Name & No. Madison Test Well #2
Location Section 18, T1N-R54E, Custer County, Montana
DST No. 11 Test Interval: 7775-8015' Formation Tested: Devonian & Silurian
Surface Recorder No. ----- Recorder Depth 2'above K.B.

INITIAL SHUT-IN				FINAL SHUT-IN			
Initial Flow Time, t = 544				Total Flow Time, t = 920			
θ	t + θ	(t + θ)/θ	Pressure (p.s.i.)	θ	t + θ	(t + θ)/θ	Pressure (p.s.i.)
2	546	278.00	191.0	5	925	185.00	242.5
4	548	137.00	212.5	10	930	93.00	258.0
8	552	69.00	229.5	16	936	58.50	267.0
12	556	46.33	238.5	20	940	47.00	271.0
16	560	35.00	244.5	30	950	31.67	278.0
20	564	28.20	249.0	40	960	24.00	282.5
25	569	22.76	253.5	50	970	19.40	286.0
30	574	19.13	256.0	60	980	16.33	288.5
35	579	16.54	259.0	70	990	14.14	291.0
40	584	14.60	261.0	80	1000	12.50	292.0
50	594	11.88	265.5	90	1010	11.22	294.0
60	604	10.07	268.0	100	1020	10.20	295.0
70	614	8.77	270.5	120	1040	8.67	296.5
				140	1060	7.57	298.0
				160	1080	6.75	299.0
				180	1100	6.11	300.0



U.S. Geological Survey, Madison Test Well #2 (DST #11)
Lynes Ticket No. 6658
Shut-in Pressure Build-up Data Recorded on
Surface Pressure Recorder;
Recorder Elevation +2811
P_{si} = 311 psi
P_{sf} = 319 psi
ΔP_f = 24 psi/cycle
Final Shut-in
Initial Shut-in
Pressure, psig
$\frac{t + \theta}{\theta}$
360
340
320
300
280
260
240
220
10 9 8 7 6 5 4 3 2 1 9 8 7 6 5 4 3 2 1

Phone
522-1206 Area 303

LYNES, INC.

Box 712
Sterling, Colo.

Operator: United States Geological Survey
Address: Box 25046, Denver Federal Center, Stop 412, Lakewood, Colorado 80225
Well Name and No.: Madison Test Well #2
Type Tool: Straddle Treating & Testing Tool
Date: 4-16-77
Ticket No.: 6660

Spot	--	Csg. Size & Grade	9 5/8"
Sec.	18	Tubing Size	2 7/8"
Twp.	1 N	Tool Depth	6814-7054'
Rng.	54 E	On Location @	--
Field	Wildcat	Off Location @	--
County	Custer	Lynes Rep.	Paul Robbins
State	Montana	Well Owners Rep.	Ellwood Bennett

Tool Description: Straddle Treating & Testing Tool

Top Packer 7 3/8" X 136" Bottom Packer 7¼" X 136"

Test #13

Summary:

4-16-77

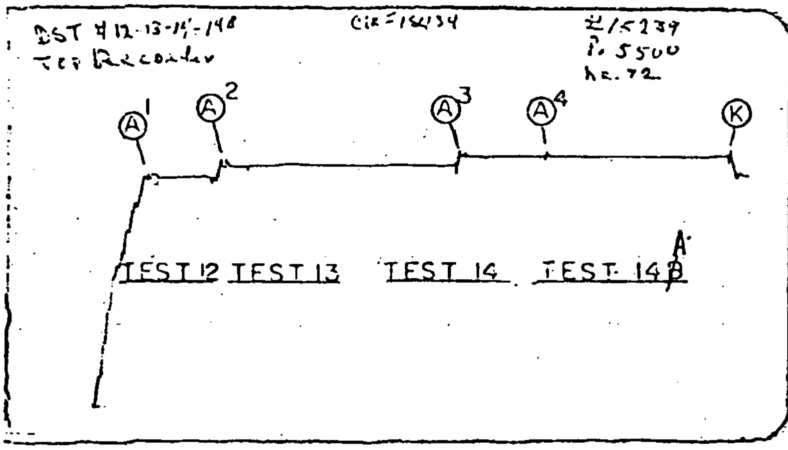
5:05 AM.	*Inflated packers, moved tool to blank position and swabbed 1000' from surface.*
7:15 AM.	Moved tool to between position. Tool opened with a strong blow, fluid to surface in 35 minutes. Flowed and swabbed well for 19 hours.

4-17-77

2:03 AM.	Shut-in at surface for 182 minutes.
5:05 AM.	Opened at surface and well flowed immediately, flowed for 45 minutes.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 13

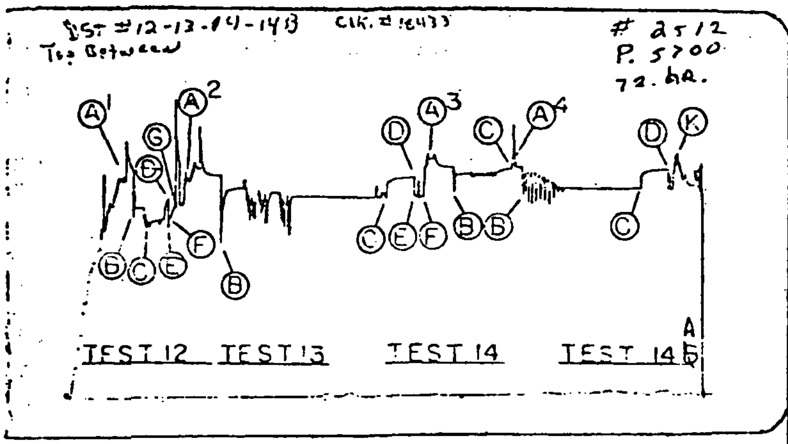


Above Interval

PRD Make Kuster K-3

No. 15239 Cap. 5500 @

Press		Corrected
Initial Hydrostatic	A	3441
Final Hydrostatic	K	--
Initial Flow	B	--
Final Initial Flow	C	--
Initial Shut-in	D	--
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



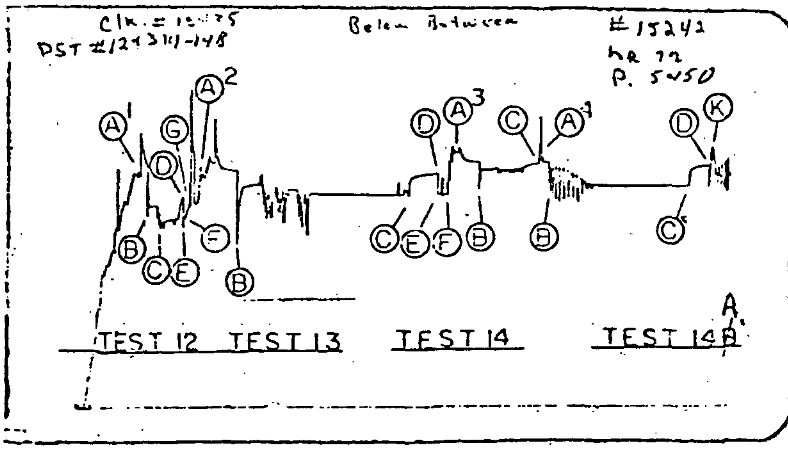
PRD Make Kuster K-3

No. 2512 Cap. 5700 @ 6924'

Press		Corrected
Initial Hydrostatic	A	3231
Final Hydrostatic	K	--
Initial Flow	B	2300
Final Initial Flow	C	2967
Initial Shut-in	D	3267
Second Initial Flow	E	2990
Second Final Flow	F	2969
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

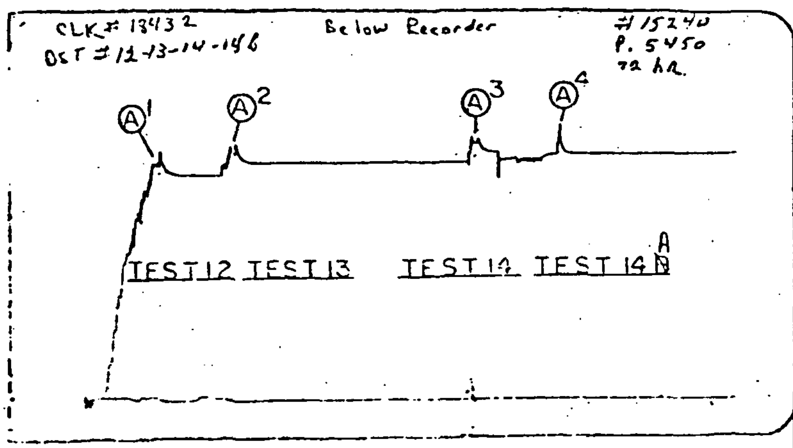
LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 13



PRD Make Kuster K-3
No. 15242 Cap. 5450 @ --

Press		Corrected
Initial Hydrostatic	A	3229
Final Hydrostatic	K	--
Initial Flow	B	2309
Final Initial Flow	C	2968
Initial Shut-in	D	3268
Second Initial Flow	E	2991
Second Final Flow	F	2975
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



Below Interval

PRD Make Kuster K-3
No. 15240 Cap. 5450 @

Press		Corrected
Initial Hydrostatic	A	3539
Final Hydrostatic	K	--
Initial Flow	B	--
Final Initial Flow	C	--
Initial Shut-in	D	--
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

ROGER L. HOEGER
Consulting Geologist
1780 So. Bellaire Street, Suite 501
Denver, Colorado 80222
(303) 759-4491

Drill-Stem-Test Pressure Analysis Report

LOCATION: T1N-R54E, Section 18 SE SE	TIME OPEN: 1128 minutes	FILE NUMBER: Special
COUNTY AND STATE: MONTANA, CUSTER	INITIAL SHUT-IN TIME: 182 minutes	I. D. NUMBER: L-6660
COMPANY: U.S. Geological Survey	FINAL SHUT-IN TIME: ---	DATE COMPUTED: 4/16/77
LEASE AND WELL NUMBER: Madison Test Well #2	TEST NUMBER: 13	DATE TESTED: 6/7/77
FORMATION TESTED: Mission Canyon	INTERVAL TESTED (Feet): 6814-7054	ELEVATION (Feet): KB 2809

RECOVERY: Fluid to surface in 35 minutes. Flowed at average rate of 5 gallons per minute.

HOLE, TOOL AND RECOVERY DATA

DRILL-PIPE CAPACITY (Barrels per foot)	Test tool run	FEET OF MUD		MUD PERCENTAGE %	
DRILL-COLLAR CAPACITY (Barrels per foot)	on 2-7/8"	FEET OF WATER		WATER PERCENTAGE %	
DRILL-COLLAR FOOTAGE (Feet)	tubing.	FEET OF OTHER		OTHER PERCENTAGE %	
HOLE DIAMETER (Inches)	9.625	FEET OF OIL		OIL PERCENTAGE %	
PIPE FOOTAGE EQUIVALENT TO ANNULUS (Feet)	---	FEET OF CUSHION		FORMATION RECOVERY PERCENTAGE %	
INTERVAL THICKNESS (Feet)	240.	TOTAL RECOVERY (Feet)	Flowed water	AVERAGE PRODUCTION RATE (Barrels per day)	171.4
MUD WEIGHT (Pounds per gallon)	---	CAPACITY OF ANNULUS (Barrels)	---		
EFFECTIVE FLOWING TIME (Minutes)	1128.	GROSS RECOVERY VOLUME (Barrels)	---	RECOVERY LESS THAN ANNULAR VOLUME, (X)	☐

GAUGE SUMMARY

A

RECORDER NUMBER	DEPTH	DATUM
2512	6824'	-4015'

B - Surface Recorder

RECORDER NUMBER	DEPTH	DATUM
	2' above K.B.	+2811'

KEY POINT SUMMARY

	A	B
First Flow		
INITIAL FLOWING PRESSURE (psig)	2300.	---
FINAL FLOWING PRESSURE (psig)	2967.	---
Second Flow		
INITIAL FLOWING PRESSURE (psig)	2990.	---
FINAL FLOWING PRESSURE (psig)	2969.	---
INITIAL SHUT-IN PRESSURE (psig)	3267.	299.5
FINAL SHUT-IN PRESSURE (psig)	None	---
INITIAL HYDROSTATIC MUD PRESSURE (psig)	3231.	---
FINAL HYDROSTATIC MUD PRESSURE (psig)	---	---

EXTRAPOLATION SUMMARY

	A	B
INITIAL (t+θ)/θ CALCULATED FROM MEASURED DATA	7.26	7.20
NUMBER OF POINTS USED FOR INITIAL CURVE-FIT	4.	10.
SLOPE OF INITIAL BUILD-UP CURVE (psi/cycle)	42.1	
INITIAL EXTRAPOLATED PRESSURE (psig)	3303.	336.
FINAL (t+θ)/θ CALCULATED FROM MEASURED DATA	---	---
NUMBER OF POINTS USED FOR FINAL CURVE-FIT	---	---
SLOPE OF FINAL BUILD-UP CURVE (psi/cycle)	---	---
FINAL EXTRAPOLATED PRESSURE (psig)	---	---

*Conversion Constant of 2.30 ft./psi used to calculate P.S. Elevation.

SUMMARY OF RESULTS

	A	B
EFFECTIVE TRANSMISSIBILITY, kh/μ (md ft per cp)	662.0	---
INDICATED AVERAGE PERMEABILITY, k/μ (md/cp)	66.2	---
PRODUCTIVITY INDEX (Barrels per day per psi)	0.51	---
DAMAGE RATIO	1.5	
FLOWING PRESSURE COMPARISON (%)	---	---
INITIAL POTENTIOMETRIC SURFACE (feet)	*3582.	*3584.
Ft. of Head above K.B.	771.	775.
FINAL POTENTIOMETRIC SURFACE (feet)	---	---

ROGER L. HOEGER
Consulting Geologist
1780 So. Bellaire Street, Suite 301
Denver, Colorado 80222
(303) 759 - 4491

Comments relative to the analysis of the pressure chart from DST #13, Interval: 6814-7054', in the U.S. Geological Survey, Madison Test Well #2, SE SE Sec. 18, T1N-R54E, Custer County, Montana:

1. Extrapolation of the Shut-in pressure build-up curve indicates a maximum reservoir pressure of 3303 psi at the recorder depth of 6815 feet. This indicated maximum reservoir pressure is equivalent to a potentiometric surface elevation of 3591' above sea level, based upon the conversion constant of 2.30 ft./psi. This potentiometric surface elevation, in turn, indicates a head of water above the K.B. (2809') of 782'.

   For comparison purposes, an extrapolation plot, using the Horner method, has been made for the pressure build-up data which were recorded by the surface pressure recorder during the shut-in period. This extrapolation plot indicates a maximum pressure of 336 psi at the elevation of the surface recorder. This extrapolated pressure is equivalent to a potentiometric surface elevation of +3584', based on the conversion constant of 2.30 ft./psi. This potentiometric surface elevation is equivalent to a head of water above the K.B. of 775'.

2. The calculated Average Production Rate which was used in this analysis, 171.4 BPD, is based upon the reported average flow rate of 5 gallons per minute. This average production rate and the measured slope of the extrapolation plot for the shut-in pressure build-up curve that was produced by the down-hole pressure recorder have been used in the basic Horner equation to calculate numerical values for the various reservoir properties shown below and on the summary page.

3. The calculated Damage Ratio of 1.5 indicates that slight well-bore damage was present at the time of this formation test. The damage ratio implies that the production rate should have been 1.5 times greater than that which occurred if well-bore damage had not been present; however, it should be noted, in view of the fact that the well flowed throughout the flow period used in this test that the indicated well-bore damage may be due to the choke effect of the test tool rather than formation damage.

4. The calculated Effective Transmissibility of 662.0 md.-ft./cp. indicates an Average Permeability of 66.2 md./cp. for the estimated 10 feet of effective porosity within the total 240 feet of interval tested.

5. The evaluation criteria used in the DST Analysis System indicate that the results obtained in this analysis should be reliable within reasonable limits relative to the assumptions which have been made.

LYNES, INC.

Operator U.S.G.S. Lease & No. Makison Test Well #2 DST No. 13

Recorder No. 2512 @ 6824'

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	2967
18.2	63.6374	3216
36.4	32.3187	3228
54.6	21.8791	3238
72.8	16.6593	3245
91.0	13.5275	3250
109.2	11.4396	3255
127.4	9.9482	3260
145.6	8.8297	3264
163.8	7.9597	3266
182.0	7.2637	3267

EXTRAPLN OF FIRST SHUT IN : 3303.3 M : 42.1

Form 2

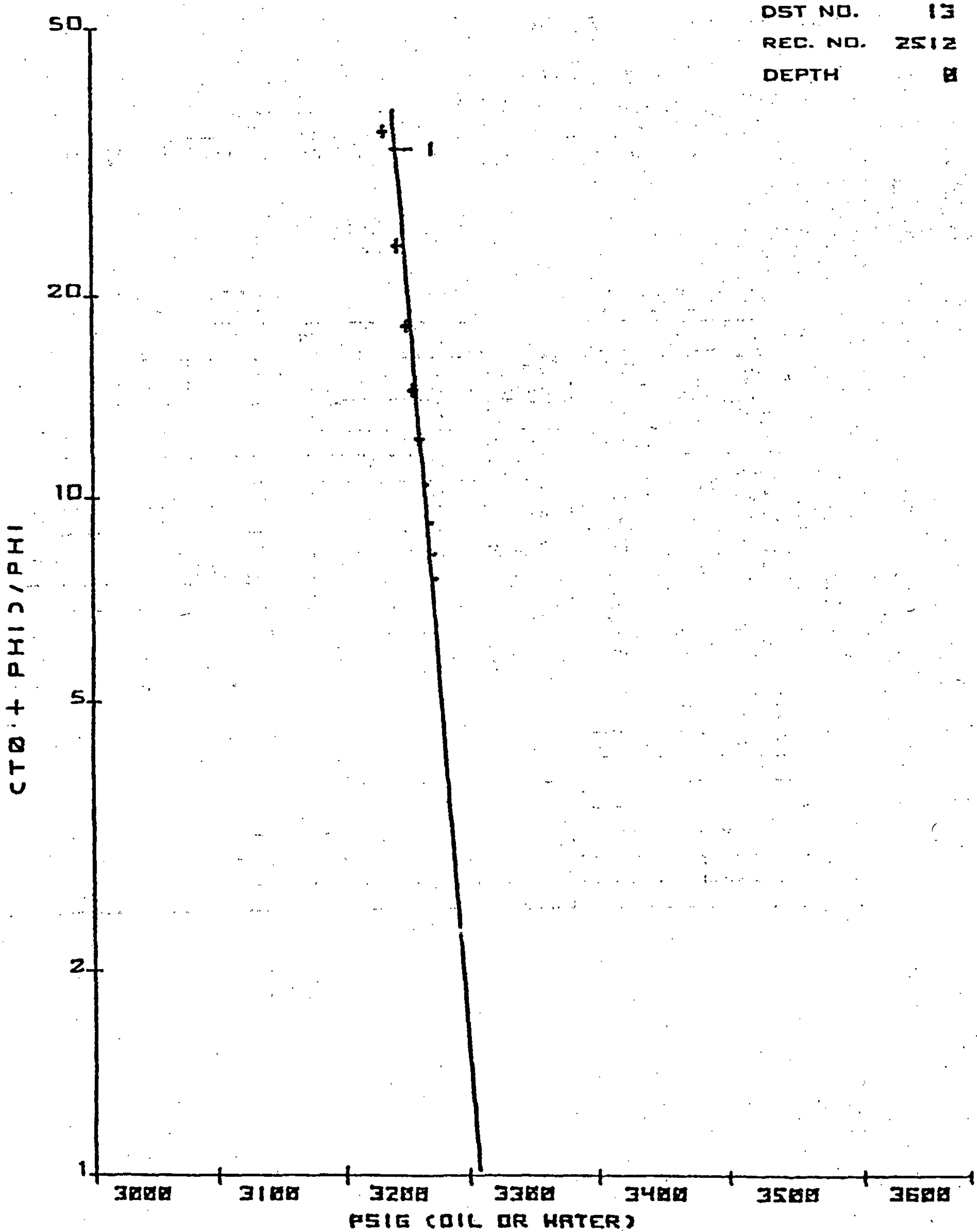
LYNES UNITED SERVICES LTD.

WELL: MADISON 2 U S G S LOCN: DATE: 4-16-77

DST NO. 13

REC. NO. 2512

DEPTH 0



PRESSURE EXTRAPOLATION PLOT

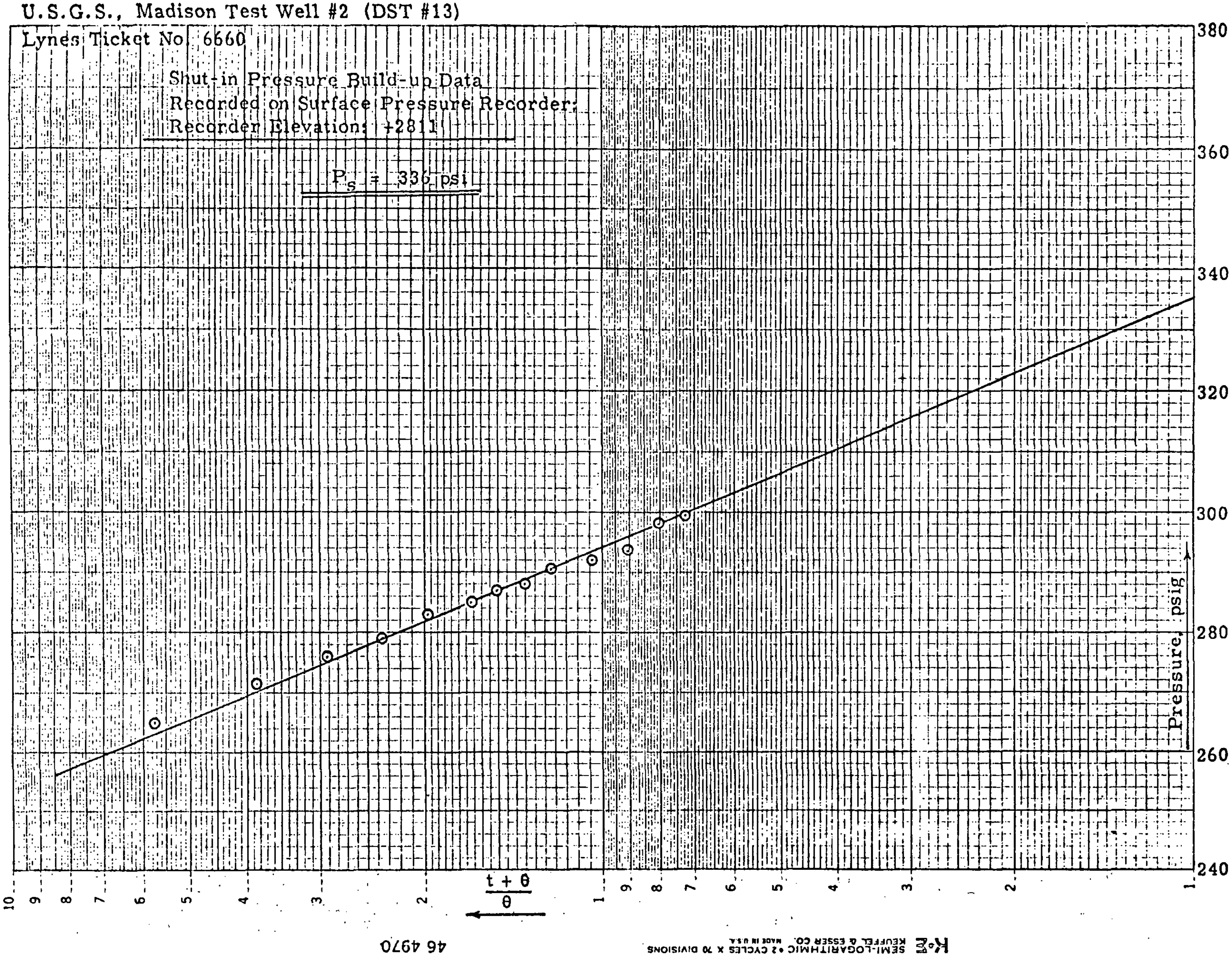
FORM 256 12-76

PRESSURE BUILD-UP CURVE INCREMENTAL-READING DATA

Company U.S. Geological Survey
Well Name & No. Madison Test Well #2
Location SE SE Sec. 18, T1N-R54E, Custer Co., Montana
DST No. 13 Test Interval: 6814-7054' Formation Tested: Mission Canyon

Surface Recorder No. --- Recorder Depth 2' above K.B.

INITIAL SHUT-IN				FINAL SHUT-IN			
Initial Flow Time, t = 1128				Total Flow Time, t =			
θ	t + θ	(t + θ)/θ	Pressure (p.s.i.)	θ	t + θ	(t + θ)/θ	Pressure (p.s.i.)
10	1138	113.80	251.5				
20	1148	57.40	265.0				
30	1158	38.60	271.5				
40	1168	29.20	276.0				
50	1178	23.56	279.0				
60	1188	19.80	283.0				
72	1200	16.67	285.0		NONE		
80	1208	15.10	287.0				
90	1218	13.53	288.0				
100	1228	12.28	290.5				
120	1248	10.40	292.0				
140	1268	9.06	293.5				
160	1288	8.05	298.0				
180	1308	7.27	299.5				



U.S.G.S., Madison Test Well #2 (DST #13)
Lynes Ticket No. 6660
Shut-in Pressure Build-up Data
Recorded on Surface Pressure Recorder;
Recorder Elevation: +2811
Ps = 336 psi
380
360
340
320
300
280
260
240
Pressure, psig
10 9 8 7 6 5 4 3 2 1 9 8 7 6 5 4 3 2 1
(t + θ)/θ
46 4970
K&E SEMI-LOGARITHMIC • 2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

Phone
522-1206 Area 303

LYNES, INC.

Box 712
Sterling, Colo.

Operator United States Geological Survey
Address Box 25046, Denver Federal Center, Stop 412
Lakewood, Colorado 80225
Well Name and No. Madison Test Well #2
Test #14A
Type Tool Straddle Testing & Treating Tool
Date 4-17-77
Ticket No. 6660

Spot	--	Csg. Size & Grade	9 5/8"
Sec.	18	Tubing Size	2 7/8"
Twp.	1 N	Tool Depth	7064-7304'
Rng.	54 E	On Location @	--
Field	Wildcat	Off Location @	--
County	Custer	Lynes Rep.	Paul Robbins
State	Montana	Well Owners Rep.	Ellwood Bennett

Tool Description Straddle Treating & Testing Tool

Top Packer 7 3/8" X 136" Bottom Packer 7 1/2" X 136"

Test #14- A

Summary:

4-17-77

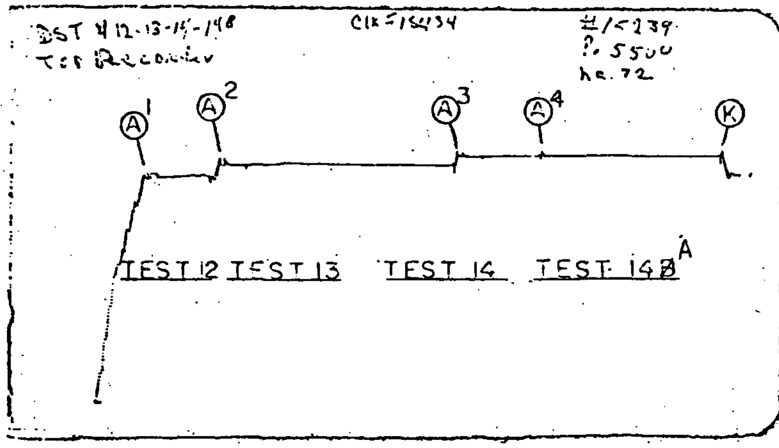
4:15 PM.	Moved tool to blank position and inflated packers.
4:25 PM.	Moved tool to between position. Tool opened with no blow. Began to swab and well started flowing.

4-18-77

8:15 AM.	Shut-in at surface for 180 minutes.
11:40 AM.	Moved tool to blank position and tripped out of hole.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 14-A

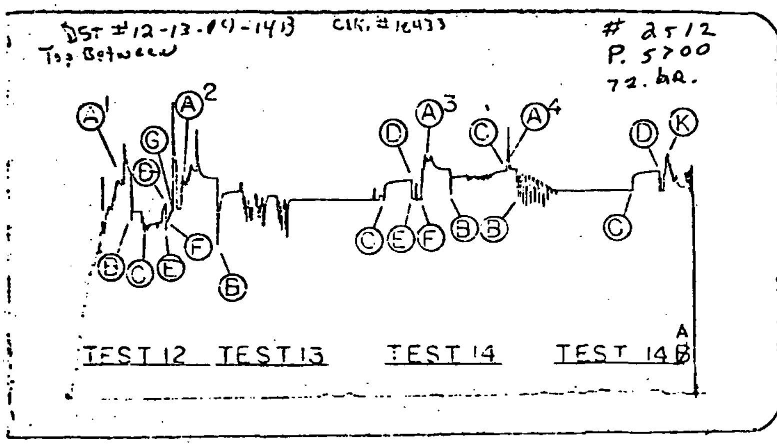


Above Interval

PRD Make Kuster K-3

No. 15239 Cap. 5500 @ --

Press		Corrected
Initial Hydrostatic	A	3564
Final Hydrostatic	K	3527
Initial Flow	B	--
Final Initial Flow	C	--
Initial Shut-in	D	--
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



PRD Make Kuster K-3

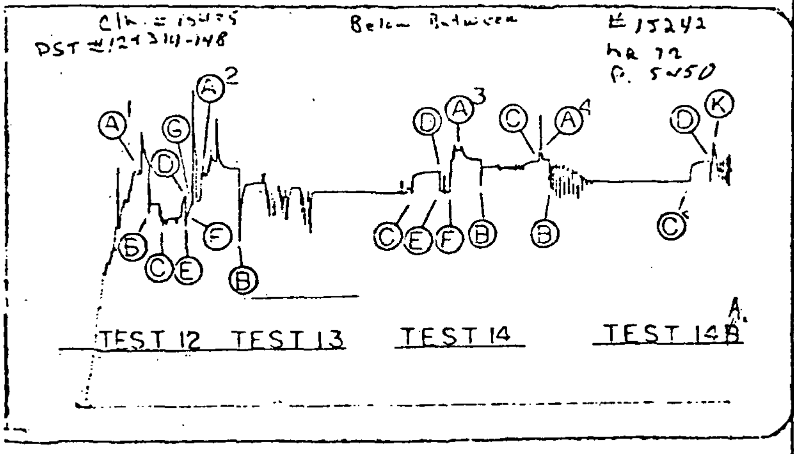
No. 2512 Cap. 5700 @ 7075'

Press		Corrected
Initial Hydrostatic	A	3555
Final Hydrostatic	K	3608
Initial Flow	B	2993
Final Initial Flow	C	3082
Initial Shut-in	D	3368
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

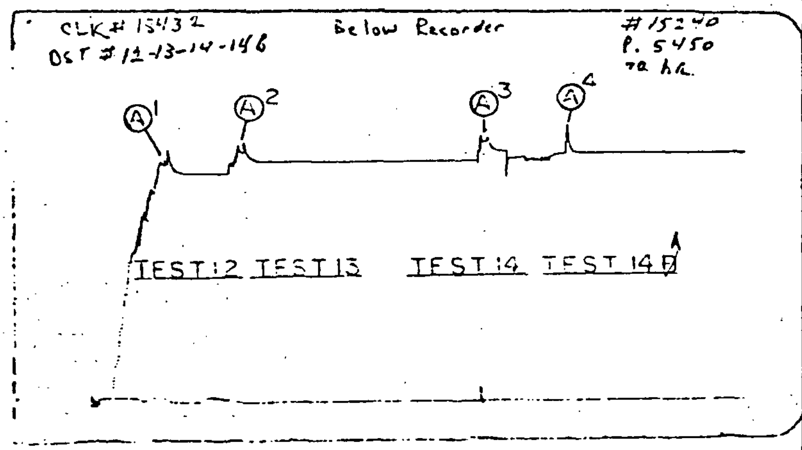
LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 14-A



PRD Make Kuster K-3
No. 15242 Cap. 5450 @ --

Press		Corrected
Initial Hydrostatic	A	3556
Final Hydrostatic	K	3605
Initial Flow	B	3000
Final Initial Flow	C	3093
Initial Shut-in	D	3365
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



Below Interval

PRD Make Kuster K-3
No. 15240 Cap. 5450 @ --

Press		Corrected
Initial Hydrostatic	A	3656
Final Hydrostatic	K	--
Initial Flow	B	--
Final Initial Flow	C	--
Initial Shut-in	D	--
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

ROGER L. HOEGER
Consulting Geologist
1780 So. Bellaire Street, Suite 301
Denver, Colorado 80222
(303) 759-4491

Drill-Stem-Test Pressure Analysis Report

LOCATION: T1N-R54E, SE SE Section 18	TIME OPEN: 950 minutes	FILE NUMBER: Special
COUNTY AND STATE: MONTANA, CUSTER	INITIAL SHUT-IN TIME: 180 minutes	I.D. NUMBER: L-6660
COMPANY: U.S. Geological Survey	FINAL SHUT-IN TIME: ---	DATE COMPUTED: 6/7/77
LEASE AND WELL NUMBER: Madison Test Well #2	TEST NUMBER: 14-A	DATE TESTED: 4/17/77
FORMATION TESTED: L. Mission Canyon & U. Lodgepole	INTERVAL TESTED (Feet): 7064-7304'	ELEVATION (Feet): KB 2809

RECOVERY: Fluid to surface after swabbing. Flowed water at average rate of 9.3 gallons per minute.

HOLE, TOOL AND RECOVERY DATA

DRILL-PIPE CAPACITY (Barrels per foot)	Test tool run	FEET OF MUD		MUD PERCENTAGE %	
DRILL-COLLAR CAPACITY (Barrels per foot)	on 2-7/8'	FEET OF WATER		WATER PERCENTAGE %	
DRILL-COLLAR FOOTAGE (Feet)	tubing.	FEET OF OTHER		OTHER PERCENTAGE %	
HOLE DIAMETER (Inches)	9.625	FEET OF OIL		OIL PERCENTAGE %	
PIPE FOOTAGE EQUIVALENT TO ANNULUS (Feet)	---	FEET OF CUSHION		FORMATION RECOVERY PERCENTAGE %	
INTERVAL THICKNESS (Feet)	240.	TOTAL RECOVERY (Feet)	Flowed water	AVERAGE PRODUCTION RATE (Barrels per day)	338.4
MUD WEIGHT (Pounds per gallon)	---	CAPACITY OF ANNULUS (Barrels)	---		
EFFECTIVE FLOWING TIME (Minutes)	950.	GROSS RECOVERY VOLUME (Barrels)	---	RECOVERY LESS THAN ANNULAR VOLUME, (X)	☐

GAUGE SUMMARY

	RECORDER NUMBER	DEPTH	DATUM
A	2512	7075'	-4266'
B Surface Recorder		2' above K.B.	+2811'

KEY POINT SUMMARY

	A	B
First Flow		
INITIAL FLOWING PRESSURE (psig)	2993.	---
FINAL FLOWING PRESSURE (psig)	3082.	---
Second Flow		
INITIAL FLOWING PRESSURE (psig)	---	---
FINAL FLOWING PRESSURE (psig)	---	---
INITIAL SHUT-IN PRESSURE (psig)	3368.	310.
FINAL SHUT-IN PRESSURE (psig)	None	---
INITIAL HYDROSTATIC MUD PRESSURE (psig)	3955.	---
FINAL HYDROSTATIC MUD PRESSURE (psig)	3608.	---

EXTRAPOLATION SUMMARY

	A	B
INITIAL (t+θ)/θ CALCULATED FROM MEASURED DATA	6.28	6.28
NUMBER OF POINTS USED FOR INITIAL CURVE-FIT	5.	12.
SLOPE OF INITIAL BUILD-UP CURVE (psi/cycle)	66.9	37.
INITIAL EXTRAPOLATED PRESSURE (psig)	3421.	340.
FINAL (t+θ)/θ CALCULATED FROM MEASURED DATA	----	---
NUMBER OF POINTS USED FOR FINAL CURVE-FIT	---	---
SLOPE OF FINAL BUILD-UP CURVE (psi/cycle)	---	---
FINAL EXTRAPOLATED PRESSURE (psig)	---	---

* Conversion Constant of 2.30 ft./psi used to calculate P.S. Elevation.

SUMMARY OF RESULTS

	A	B
EFFECTIVE TRANSMISSIBILITY, kh/μ (md ft per cp)	822.7	---
INDICATED AVERAGE PERMEABILITY, k/μ (md/cp)	82.3 (for 10' effect. φ)	
PRODUCTIVITY INDEX (Barrels per day per psi)	1.0	---
DAMAGE RATIO	0.9	---
FLOWING PRESSURE COMPARISON %	---	---
INITIAL POTENTIOMETRIC SURFACE (feet)	*3602.	*3593.
Ft. of Head above K.B.	793.	784.
FINAL POTENTIOMETRIC SURFACE (feet)	---	---

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Denver, Colorado 80222
(303) 759 - 4491

Comments relative to the analysis of the pressure chart from DST #14-A, Interval: 7064-7304', in the U.S. Geological Survey, Madison Test Well #2, SE SE Section 18, T1N-R54E, Custer County, Montana:

1. Extrapolation of the Shut-in pressure build-up curve indicates a maximum reservoir pressure of 3421 psi at the recorder depth of 7075 feet. This indicated maximum reservoir pressure is equivalent to a potentiometric surface elevation of 3602 feet above sea level, based upon the conversion constant of 2.30 ft./psi. This potentiometric surface elevation, in turn, indicates a head of water above the K.B. of 793 feet.

   For comparison pruposes, an extrapolation plot, using the Horner method, has been made for the pressure build-up data which were recorded by the surface pressure recorder during the shut-in period. This extrapolation plot indicates a maximum pressure of 340 psi at the elevation of the surface recorder. This extrapolated pressure is equivalent to a potentiometric surface elevation of +3593', based on the conversion constant of 2.30 ft./psi. This potentiometric surface elevation is equivalent to a head of water above the K.B. of 784'. It should be noted that there is very close agreement between the potentiometric surface elevations which have been calculated on the basis of the two extrapolated pressures, that recorded by the down-hole pressure instrument and that recorded by the surface pressure recorder.

2. The calculated Average Production Rate which was used in this analysis, 338.4 BPD, is based upon the reported average flow rate which was measured at the surface, about 9.3 gallons per minute. This average production rate and the measured slope of the extrapolation plot for the shut-in pressure build-up curve that was produced by the down-hole pressure recorder have been used in the basic Horner equation to calculate numerical values for the various reservoir properties shown below and on the summary page.

3. The calculated Damage Ratio of 0.9 indicates that no significant well-bore damage was present at the time of this formation test.

4. The calculated Effective Transmissibility of 822.7 md.-ft./cp. indicates an Average Permeability of 82.3 md./cp. for the estimated 10 feet of effective porosity within the total 240 feet of interval tested.

5. The evaluation criteria used in the DST Analysis System indicate that the results obtained in this analysis should be reliable within reasonable limits relative to the assumptions which have been made.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 14-A

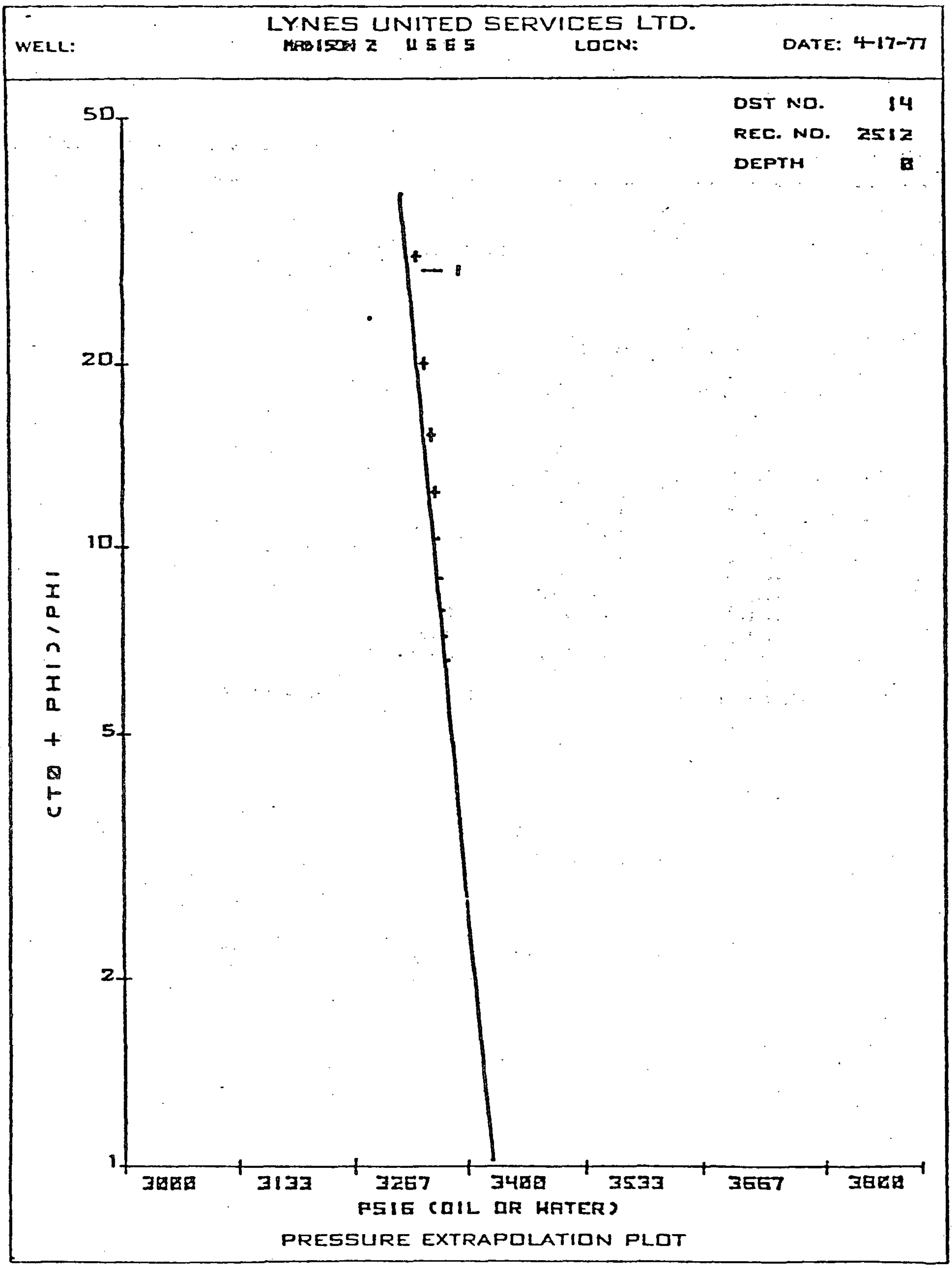
Recorder #2512 @ 7075'

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	3082
18.0	53.7778	3313
36.0	27.3889	3332
54.0	18.5926	3341
72.0	14.1944	3349
90.0	11.5556	3353
108.0	9.7963	3356
126.0	8.5397	3359
144.0	7.5972	3362
162.0	6.8642	3365
180.0	6.2778	3368

EXTRAPLN OF FIRST SHUT IN : 3421.4 M : 66.9

Form 2



FORM 286 12-76

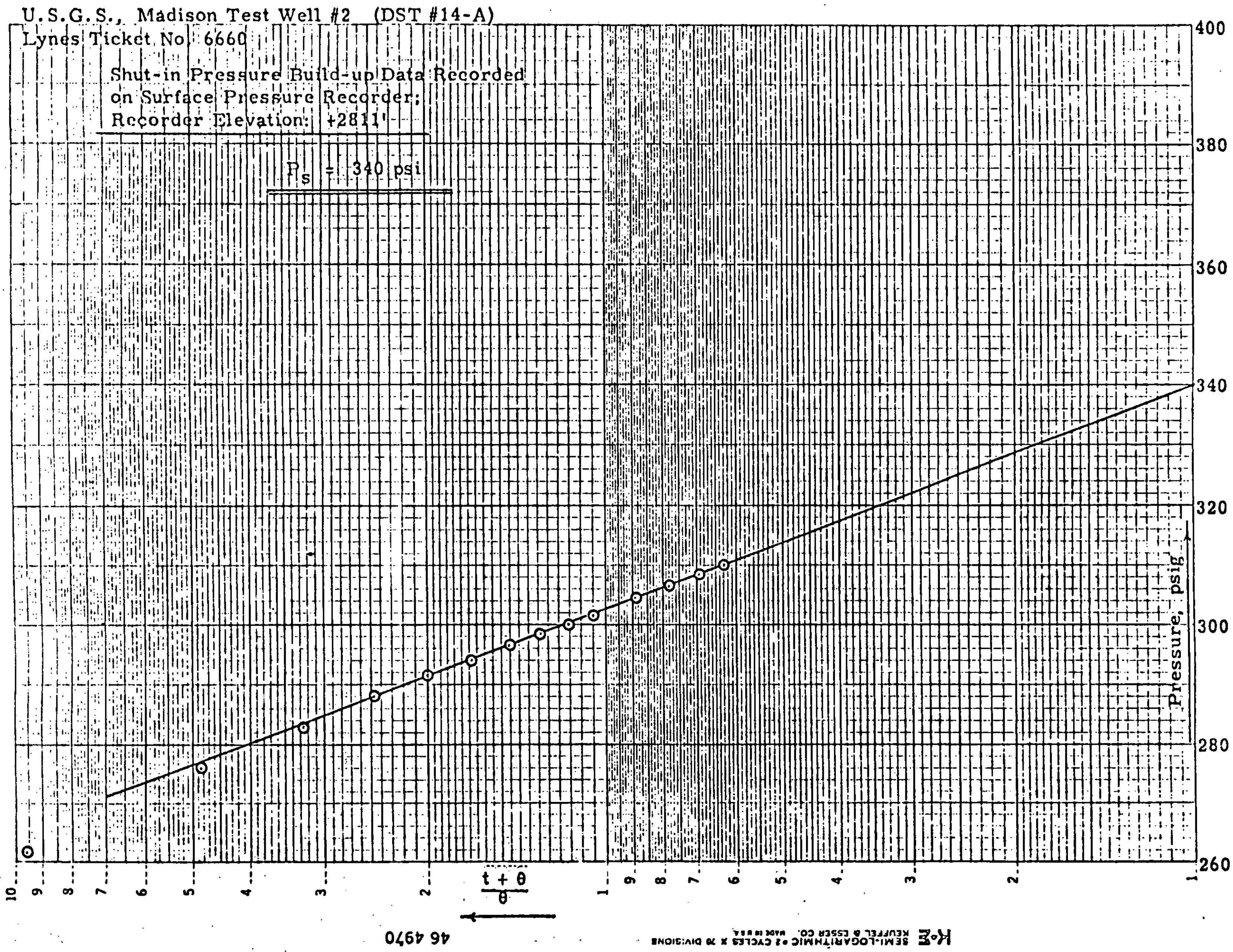
PRESSURE BUILD-UP CURVE INCREMENTAL-READING DATA

Company U.S. Geological Survey
Well Name & No. Madison Test Well #2
Location SE SE Sec. 18, T1N-R54E, Custer Co., Montana
DST No. 14-A Test Interval: 7064-7304' Formation Tested: L. MissionCanyon and U. Lodgepole

Surface Recorder No. --- Recorder Depth 2'above K.B.

INITIAL SHUT-IN / **FINAL SHUT-IN**

Initial Flow Time, t = 950				Total Flow Time, t =			
θ	t + θ	$\frac{t+\theta}{\theta}$	Pressure (p.s.i.)	θ	t + θ	$\frac{t+\theta}{\theta}$	Pressure (p.s.i.)
10	960	96.00	261.5				
20	970	48.50	276.0				
30	980	32.67	283.0				
40	990	24.75	288.0				
50	1000	20.00	291.5				
60	1010	16.83	294.0		NONE		
70	1020	14.57	296.5				
80	1030	12.88	298.5				
90	1040	11.56	300.0				
100	1050	10.50	301.5				
120	1070	8.92	304.5				
140	1090	7.79	306.5				
160	1110	6.94	308.5				
180	1130	6.28	310.0				



U.S.G.S., Madison Test Well #2 (DST #14-A)
Lynes Ticket No. 6660
Shut-in Pressure Build-up Data Recorded on Surface Pressure Recorder; Recorder Elevation: +2811'
P_s = 340 psi
Pressure, psig
$\frac{t+\theta}{\theta}$
400
380
360
340
320
300
280
260
10
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
1
46 4970
K+E SEMI-LOGARITHMIC 2 CYCLES X 70 DIVISIONS
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Phone
522-1206 Area 303

LYNES, INC.

Box 712
Sterling, Colo.

Operator United States Geological Survey
Address Box 25046, Denver Federal Center, Stop 412
Lakewood, Colorado 80225
Well Name and No. Madison Test Well #2
Type Tool Single Set Production Injection Packer
Date 4-23-77
Ticket No. 6662

Spot	--	Csg. Size & Grade	9 5/8"
Sec.	18	Tubing Size	2 7/8"
Twp.	1 N	Tool Depth	8520-9394'
Rng.	54 E	On Location @	--
Field	Wildcat	Off Location @	--
County	Custer	Lynes Rep.	Paul Robbins
State	Montana	Well Owners Rep.	Ellwood Bennett

Tool Description Single Set Production Injection Packer

Top Packer 7½" X 136"

Test #17

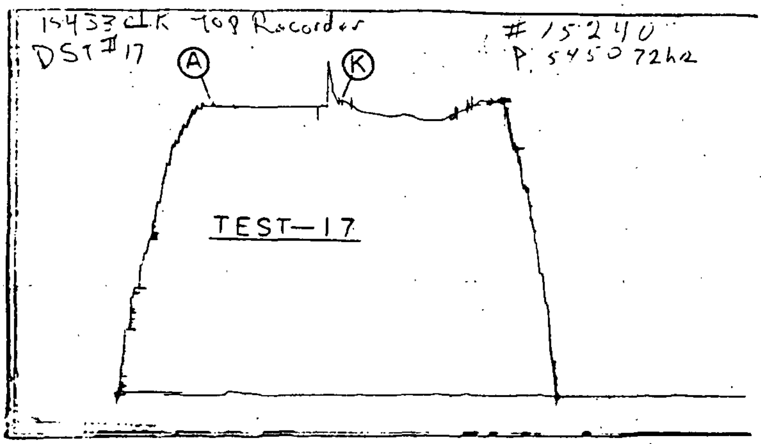
Summary:

4-23-77
2:30 AM. Inflated packer with 2300 psig. at surface.
4:57 AM. With tool in blank position, dropped bar to open sleeve, and swabbed down 2000'.
5:02 AM. Opened tool below with strong blow. Fluid to surface in 9 minutes, flowing approximately 50 gallons per minute.

4-24-77
1:26 AM. Shut-in at surface for 1 hour.
2:26 AM. Released packer.

LYNES, INC.

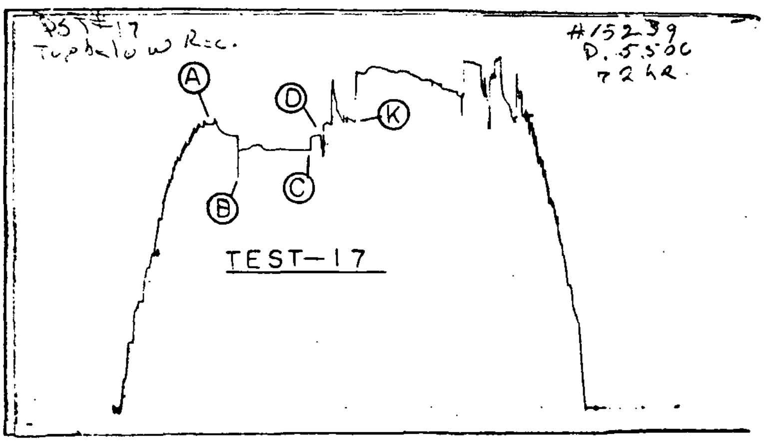
Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 17



Above Interval

PRD Make Kuster K-3
No. 15240 Cap. 5450 @

Press		Corrected
Initial Hydrostatic	A	4205
Final Hydrostatic	K	4244
Initial Flow	B	--
Final Initial Flow	C	--
Initial Shut-in	D	--
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



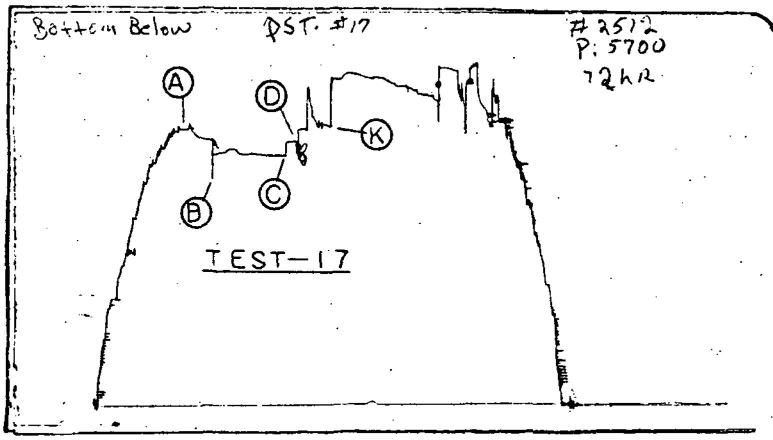
PRD Make Kuster K-3
No. 15239 Cap. 5500 @ 8528

Press		Corrected
Initial Hydrostatic	A	4199
Final Hydrostatic	K	4215
Initial Flow	B	3402
Final Initial Flow	C	3799
Initial Shut-in	D	4027
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 17



PRD Make Kuster K-3
No. 2512 Cap. 5700 @ 8535'

Press		Corrected
Initial Hydrostatic	A	4220
Final Hydrostatic	K	4239
Initial Flow	B	3433
Final Initial Flow	C	3808
Initial Shut-in	D	4029
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

PRD Make
No. Cap. @

Press		Corrected
Initial Hydrostatic	A	
Final Hydrostatic	K	
Initial Flow	B	
Final Initial Flow	C	
Initial Shut-in	D	
Second Initial Flow	E	
Second Final Flow	F	
Second Shut-in	G	
Third Initial Flow	H	
Third Final Flow	I	
Third Shut-in	J	
Pressure Below Bottom Packer Bled To		

Form 3

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Drill-Stem-Test Pressure Analysis Report

LOCATION:	TIME OPEN:	FILE NUMBER:
T1N-R54E, SE SE Section 18	504 minutes	Special
COUNTY AND STATE: MONTANA, CUSTER	INITIAL SHUT-IN TIME: 60 minutes	I. D. NUMBER: L-6662
COMPANY: U.S. Geological Survey	FINAL SHUT-IN TIME: None	DATE COMPUTED: 6/8/77
LEASE AND WELL NUMBER: Madison Test Well #2	TEST NUMBER: 17	DATE TESTED: 4/23/77
FORMATION TESTED: Winnipeg	INTERVAL TESTED: (Feet) 8520-9394	ELEVATION: (Feet) KB 2809

RECOVERY: Fluid to surface in 9 minutes; flowed at approximate average rate of 50 gallons per minute.

HOLE, TOOL AND RECOVERY DATA

DRILL-PIPE CAPACITY (Barrels per foot)	Test tool run	FEET OF MUD		MUD PERCENTAGE %	
DRILL-COLLAR CAPACITY (Barrels per foot)	on 2-7/8"	FEET OF WATER		WATER PERCENTAGE %	
DRILL-COLLAR FOOTAGE (Feet)	tubing.	FEET OF OTHER		OTHER PERCENTAGE %	
HOLE DIAMETER (Inches)	9.625	FEET OF OIL		OIL PERCENTAGE %	
PIPE FOOTAGE EQUIVALENT TO ANNULUS (Feet)	---	FEET OF CUSHION		FORMATION RECOVERY PERCENTAGE %	
INTERVAL THICKNESS (Feet)	874.	TOTAL RECOVERY (Feet)	Flowed water	AVERAGE PRODUCTION RATE (Barrels per day)	1714.3
MUD WEIGHT (Pounds per gallon)	---	CAPACITY OF ANNULUS (Barrels)	---		
EFFECTIVE FLOWING TIME (Minutes)	504.	GROSS RECOVERY VOLUME (Barrels)	---	RECOVERY LESS THAN ANNULAR VOLUME. (X)	☐

GAUGE SUMMARY

A

RECORDER NUMBER	DEPTH:	DATUM:
2512	8535'	-5726'

B Surface Recorder

RECORDER NUMBER	DEPTH:	DATUM:
	2' above K.B.	+2811'

KEY POINT SUMMARY

	A	B
First Flow		
INITIAL FLOWING PRESSURE: (psig)	3433.	---
FINAL FLOWING PRESSURE: (psig)	3808.	---
Second Flow		
INITIAL FLOWING PRESSURE: (psig)	None	---
FINAL FLOWING PRESSURE: (psig)	None	---
INITIAL SHUT-IN PRESSURE: (psig)	4029.	309.
FINAL SHUT-IN PRESSURE: (psig)	None	---
INITIAL HYDROSTATIC MUD PRESSURE: (psig)	4220.	---
FINAL HYDROSTATIC MUD PRESSURE: (psig)	4239.	

EXTRAPOLATION SUMMARY

	A	B
INITIAL (t+θ)/θ CALCULATED FROM MEASURED DATA:	9.4	9.4
NUMBER OF POINTS USED FOR INITIAL CURVE-FIT:	6.	---
SLOPE OF INITIAL BUILD-UP CURVE: (psi/cycle)	9.3	---
INITIAL EXTRAPOLATED PRESSURE: (psig)	4038.	317. (?)
FINAL (t+θ)/θ CALCULATED FROM MEASURED DATA:	---	
NUMBER OF POINTS USED FOR FINAL CURVE-FIT:	---	
SLOPE OF FINAL BUILD-UP CURVE: (psi/cycle)	---	
FINAL EXTRAPOLATED PRESSURE: (psig)	---	

*Conversion Constant of 2.30 ft./psi used to calculate P.S. Elevation

SUMMARY OF RESULTS

	A	B
EFFECTIVE TRANSMISSIBILITY, kh/μ: (md ft per cp)	29972.6	
INDICATED AVERAGE PERMEABILITY, k/μ: (md/cp)	2997.3 (for est. 10' effect. ϕ)	
PRODUCTIVITY INDEX: (Barrels per day per psi)	7.45	
DAMAGE RATIO:	4.5	
FLOWING PRESSURE COMPARISON: %	---	
INITIAL POTENTIOMETRIC SURFACE: (feet)	*3561.	*3540 (?)
Ft. of Head above K.B.	752.	731.
FINAL POTENTIOMETRIC SURFACE: (feet)	---	
INITIAL MUD PRESSURE COMPARISON: %	---	
FINAL MUD PRESSURE COMPARISON: %	---	

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Comments relative to the analysis of the pressure chart from DST #17, Interval: 8520-9394', in the U.S.Geological Survey, Madison Test Well #2, SE SE Sec. 18, T1N-R54E, Custer County, Montana:

1. Extrapolation of the Shut-in pressure build-up curve indicates a maximum reservoir pressure of 4038 psi at the recorder depth of 8535 feet. This indicated maximum reservoir pressure is equivalent to a potentiometric surface elevation of 3561 feet above sea level, based upon the conversion constant of 2.30 ft./psi. This potentiometric surface elevation, in turn, indicates a head of water above the K.B. of 752 feet.

   For comparison purposes, an extrapolation plot, using the Horner method, has been made for the pressure build-up data which were recorded by the surface pressure recorder during the shut-in period. This extrapolation plot indicates a maximum pressure of 317 psi at the elevation of the surface recorder. This extrapolated pressure is equivalent to a potentiometric surface elevation of +3540', based on the conversion constant of 2.30 ft./psi. This potentiometric surface elevation is equivalent to a head of water above the K.B. of 731 feet.

2. The calculated Average Production Rate which was used in this analysis, 1714.3 BPD, is based upon the reported average flow rate of 50 gallons per minute which was recorded at the surface throughout the 504-minute flow period. This average production rate and the measured slope of the extrapolation plot for the shut-in pressure build-up curve that was produced by the down-hole pressure recorder have been used in the basic Horner equation to calculate numerical values for the various reservoir properties shown below and on the summary page.

3. The calculated Damage Ratio of 4.5 indicates that significant well-bore damage was present at the time of this formation test; however, it should be noted, in view of the volume-rate of production which occurred, this indicated well-bore damage is most probably due to the choke effect of the test tool rather than formation damage.

4. The calculated Effective Transmissibility of 29972.6 md.-ft./cp. indicates an Average Permeability of 2997.3 md./cp. for the estimated 10 feet of effective porosity within the total 874 feet of interval tested.

5. The evaluation criteria used in the DST Analysis System indicate that the results obtained in this analysis should be reliable within reasonable limits relative to the assumptions which have been made.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Test Well #2 DST No. 17

Recorder #2512 @ 8535'

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	3808
6.0	85.0000	4010
12.0	43.0000	4016
18.0	29.0000	4019
24.0	22.0000	4022
30.0	17.8000	4025
36.0	15.0000	4027
42.0	13.0000	4028
48.0	11.5000	4029
54.0	10.3333	4029
60.0	9.4000	4029

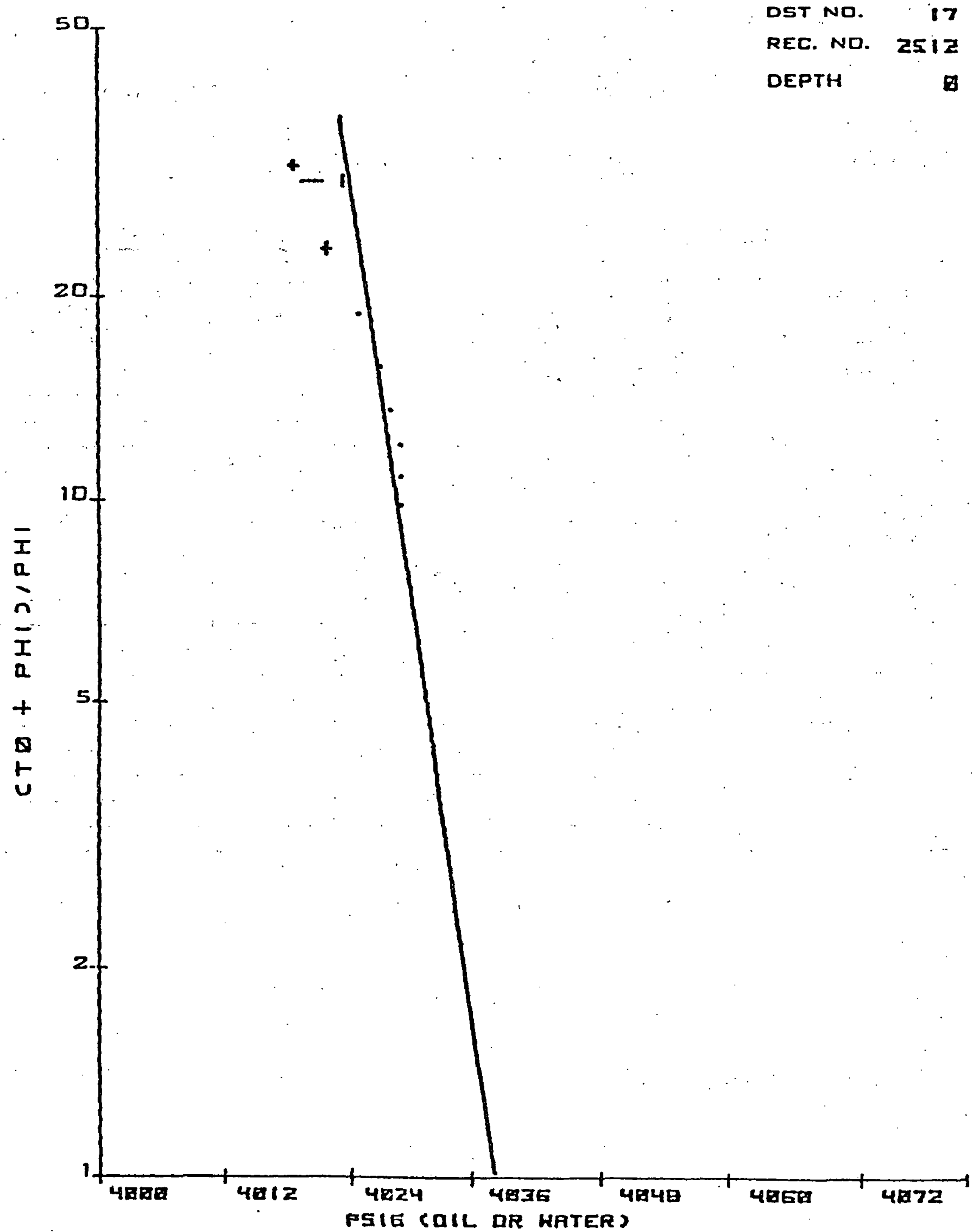
EXTRAPLN OF FIRST SHUT IN : 4038.1 M : 9.3

Form 2

LYNES UNITED SERVICES LTD.

WELL: MADISON #2 U 5 6 5 LOCN: DATE: 4-22-77

DST NO. 17
REC. NO. 2512
DEPTH 0



PRESSURE EXTRAPOLATION PLOT

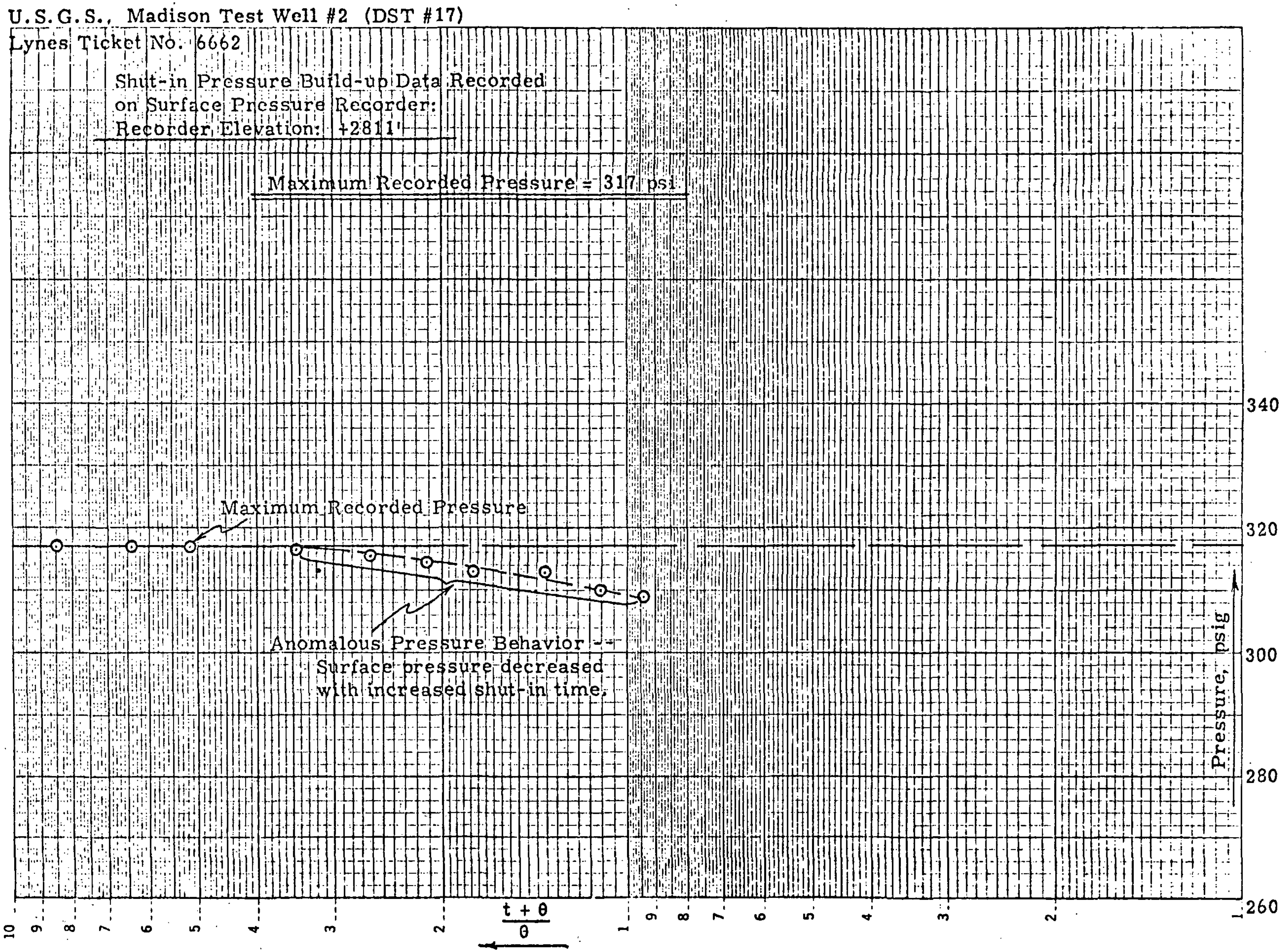
PRESSURE BUILD-UP CURVE INCREMENTAL-READING DATA

Company U.S. Geological Survey
Well Name & No. Madison Test Well #2
Location SE SE Sec. 18, T1N-R54E, Custer County, Montana
DST No. 17 Test Interval: 8520-9394 Formation Tested: Winnipeg

Surface
Recorder No. --- Recorder Depth 2' above K.B.

INITIAL SHUT-IN | FINAL SHUT-IN

Initial Flow Time, t = 504				Total Flow Time, t =			
θ	t + θ	$\frac{t+\theta}{\theta}$	Pressure (p.s.i.)	θ	t + θ	$\frac{t+\theta}{\theta}$	Pressure (p.s.i.)
2	506	253.00	313.5				
4	508	127.00	316.0				
6	510	85.00	317.0				
8	512	64.00	317.0				
10	514	51.40	317.0		NONE		
15	519	34.60	316.5				
20	524	26.20	315.5				
25	529	21.16	314.5				
30	534	17.80	313.0				
40	544	13.60	313.0				
50	554	11.08	310.0				
60	564	9.40	309.0				



U.S.G.S., Madison Test Well #2 (DST #17)
Lynes Ticket No. 6662
Shut-in Pressure Build-up Data Recorded on Surface Pressure Recorder:
Recorder Elevation: +2811'
Maximum Recorded Pressure = 317 psi
Maximum Recorded Pressure
Anomalous Pressure Behavior -- Surface pressure decreased with increased shut-in time.
Pressure, psig
340
320
300
280
260
t + θ / θ

Geochemistry

Water samples were collected from drill-stem test zones that were selected to represent major rock types, formations of various ages, and types of porosity. The water chemistry from the selected intervals in Madison test wells 1 and 2 and subsequent tests will be used as control points for interpreting regional geologic, geophysical, isotopic, and chemical data.

If the interval flowed when the inflatable packers were set above and below the zone to be sampled, measurements were made of the pH and conductivity of the fluid until stabilization of these values and clearing of the water were obtained, indicating formation water was being monitored. If the interval did not flow, swabbing was begun to remove sufficient heavy drilling mud from the water column and formation to develop the zone. If possible, water samples were collected for analysis only after pH and conductivity measurements indicated that the water represented the formation fluid in the interval tested. Characteristics subject to variation with time such as pH, temperature, alkalinity, and conductance were measured in the field at the time of collection. Alkalinity was determined by pH titration using a standard sulfuric acid solution and preparing a titration curve. The field data are included with the laboratory data in the analyses tables.

The analyses of water samples from the Lakota Sandstone, Minnelusa, Mission Canyon, Devonian and Silurian, Red River, Roughlock to Precambrian, and a composite of waters from the Madison into the Red River are shown in tables 3-9.

Table 3.--Water-quality analysis--Lakota Sandstone

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 43902 RECORD # 57099

SAMPLE LOCATION: 01N54E18DDAC
STATION ID: 455001105024304 LAT.LONG.SEQ.: 455001 1050243 04
DATE OF COLLECTION: BEGIN--770125 END-- TIME--1200
STATE CODE: 30 COUNTY CODE: 075 PROJECT IDENTIFICATION: 463004900
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 217LKOT
COMMENTS: LAKOTA SANDSTONE

BICARBONATE	MG/L	1130	MERCURY DISSOLVED	UG/L	0.0
BROMIDE	MG/L	1.0	NO2+NO3 AS N DISS	DETR.	DELETED
CALCIUM DISS	MG/L	6.0	PH FIELD		8.3
CARBONATE	MG/L	69	PH LAB		8.5
CHLORIDE DISS	MG/L	300	POTASSIUM DISS	MG/L	3.8
FLUORIDE DISS	MG/L	3.8	SAR		72
HARDNESS NONCARB	MG/L	0	SELENIUM DISSOLVED	UG/L	0
HARDNESS TOTAL	MG/L	18	SODIUM DISS	MG/L	700
IODIDE	MG/L	0.22	SODIUM PERCENT		99
IRON DISSOLVED	UG/L	1300	SP. CONDUCTANCE FLD		2790
IRON TOTAL	UG/L	16000	SP. CONDUCTANCE LAB		2950
LITHIUM DISSOLVED	UG/L	120	STRONTIUM DISSOLVED	UG/L	130
MAGNESIUM DISS	MG/L	0.7	SULFATE DISS	MG/L	130
MANGANESE DISSOLVED	UG/L	70	ZINC DISSOLVED	UG/L	30

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	6.0	0.300	BICARBONATE	1130	18.521
MAGNESIUM DISS	0.7	0.058	CARBONATE	69	2.300
POTASSIUM DISS	3.8	0.098	CHLORIDE DISS	300	8.463
SODIUM DISS	700	30.450	FLUORIDE DISS	3.8	0.201
			SULFATE DISS	130	2.707
TOTAL		30.904	TOTAL		32.190

PERCENT DIFFERENCE = -2.04

Table 4.--Water-quality analysis--Minnelusa

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 43901 RECORD # 57097

SAMPLE LOCATION: 01N54E18DDAC
STATION ID: 455001105024303 LAT.LONG.SEQ.: 455001 1050243 03
DATE OF COLLECTION: BEGIN--770123 END-- TIME--1200
STATE CODE: 30 COUNTY CODE: 075 PROJECT IDENTIFICATION: 463004900
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 310MNLS
COMMENTS: MINNELUSA

BICARBONATE	MG/L	443	MERCURY DISSOLVED	UG/L	0.0
BROMIDE	MG/L	0.5	NO2+NO3 AS N DISS		DETR. DELETED
CALCIUM DISS	MG/L	420	PH FIELD		7.0
CARBONATE	MG/L	0	PH LAB		7.5
CHLORIDE DISS	MG/L	15000	POTASSIUM DISS	MG/L	420
FLUORIDE DISS		DETR. DELETED	SAR		82
HARDNESS NONCARB	MG/L	5200	SELENIUM DISSOLVED	UG/L	1
HARDNESS TOTAL	MG/L	5600	SODIUM DISS	MG/L	14000
IODIDE	MG/L	0.03	SODIUM PERCENT		83
IRON DISSOLVED	UG/L	1800	SP. CONDUCTANCE FLD		43200
IRON TOTAL	UG/L	40000	SP. CONDUCTANCE LAB		50000
LITHIUM DISSOLVED	UG/L	15000	STRONTIUM DISSOLVED	UG/L	2400
MAGNESIUM DISS	MG/L	1100	SULFATE DISS	MG/L	13000
MANGANESE DISSOLVED	UG/L	710	ZINC DISSOLVED	UG/L	830

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	420	20.958	BICARBONATE	440	7.212
MAGNESIUM DISS	1100	90.486	CARBONATE	0	0.000
POTASSIUM DISS	420	10.740	CHLORIDE DISS	15000	423.150
SODIUM DISS	14000	609.000	SULFATE DISS	13000	270.660
	TOTAL	731.183		TOTAL	701.021

PERCENT DIFFERENCE = 2.11

Table 5.--Water-Quality analysis--Mission Canyon

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 111011 RECORD # 65895

SAMPLE LOCATION: 01N54E18DDAC
STATION ID: 455001105024313 LAT.LONG.SEQ.: 455001 1050243 13
DATE OF COLLECTION: BEGIN--770417 END-- TIME--0100
STATE CODE: 30 COUNTY CODE: 017 PROJECT IDENTIFICATION: 463004900
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 331MSNC
MISSION CANYON
COMMENTS:
SULFUROUS ODOR--BLACK SUSPENDED MATERIAL,CLOUDY, MAY BE COMPOSITED AS SP COND WAS NOT STABLE: FIELD VALUE USED FOR BICARB: RAD-CHEM SPLIT OFF: DEPTH(FT):6796-7036

ALK,TOT (AS CACO3)	MG/L	330	MERCURY DISSOLVED	UG/L	0.0
ALUMINUM DISSOLVED	UG/L	0	MOLYBDENUM DISSOLVED	UG/L	0
ARSENIC DISSOLVED	UG/L	5	NITROGEN TOTKJD AS N	MG/L	0.10
BARIUM DISSOLVED	UG/L	100	PH FIELD		7.2
BICARBONATE	MG/L	407	PH LAB		7.2
BORON DISSOLVED	UG/L	1400	PHOSPHORUS DIS AS P	MG/L	0.10
BROMIDE	MG/L	3.0	POTASSIUM DISS	MG/L	62
CADMIUM DISSOLVED	UG/L	1	RESIDUE DIS CALC SUM	MG/L	3210
CALCIUM DISS	MG/L	350	RESIDUE DIS TON/AFT		4.54
CARBONATE	MG/L	0	RESIDUE DIS 180C	MG/L	3340
CHLORIDE DISS	MG/L	580	SAR		7.2
CHROMIUM DISSOLVED	UG/L	70	SELENIUM DISSOLVED	UG/L	0
COPPER DISSOLVED	UG/L	0	SILICA DISSOLVED	MG/L	59
FLUORIDE DISS	MG/L	4.3	SODIUM DISS	MG/L	560
HARDNESS NONCARB	MG/L	820	SODIUM PERCENT		50
HARDNESS TOTAL	MG/L	1200	SP. CONDUCTANCE FLD		3600
IODIDE	MG/L	0.08	SP. CONDUCTANCE LAB		4330
IRON DISSOLVED	UG/L	11000	STRONTIUM DISSOLVED	UG/L	12000
LEAD DISSOLVED	UG/L	11	SULFATE DISS	MG/L	1300
LITHIUM DISSOLVED	UG/L	600	SULFIDE TOTAL	MG/L	3.4
MAGNESIUM DISS	MG/L	65	VANADIUM DISSOLVED	UG/L	20
MANGANESE DISSOLVED	UG/L	1800	WATER TEMP (DEG C)		33.8
			ZINC DISSOLVED	UG/L	320

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	350	17.465	BICARBONATE	407	6.671
MAGNESIUM DISS	65	5.347	CARBONATE	0	0.000
POTASSIUM DISS	62	1.586	CHLORIDE DISS	580	16.362
SODIUM DISS	560	24.360	FLUORIDE DISS	4.3	0.227
			SULFATE DISS	1300	27.066
	TOTAL	48.757		TOTAL	50.325

PERCENT DIFFERENCE = -1.58

Table 6.--Water-quality analysis--Devonian and Silurian

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 111008 RECORD # 65887

SAMPLE LOCATION: 01N54E18DDAC
STATION ID: 455001105024311 LAT.LONG.SEQ.: 455001 1050243 11
DATE OF COLLECTION: BEGIN--770414 END-- TIME--1700
STATE CODE: 30 COUNTY CODE: 017 PROJECT IDENTIFICATION: 463004900
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: DEVONIAN AND SILURIAN
COMMENTS:
MUDDY--LT BROWN COLOR AFTER SETTLED: FIELD VALUE USED FOR BICARB:
DEPTH(FT): 7766-8006

ALK.TOT (AS CACO3)	MG/L	380	MERCURY DISSOLVED	UG/L	0.0
ALUMINUM DISSOLVED	UG/L	50	MOLYBDENUM DISSOLVED	UG/L	13
ARSENIC DISSOLVED	UG/L	2	NITROGEN TOTKJD AS N	MG/L	9.9
BARIUM DISSOLVED	UG/L	100	PH FIELD		7.0
BICARBONATE	MG/L	464	PH LAB		6.9
BORON DISSOLVED	UG/L	19000	PHOSPHORUS DIS AS P	MG/L	0.02
BROMIDE	MG/L	7.4	POTASSIUM DISS	MG/L	190
CADMIUM DISSOLVED	UG/L	1	RESIDUE DIS CALC SUM	MG/L	7420
CALCIUM DISS	MG/L	270	RESIDUE DIS TON/AFT		10.5
CARBONATE	MG/L	0	RESIDUE DIS 180C	MG/L	7700
CHLORIDE DISS	MG/L	1700	SAR		32
CHROMIUM DISSOLVED	UG/L	140	SELENIUM DISSOLVED	UG/L	0
COPPER DISSOLVED	UG/L	4	SILICA DISSOLVED	MG/L	40
FLUORIDE DISS	MG/L	5.9	SODIUM DISS	MG/L	2100
HARDNESS NONCARB	MG/L	460	SODIUM PERCENT		81
HARDNESS TOTAL	MG/L	840	SP. CONDUCTANCE FLD		8200
IODIDE	MG/L	0.15	SP. CONDUCTANCE LAB		10600
IRON DISSOLVED	UG/L	5400	STRONTIUM DISSOLVED	UG/L	3400
LEAD DISSOLVED	UG/L	2	SULFATE DISS	MG/L	2800
LITHIUM DISSOLVED	UG/L	4800	VANADIUM DISSOLVED	UG/L	61
MAGNESIUM DISS	MG/L	40	WATER TEMP (DEG C)		39.2
MANGANESE DISSOLVED	UG/L	1500	ZINC DISSOLVED	UG/L	140

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	270	13.473	BICARBONATE	464	7.605
MAGNESIUM DISS	40	3.291	CARBONATE	0	0.000
POTASSIUM DISS	190	4.859	CHLORIDE DISS	1700	47.957
SODIUM DISS	2100	91.350	FLUORIDE DISS	5.9	0.311
			SULFATE DISS	2800	58.296
	TOTAL	112.972		TOTAL	114.168

PERCENT DIFFERENCE = -0.53

Table 7.--Water-quality analysis--Red River

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 111009 RECORD # 65890

SAMPLE LOCATION: 01N54E18DDAC
STATION ID: 455001105024310 LAT.LONG.SEQ.: 455001 1050243 10
DATE OF COLLECTION: BEGIN--770413 END-- TIME--0800
STATE CODE: 30 COUNTY CODE: 017 PROJECT IDENTIFICATION: 463004900
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 361RDRV
COMMENTS: RED RIVER
V. SLIGHT CLOUD--OILY SLICK: FIELD VALUE USED FOR BICARB: RAD-CHEM
SPLIT OFF: DEPTH(FT): 8115-8355

ALK.TOT (AS CACO3)	MG/L	290	MERCURY DISSOLVED	UG/L	0.0
ALUMINUM DISSOLVED	UG/L	0	MOLYBDENUM DISSOLVED	UG/L	4
ARSENIC DISSOLVED	UG/L	1	NITROGEN TOTKJD AS N	MG/L	3.2
BARIUM DISSOLVED	UG/L	100	PH FIELD		6.8
BICARBONATE	MG/L	351	PH LAB		6.6
BORON DISSOLVED	UG/L	9500	PHOSPHORUS DIS AS P	MG/L	0.02
BROMIDE	MG/L	3.9	POTASSIUM DISS	MG/L	140
CADMIUM DISSOLVED	UG/L	0	RESIDUE DIS CALC SUM	MG/L	4570
CALCIUM DISS	MG/L	270	RESIDUE DIS TON/AFT		6.38
CARBON TOT ORGANIC	MG/L	17	RESIDUE DIS 180C	MG/L	4690
CARBONATE	MG/L	0	SAR		16
CHLORIDE DISS	MG/L	850	SELENIUM DISSOLVED	UG/L	0
CHROMIUM DISSOLVED	UG/L	30	SILICA DISSOLVED	MG/L	43
COPPER DISSOLVED	UG/L	0	SODIUM DISS	MG/L	1100
FLUORIDE DISS	MG/L	6.0	SODIUM PERCENT		70
HARDNESS NONCARB	MG/L	590	SP. CONDUCTANCE FLD		5200
HARDNESS TOTAL	MG/L	880	SP. CONDUCTANCE LAB		6400
IODIDE	MG/L	0.09	STRONTIUM DISSOLVED	UG/L	9000
IRON DISSOLVED	UG/L	18000	SULFATE DISS	MG/L	1900
LEAD DISSOLVED	UG/L	4	SULFIDE TOTAL	MG/L	1.0
LITHIUM DISSOLVED	UG/L	2000	VANADIUM DISSOLVED	UG/L	18
MAGNESIUM DISS	MG/L	47	WATER TEMP (DEG C)		45.9
MANGANESE DISSOLVED	UG/L	480	ZINC DISSOLVED	UG/L	770

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	270	13.473	BICARBONATE	351	5.753
MAGNESIUM DISS	47	3.867	CARBONATE	0	0.000
POTASSIUM DISS	140	3.580	CHLORIDE DISS	850	23.979
SODIUM DISS	1100	47.850	FLUORIDE DISS	6.0	0.316
			SULFATE DISS	1900	39.558
TOTAL		68.769	TOTAL		69.605

PERCENT DIFFE -0.60

Table 8.--Water-quality analysis--Roughlock to Precambrian

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 118901 RECORD # 67194

SAMPLE LOCATION: 01N54E18DDAC
STATION ID: 455001105024301 LAT.LONG.SEQ.: 455001 1050243 01
DATE OF COLLECTION: BEGIN--770423 END-- TIME--1300
STATE CODE: 30 COUNTY CODE: 017 PROJECT IDENTIFICATION: 463004900
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: ROUGHLOCK TO PRECAMBRIAN
COMMENTS:
CLOUDY-- VERY GASSY SAMPLE: FIELD VALUE USED FOR
BICARB

ALK,TOT (AS CACO3)	MG/L	350	MOLYBDENUM DISSOLVED	UG/L	3
ALUMINUM DISSOLVED	UG/L	0	NITROGEN TOTKJD AS N		DETR. DELETED
ARSENIC DISSOLVED	UG/L	17	PH FIELD		6.5
BARIUM DISSOLVED	UG/L	800	PH LAB		6.5
BICARBONATE	MG/L	427	PHOSPHORUS DIS AS P	MG/L	0.04
BORON DISSOLVED	UG/L	9700	POTASSIUM DISS	MG/L	350
BROMIDE	MG/L	9.4	RESIDUE DIS CALC SUM	MG/L	26100
CADMIUM DISSOLVED	UG/L	0	RESIDUE DIS TON/AFT		36.4
CALCIUM DISS	MG/L	1000	RESIDUE DIS TON/DAY		3620
CARBONATE	MG/L	0	RESIDUE DIS 180C	MG/L	26800
CHLORIDE DISS	MG/L	15000	SAR		63
CHROMIUM DISSOLVED	UG/L	40	SELENIUM DISSOLVED	UG/L	0
COPPER DISSOLVED	UG/L	0	SILICA DISSOLVED	MG/L	46
DEPTH(FT.FR.SURFACE)		8520	SODIUM DISS	MG/L	8400
FLUORIDE DISS	MG/L	2.9	SODIUM PERCENT		83
HARDNESS NONCARB	MG/L	3000	SP. CONDUCTANCE FLD		38500
HARDNESS TOTAL	MG/L	3400	SP. CONDUCTANCE LAB		39800
IODIDE	MG/L	1.1	STREAMFLOW(CFS)-INST		50
IRON DISSOLVED	UG/L	39000	STRONTIUM DISSOLVED	UG/L	40000
LEAD DISSOLVED	UG/L	2	SULFATE DISS	MG/L	790
LITHIUM DISSOLVED	UG/L	12000	SULFIDE TOTAL	MG/L	1.4
MAGNESIUM DISS	MG/L	200	VANADIUM DISSOLVED	UG/L	500
MANGANESE DISSOLVED	UG/L	1700	WATER TEMP (DEG C)		67.0
MERCURY DISSOLVED	UG/L	0.0	ZINC DISSOLVED	UG/L	90

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	1000	49.900	BICARBONATE	427	6.999
MAGNESIUM DISS	200	16.452	CARBONATE	0	0.000
POTASSIUM DISS	350	8.950	CHLORIDE DISS	15000	423.150
SODIUM DISS	8400	365.400	FLUORIDE DISS	2.9	0.153
			SULFATE DISS	790	16.448
TOTAL		440.701	TOTAL		446.749

PERCENT DIFFERENCE = -0.68

Table 9.--Water quality analysis--Composite of waters from Madison into Red River

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 123058 RECORD # 223

SAMPLE LOCATION: 01N54E18DDAC
STATION ID: 455001105024303 LAT.LONG.SEQ.: 455001 1050243 03
DATE OF COLLECTION: BEGIN--770429 END-- TIME--1000
STATE CODE: 30 COUNTY CODE: 017 PROJECT IDENTIFICATION: 463004900
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: MADISON INTO RED RIVER
COMMENTS:
CLOUDY WITH BLACK SPECKS--EFFERVESCENT WITH SULPHUROUS ODOR; FIELD VALUE USED FOR BICARB; RAD CHEM SPLIT

ALK,TOT (AS CACO3)	MG/L	270	MANGANESE DISSOLVED	UG/L	560
ALUMINUM DISSOLVED	UG/L	30	MERCURY DISSOLVED	UG/L	0.0
ARSENIC DISSOLVED	UG/L	1	MOLYBDENUM DISSOLVED	UG/L	0
BARIUM DISSOLVED	UG/L	0	NITROGEN TOTKJD AS N	MG/L	5.3
BICARBONATE	MG/L	329	PH FIELD		5.8
BORON DISSOLVED	UG/L	9000	PH LAB		7.0
BROMIDE	MG/L	3.3	PHOSPHORUS DIS AS P	MG/L	0.08
CADMIUM DISSOLVED	UG/L	1	POTASSIUM DISS	MG/L	130
CALCIUM DISS	MG/L	320	RESIDUE DIS TON/AFT		5.97
CARBONATE	MG/L	0	RESIDUE DIS 180C	MG/L	4390
CHLORIDE DISS	MG/L	770	SELENIUM DISSOLVED	UG/L	0
CHROMIUM DISSOLVED	UG/L	20	SILICA DISSOLVED	MG/L	56
COPPER DISSOLVED	UG/L	0	SODIUM DISS	MG/L	940
DEPTH(FT.FR.SURFACE)		8000	SP. CONDUCTANCE FLD		5900
FLUORIDE DISS	MG/L	5.5	SP. CONDUCTANCE LAB		5800
IODIDE	MG/L	0.06	STRONTIUM DISSOLVED	UG/L	8600
IRON DISSOLVED	UG/L	920	SULFATE DISS	MG/L	1800
LEAD DISSOLVED	UG/L	1	SULFIDE TOTAL	MG/L	5.2
LITHIUM DISSOLVED	UG/L	2100	VANADIUM DISSOLVED	UG/L	0.0
MAGNESIUM DISS	MG/L	53	WATER TEMP (DEG C)		49.2
			ZINC DISSOLVED	UG/L	20

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	320	15.968	BICARBONATE	329	5.393
MAGNESIUM DISS	53	4.360	CARBONATE	0	0.000
POTASSIUM DISS	130	3.325	CHLORIDE DISS	770	21.722
SODIUM DISS	940	40.890	FLUORIDE DISS	5.5	0.290
			SULFATE DISS	1800	37.476
TOTAL		64.542	TOTAL		64.880

PERCENT DIFFERENCE = -0.26

Preliminary results and future testing plans

Preliminary analysis of some of the infomation obtained during the drilling, coring, and testing of Madison Limestone test hole 2 follows:

Based on the drill-stem and packer-swabbing tests, all significant water-bearing units below the Lakota Sandstone have sufficient head to cause the water in them to flow at the land surface, 2,793 ft above sea level.

The chemical-quality tests indicate that, in the zones tested, there is no freshwater (less than 1,000 mg/L dissolved solids). Dissolved solids range from a low of about 2,000 mg/L in the Lakota Sandstone and the Madison Limestone to about 46,500 mg/L in the Minnelusa. In the Paleozoic section, the water freshens relative to the Minnelusa and, with the exception of the Red River, becomes saltier with depth.

None of the units tested yielded significant quantities of water. Flow rates ranged from about 5 to 50 gal/min. Pressure heads in the Paleozoic units were in general in excess of 750 ft above land surface. (See table 2 for complete flow data.)

Two cement plugs were placed in the bottom of the well--one from 9,378 to 9,084 ft and the other from 8,884 to 8,422 ft below land surface. The plugs were placed to block upward leakage of highly saline water (about 26,000 mg/L dissolved solids) that included a gas show in the basal Cambrian section.

Drill-stem tests 6A and 7 included the interval of the gas show in the Cambrian sand. Apparently the porosity and permeability of this sand are very low as the sand did not yield gas or fluid during the testing periods.

Water from the open-hole part of the well, which begins about 19 ft below the top of the Madison Limestone and ends about 120 ft above the base of the Red River, has a head at the surface of 333 lb/in^2 or about 768 ft above land surface. Because of the well-head equipment, the water cannot flow freely from the 13-3/8-in casing at the land surface. However, one of the 2-in valves in the well head was opened and the well flowed about 44 gal/min with about 3 lb/in^2 back pressure. Using these values, the specific capacity is about 0.06 (gal/min)/ft of drawdown. This specific capacity is about two orders of magnitude less than that of a similar interval in the Madison Limestone test well 1. The water from the open-hole part of the well has a dissolved-solids concentration of about 4,390 mg/L.

It is planned to run additional geophysical logs and tests in the test well this fall. The logs will include televiewer, gamma spectrometer, and possibly trace ejector and spinner surveys. A vertical seismic profile will be run in August.

The well construction and well-head equipment are such that the well can be used for several years as an observation point, a test laboratory, and for geophysical-tool calibration.

References

Blankennagel, R. K., Miller, W. R., Brown, D. L., and Cushing, E. M., 1977, Report on preliminary data for Madison Limestone test well 1, NE¼SE¼ sec. 15, T. 57 N., R. 65 W., Crook County, Wyoming: U.S. Geol. Survey Open-File Rept. 77-164, 97 p.

U.S. Geological Survey, 1975, Plan of study of the hydrology of the Madison Limestone and associated rocks in parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming: Open-File Rept. 75-631, 35 p.