HOLE HISTORY

ROTARY HOLE DC-5

HANFORD, WASHINGTON

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Prepared for Rockwell Hanford Operations,
A Prime Contractor to the U. S. Department of Energy,
Under Contract Number EY-77-C-06-1030

by

FENIX & SCISSON, INC.
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Under U. S. Department of Energy
Contract Number EY-76-C-06-2175

AC06-76RL02175

N O T I C E

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INTRODUCTION

Borehole DC-5 was drilled by Century Drilling Company, Shelby, Montana, under subcontract to Fenix & Scisson, Inc. The hole was drilled for the U.S. Department of Energy and the Rockwell Hanford Operations' Department of Waste Isolation. Fenix & Scisson, Inc. furnished the engineering, daily supervision of the drilling activities and geological analysis of cuttings from DC-5.

The purpose of hole DC-5 was to drill through the Umtanum basalt flow to provide a borehole for hydrological testing, seismic shear and pressure wave velocity studies and geophysical-electrical logging measurements of the strata penetrated for the Basalt Waste Isolation Program.

Hole DC-5 is located at Site 1 as depicted on Figure 1. Drilling commenced December 10, 1977 and the demobilization began February 10, 1978. The drilling progress curve for DC-5 is shown in Figure 2. The total depth of DC-5 is 3,990 feet. The open hole diameter is 8-5/8 inches and extends 1,355 feet from the longstring casing depth of 2,635 feet. Figure 3 is the As-Built Diagram of Hole DC-5.

Borehole DC-5 was completed successfully with an inflatable packer set at 3,770 feet. The packer was set to isolate an aquifer zone at 3,340 feet from a lost circulation zone at 3,954 feet. The packer is suspended on 2-7/8-inch diameter tubing. A split cap plate was welded to the tubing and the 9-5/8-inch diameter casing. Hydrological testing and various logging measurements are to be conducted at a later date.

SUMMARY

Century Drilling Company utilized rotary Rig Number 1 - Brewster Model N-4A for drilling and construction of borehole DC-5. Mobilization of the rig to DC-5 began December 7, 1977. A 26-inch diameter conductor hole was spudded December 10, 1977. One joint (42 feet) of 20-inch diameter conductor casing was set and cemented with 80 cubic feet of Type II cement containing 2 percent calcium chloride.

A surface hole diameter of 17-1/2 inches was drilled from 42 feet to 635 feet. The deviation of the borehole from vertical at 63.5 feet was 1/2 degree. Table I lists the depths and deviation surveys performed during the drilling of DC-5.

Surface casing, 13-3/8-inch outside diameter, was set at 622 feet. The as-built tally for the surface casing is presented in Table II. The design criteria for the surface casing are shown in Table III. The initial cementation of the surface casing was interrupted after 300 cubic feet of cement had been pumped into the casing. The interruption was caused by the cementing subcontractor's equipment malfunctioning. The cement was washed out of the casing and the subcontractor's equipment was replaced.

The casing was cemented to surface with Class B cement containing 2 percent calcium chloride. The cementing and displacement details are presented in Table IV. The total cement volume, 792 cubic feet, was circulated into the casing annulus by the single stage, positive displacement-plug bump method with 610 cubic feet of displacement fluid.

A 12-1/4-inch diameter hole was drilled from the surface casing on December 18, 1977 with a bentonite base mud system. The record of the daily mud properties is presented in Table V. At 912 feet, complete lost circulation of the drilling fluid occurred in a permeable zone while drilling. All normal methods (polymer-particulate plugs and kwik-seal type plugs) to stop circulation were unsuccessful. The drilling rig shut down December 22, 1977 in observation of the holidays.

Rig operations were restored December 30, 1977. The drill string was struck at 780 feet upon tripping in the hole. A total volume of 4,700 gallons of diesel oil was spotted to free the stuck pipe. Lost circulation occurred when the drill pipe was tripped to total depth. Several lost circulation pills with a volume of 4,200 gallons each were spotted at 912 feet. Loss of circulation returns continued to be observed at 912 feet. The cementing subcontractor pumped 220 cubic feet of Type II cement containing 20 percent gilsonite and 3 percent calcium chloride. The cement was pumped through the drill pipe spotted at 912 feet. Twelve hours were alloted for cement setting time. Upon tripping in the hole, the cement top was found at 911 feet.

The 12-1/4-inch diameter hole was drilled to 924 feet where lost circulation was observed. The cement subcontractor pumped 205 cubic feet of cement containing 4 percent calcium chloride. The cement was pumped through the drill pipe spotted at 915 feet. The cement set for eight hours. The cement top was found at 851 feet. The cement was drilled and circulated from the hole. No circulation loss was observed.

The 12-1/4-inch hole was drilled to 2,635 feet. No significant hole problems were encountered from 924 feet to 2,635 feet. Sixty-five joints of 9-5/8-inch

diameter casing were run. The design criteria of the 9-5/8-inch longstring casing are shown in Table VI. The as-built tally for the longstring casing is presented in Table VII.

Initial cementation of the 9-5/8-inch casing occurred on January 21, 1978. A total volume of 1,032 cubic feet of Class B cement containing 2 percent calcium chloride was circulated into the casing. After 264 cubic feet of displacement fluid had been circulated into the casing, the annulus bridged. All attempts to jar the casing and to re-establish circulation were futile. The cement remaining inside the casing was washed out.

Schlumberger Well Services, Inc. was contacted to run a cement bond log. From the results of the bond log millivolt amplitude and the Murray Waves on the variable density log, the uppermost competent casing to cement to formation bond was at 2,280 feet. The casing was subsequently perforated with six 1/2-inch diameter shaped charges from 2,270 to 2,276 feet.

The cementing head for the 9-5/8-inch casing was screwed on to the casing. Circulation was attempted to a maximum applied surface pressure of 2,200 pounds per square inch. Circulation was not established.

A compensated neutron log was run so that the exact locations of the formations could be determined from the porosity index. Seven shaped charges, 1/2 inch in diameter, were used to perforate the casing from 1,756 to 1,762 feet. The perforated interval was chosen primarily for two reasons. First, the compensated neutron log indicated the deepest interbed was the Mabton from 1,382 to 1,508 feet. As such, by perforating below the deepest water-bearing interbed, if cementation through the perforations were successful, ample cement would exist in the annulus to prevent water from circulating between porous zones penetrated by the borehole. The second reason for selecting the 1,756 to 1,762 foot interval was determined from the bond log and variable density log. The bond log maximum millivolt amplitude indicated totally unsupported casing through this interval. The variable density log had a total lack of Murray Wave activity on the microsecond recording which indicates total lack of formation bonding throughout the annular space.

The cementing head was connected to the casing and circulation was attempted. Circulation was established initially at 400 pounds per square inch applied surface pressure. However, no fluid returns were observed from the annulus at surface. The circulating pressure stabilized at 175 pounds per square inch for five minutes. Cement was pumped until the circulating pressure suddenly

increased to 2,600 pounds per square inch. Displacement of the cement with water was attempted. After the displacement of 17 cubic feet of water into the casing, the applied circulating pressure increased to 3,200 pounds per square inch. The cement, 342 cubic feet of Class B with 2 percent calcium chloride, was washed out of the casing.

Schlumberger Well Services, Inc. perforated seven 1/2-inch diameter holes with shaped charges from 1,586 to 1,592 feet. The perforated interval was chosen for the same reasons stated above for the 1,756- to 1,762-foot perforation interval.

Circulation was established with 100 pounds per square inch applied surface pressure. Full circulating returns were observed at the surface from the annulus. Cement was pumped into the casing. The cement volume was 660 cubic feet and the cement type was Class B with 2 percent calcium chloride. The wiper plug was dropped and displaced with 645 cubic feet of water. Approximately 45 cubic feet of cement were displaced to the reserve pit. The details of the two unsuccessful and the last successful cementing and displacement programs are presented in Table IV.

The cement was allowed to set seven hours. The cement top was found at a depth of 1,545 feet inside the casing. The cement was drilled out of the casing from 1,545 to 1,810 feet. A temperature log was run to check for thermal variance caused by the heat of hydration of the cement. Due to the high temperature of the water (high temperature caused by rig boiler) which was used to drill through the cement in the casing, several hours were allowed for the temperature to stabilize. A second temperature log and a cement bond log were run. The bond log did not display conclusive bonding because of inadequate time for the cement to set up (a minimum of 36 to 48 hours is generally required to achieve bonding capable of being recorded). The temperature log, however, demonstrated significant increases from 1,760 to 1,670 feet and from 1,580 feet to surface. Since the temperature gradient from 2,635 feet to surface does not normally demonstrate variational increases, the significant increases are attributed to the heat of hydration of the cement.

An 8-5/8-inch diameter hole was drilled from the longstring casing at 2,635 feet. Water was utilized as the drilling fluid from 2,635 to 3,990 feet. At 3,340 feet, water was observed flowing from the annulus (between drill pipe and casing) during a drill pipe connection. The rate of water flow was estimated to be 12 gallons per minute. The water flow continued during trips and connections when the circulating pump was not engaged.

Between 3,400 and 3,700 feet, the deviation of the hole increased from 1-3/4 to 4-1/4 degrees. Additional stabilizers were placed in the bottom hole assembly and the stabilizer positions were changed. The packed bottom hole assembly was used to ream through the deviated hole section from 3,400 to 3,700 feet.

At a drill depth of 3,954 feet, lost circulation was observed. Particulate lost circulation material in the form of ground nut shells was spotted. Drilling continued to the total depth of 3,990 feet with partial circulation returns. Total depth was reached on February 7, 1978. A packer was set at 3,770 feet to prevent cross flow between a flowing zone at 3,340 feet and a lost circulation zone at 3,954 feet. The packer was an inflatable production type with a J-type circulating head. The packer is suspended on 2-7/8-inch tubing. A cap split plate was welded to the 2-7/8-inch tubing and the 9-5/8-inch casing head.

The tri-cone bits used to drill hole DC-5 and the record of their performance are presented in Table VIII. The 26-inch diameter conductor hole was drilled with a standard-tooth type bit. The ten other bits used for drilling were tungsten carbide chisel-tooth insert type bits. The tungsten carbide bits averaged more than 390 feet drilled per bit.

The service companies and equipment suppliers who participated in the successful drilling of hole DC-5 are listed in Table IX.

DRILLING CHRONOLOGY

12-07-77 - Mobilizing rig to DC-5 location from DC-7 site.

12-08-77 - Mobilization completed; rig-up.

12-09-77 - Completed rig-up; drilled rat hole.

12-10-77 - Drilled mouse hole; drilled 26-inch conductor hole to 17 feet.

12-11-77 - Conductor hole drilled to 42 feet; ran one joint of 20-inch conductor casing; cemented conductor casing with 80 cubic feet of Type II cement containing 2 percent calcium chloride; picked up 17-1/2-inch bottom hole assembly; waited on cement 11-1/2 hours.

12-12-77 - Began drilling 17-1/2-inch hole at 0030 hours; drilled to 128 feet; survey at 85 feet = 1/2 degree from vertical.

12-13-77 - Drilled 17-1/2-inch hole to 245 feet; cemented top of 20-inch conductor pipe with 3 sacks of neat cement; survey at 206 feet = 1/4 degree.

12-14-77 - Drilled 17-1/2-inch hole to 388 feet; survey at 368 feet = 0 degree.

12-15-77 - Drilled 17-1/2-inch hole to 593 feet; trip for balled bit at 510 feet; 85 feet of bottom hole fill; survey at 552 feet = 1/2 degree.

12-16-77 - Drilled 17-1/2-inch hole to 635 feet; circulated bottoms up; tripped out to run 13-3/8-inch surface casing; ran 622 feet of 13-3/8-inch casing; pumped 300 cubic feet of Class B cement with 2 percent calcium chloride - both cementing pumps stopped operating; displaced cement from casing and annulus; waited on new pump truck.

12-17-77 - Waited on cement pump truck; circulated complete hole cycle every six hours.

12-18-77 - Cement pumper and bulk truck arrived at 0330 hours; pumped 600 sacks of Class B cement with 2 percent calcium chloride; displaced cement with 610 cubic feet of water - plug bumped at 0500 hours; waited on cement to set; cut casing up on last joint and nippled up blowout preventer; drilled 12-1/4-inch hole to 638 feet.

12-19-77 - Drilled 12-1/4-inch hole to 668 feet; survey at 663 feet = 3/4 degree; trip out to check collars.

12-20-77 - Drilled 12-1/4-inch hole to 733 feet; trip to check bit at 678 feet; survey at 710 feet = 3/4 degree.

12-21-77 - Drilled 12-1/4-inch hole to 870 feet; survey at 867 feet = 1/2 degree.

12-22-77 - Drilled 12-1/4-inch hole to 912 feet; lost circulation; short trip - spotted lost circulation material; 200 feet of bottom hole fill; washed through fill; lost returns; spotted second 100-barrel pill; drained pits; pulled up into casing; closed pipe rams; shut down for Christmas holidays.

12-30-77 - Rig-up - started boiler; mix mud and lost circulation material; trip out for bit; trip in; drill string stuck in the hole at 780 feet; spotted 1,900 gallons of diesel oil - worked pipe.

12-31-77 - Spotted 2,800 gallons of diesel and organic mud lubricant - worked pipe; pipe free; circulated hole clean; washed to 880 feet.

1-01-78 - Washed - reamed hole to total depth; lost circulation; trip out to casing shoe; spot 100-barrel lost circulation pill; waited 4 hours, attempted to circulate; spotted second pill - no returns; trip in to 912 feet; spotted lost circulation material pill; trip out 6 stands; broke circulation; trip in-stage circulating; lost returns at 912 feet.

1-02-78 - Short trip up to casing shoe; mix high lime lost circulation pill; spotted pill; mixed mud and lost circulation material; pumped mud with 20 percent particulate lost circulation material; trip out - lay down drill collars; trip in with drill pipe; wait on cementers.

1-03-78 - Wait on cementers; trip drill pipe out; trip in 1 stand of collars and drill pipe; stage circulation attempted every stand; drilled 12-1/4-inch hole to 920 feet; trip out; trip in with drill pipe; spotted 220 cubic feet of Type II cement with 20 percent gilsonite and 3 percent calcium chloride; trip out.

1-04-78 - Trip in; mix mud and lost circulation material; tagged cement at 911 feet; drilled 12-1/4-inch hole 920 to 924 feet; lost returns; pumped 205 cubic feet of Type II cement with 4 percent calcium chloride; wait on cement; trip in - tagged cement at 851 feet.

1-05-78 - Drilling cement from 851 feet to 924 feet; drilled 12-1/4-inch hole to 1,016 feet; survey at 992 feet = 1 degree.

1-06-78 - Drilled 12-1/4-inch hole to 1,102 feet; survey at 1,085 feet = 3/4 degree.

1-07-78 - Drilled 12-1/4-inch hole to 1,231 feet; survey at 1,180 feet = 0 degree.

1-08-78 - Drilled 12-1/4-inch hole to 1,303 feet; survey at 1,243 feet = 1/2 degree.

1-09-78 - Drilled 12-1/4-inch hole to 1,370 feet; trip for bit; tight hole to bottom of casing; survey at 1,369 feet = 3/4 degree.

1-10-78 - Drilled 12-1/4-inch hole to 1,508 feet; survey at 1,494 feet = 3/4 degree.

1-11-78 - Drilled 12-1/4-inch hole to 1,606 feet; mud foaming from high pH corrosion inhibitor reaction; displaced hole volume; dump pits and mix fresh mud; survey at 1,556 feet = 1/2 degree.

1-12-78 - Drilled 12-1/4-inch hole to 1,711 feet; losing mud volume; survey at 1,711 feet = 1-1/4 degrees.

1-13-78 Drilled 12-1/4-inch hole to 1,868 feet; survey at 1,838 feet = 1-1/4 degrees.

1-14-78 Drilled 12-1/4-inch hole to 2,001 feet; slow mud loss; survey at 1,964 feet = 1-1/2 degrees.

1-15-78 - Drilled 12-1/4-inch hole to 2,128 feet; survey at 2,088 feet = 1 degree.

1-16-78 - Drilled 12-1/4-inch hole to 2,235 feet; trip for bit at 2,128 feet; replaced shock sub; survey at 2,183 feet = 1-1/4 degrees.

1-17-78 - Drilled 12-1/4-inch hole to 2,403 feet; losing approximately 10 percent of the returns; survey at 2,369 feet = 3/4 degree.

1-18-78 - Drilled 12-1/4-inch hole to 2,503 feet; survey at 2,494 feet = 1 degree.

1-19-78 - Drilled 12-1/4-inch hole to 2,562 feet; survey at 2,555 feet = 1 degree.

1-20-78 - Drilled 12-1/4-inch hole to 2,625 feet; trip for bit; survey at 2,616 feet = misfire.

1-21-78 - Drilled 12-1/4-inch hole to 2,635 feet; circulated two hole cycles; strapped out; laid down drill collars; cleaned cellar; rigged up 9-5/8-inch elevators and tong crew; ran 65 joints of 9-5/8-inch casing; rigged up cement truck, lines and head; circulated hole two cycles; pumped 1,032 cubic feet of cement with full returns; dropped wiper plug; pumped 47 barrels of water for displacement (total calculated displacement volume was 202 barrels) when annulus bridged off; no returns; worked pipe; maximum pull was 220,000 pounds; maximum recorded displacement pressure at surface was 2,500 pounds per square inch; rigged down cementers; cut 9-5/8-inch pipe 3 feet above cellar floor; trip in to wash cement out of casing.

1-22-78 - Tagged cement at 560 feet; drilled wiper plug and cement to 2,635 feet.

1-23-78 - Circulated hole; waited on Schlumberger Well Services, Inc.; ran bond log; waited on welder to weld collar on pipe for cement head connection.

1-24-78 - Welded collar on 9-5/8-inch casing; perforated 6 half-inch holes at 2,276 feet; attempted to circulate; no circulation with 2,200 pounds per square inch surface pressure; wait on orders.

1-25-78 - Wait on orders; ran neutron log; perforated 7 half-inch holes, at 1,760 feet; rig up cementing head; broke circulation with 400 pounds per square inch, no returns to surface; pumped 342 cubic feet of cement - circulating pressure increased to 2,600 pounds per square inch; attempted to displace cement from casing - maximum pressure increased to 2,600 pounds per square inch; re-rack pipe in derrick; nippled up to wash cement out of casing.

1-26-78 - Washed cement out of casing; rigged up Schlumberger Well Services, Inc.; perforated 7 half-inch holes at 1,590 feet; rigged up cementing head; broke circulation with water at 100 pounds per square inch; pumped 660 cubic feet of cement - maximum circulating pressure was 800 pounds per square inch; dropped wiper plug; displaced cement with 115 barrels of water; approximately 45 cubic feet of cement displaced to reserve pit; back-off cement head; nippled up blowout preventer; trip in; tagged cement at 1,545 feet; wait on cement; drilled cement to 1,810 feet; circulated hole; trip out; ran temperature log.

1-27-78 - Completed temperature log; wait on orders; ran second temperature log and cement bond log; drilled 8-5/8-inch hole to 2,770 feet; survey at 2,740 feet = 3/4 degree; fluid loss of 25 barrels of water per hour.

1-28-78 - Drilled 8-5/8-inch hole to 2,988 feet; lost 15 to 25 barrels of water per hour; survey at 2,929 feet = 3/4 degree.

1-29-78 - Drilled 8-5/8-inch hole to 3,168 feet; survey at 3,115 feet = 1-1/4 degrees.

1-30-78 - Drilled 8-5/8-inch hole to 3,248 feet; trip for bit; survey at 3,239 feet = 1-3/4 degrees.

1-31-78 - Drilled 8-5/8-inch hole to 3,449 feet; connection made at 3,340 feet, annulus was flowing water; survey at 3,428 feet = 1-3/4 degrees.

2-01-78 - Drilled 8-5/8-inch hole to 3,630 feet; hole sloughed at 3,550 feet; survey at 3,613 feet = 2-1/2 degrees.

2-02-78 - Drilled 8-5/8-inch hole to 3,737 feet; dropped Totco instrument; trip out; picked up stabilizers; survey at 3,737 feet = 4-1/4 degrees.

2-03-78 - Trip in; tight hole at 3,683 - stuck pipe; worked pipe free; reamed to total depth; drilled 8-5/8-inch hole to 3,780 feet; survey at 3,778 feet = 4-3/4 degrees.

2-04-78 - Drilled 8-5/8-inch hole to 3,851 feet; survey at 3,838 feet = 5 degrees.

2-05-78 - Drilled 8-5/8-inch hole to 3,930 feet; survey at 3,930 feet = 5 degrees.

2-06-78 - Drilled 8-5/8-inch hole to 3,976 feet; lost circulation at 3,954 feet; trip out and remove jets; trip in and spotted lost circulation material plug; regained partial circulation.

2-07-78 - Drilled 8-5/8-inch hole to 3,990 feet; layed down drill pipe; tear down blowout preventer; wait on packer.

2-08-78 - Wait on packer.

2-09-78 - Wait on packer; ran inflatable packer with J-type circulating head on 2-7/8-inch tubing; set packer at 3,770 feet; circulated 300 barrels of calcium chloride water into annulus from packer head to surface; start rig tear down.

2-10-78 - Completed rig tear down; radiation monitoring cleared rig; demobilize.

GEOLOGICAL SUMMARY

The approximate depths and thicknesses of stratigraphic units penetrated by hole DC-5 are shown on Figure 3.

Preliminary identification of stratigraphic units was accomplished by microscopic examination of drill cuttings and by Energy Nondispersive X-ray analysis of pulverized cuttings samples from the central portions of the basalt flows. All major stratigraphic horizons, such as the titania and magnesia breaks, were identified by the X-ray tests.

Preliminary determination of rock unit contacts was made by inspection of the drilled cuttings, changes in drilling penetration rates (noting weight on the bit) and observation of drill fluid loss. In many cases, the flow contacts could not be precisely determined due to contamination of the cuttings from overlying units and to misleading Geolograph drilling rate changes. Many of the flow top breccias can be drilled at a similar rate of penetration as the soft interbeds; hence, no drilling rate break would result until the bit reached competent basalt.

Compensated neutron logging of the upper portion of the hole, 0 to 2,634 feet, confirmed the previously identified contacts generally within a few feet. Confirmation of flow contacts below 2,634 feet will be possible by inspection of future geophysical logs planned for this hole and further verification of the entire section penetrated will result from inspection of cores from the planned nearby core hole DC-4.

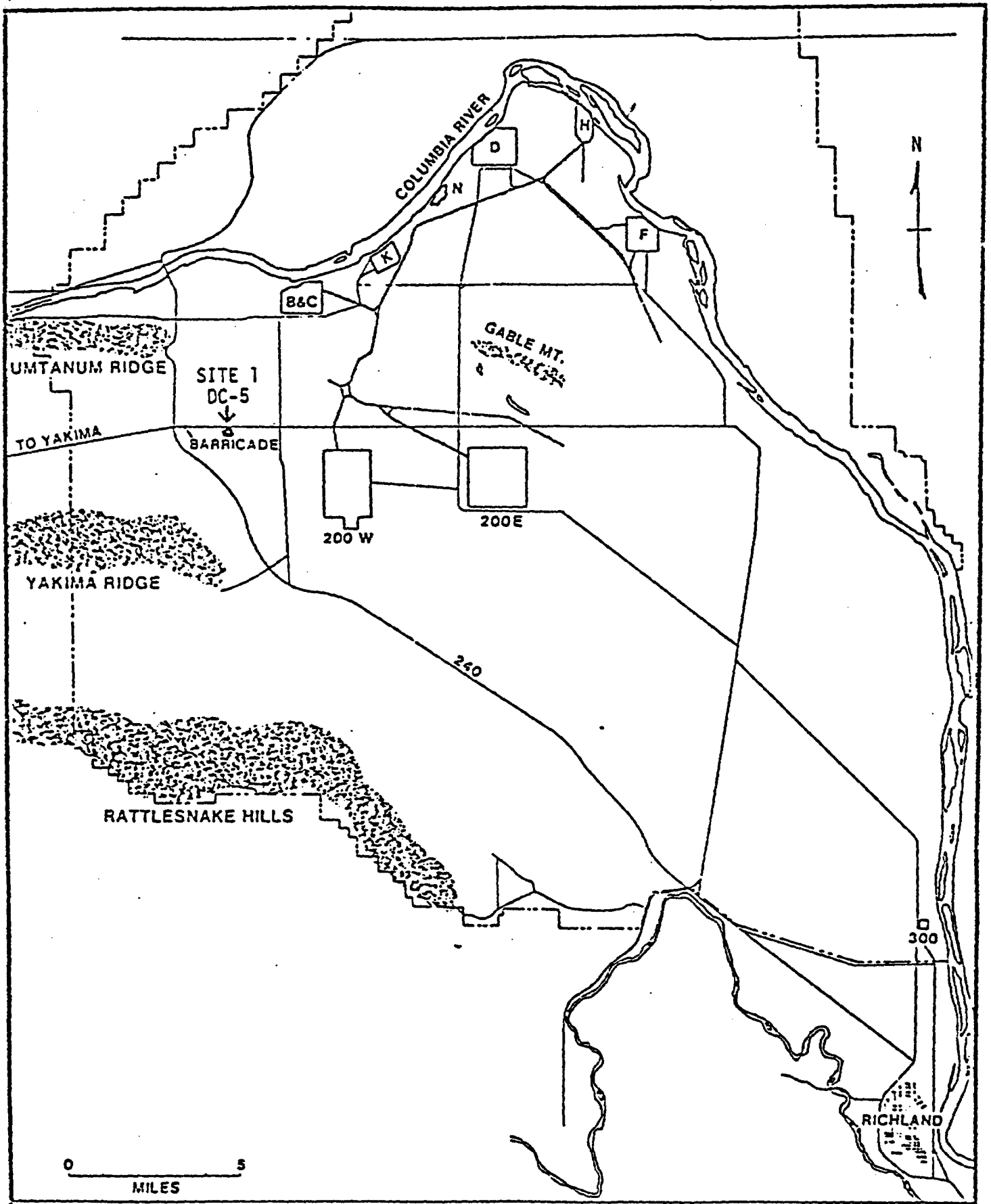

FIGURE 1
SITE MAP FOR HOLE DC-5 AT SITE 1

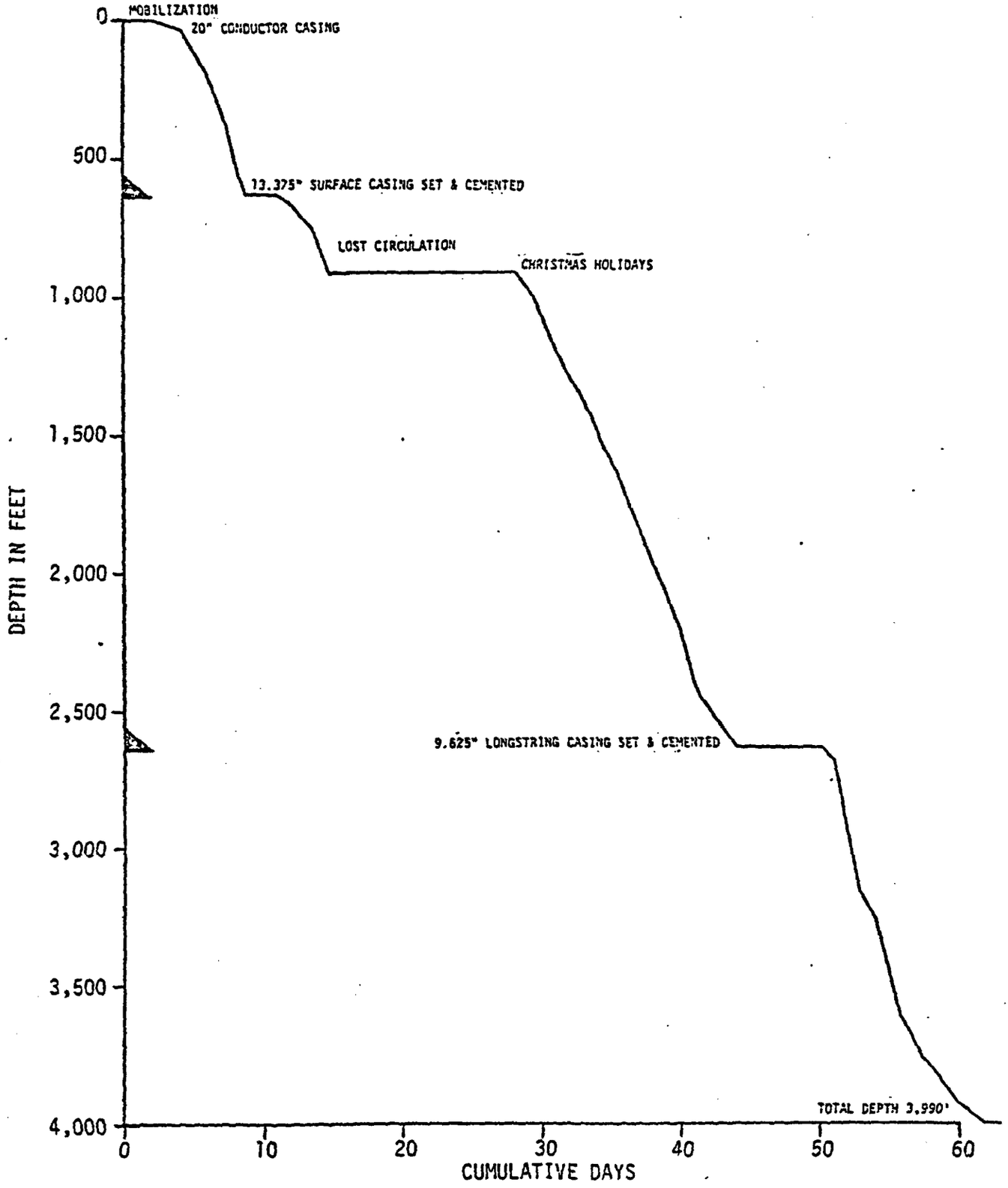

FIGURE 2

DRILLING PROGRESS CURVE HOLE DC-5

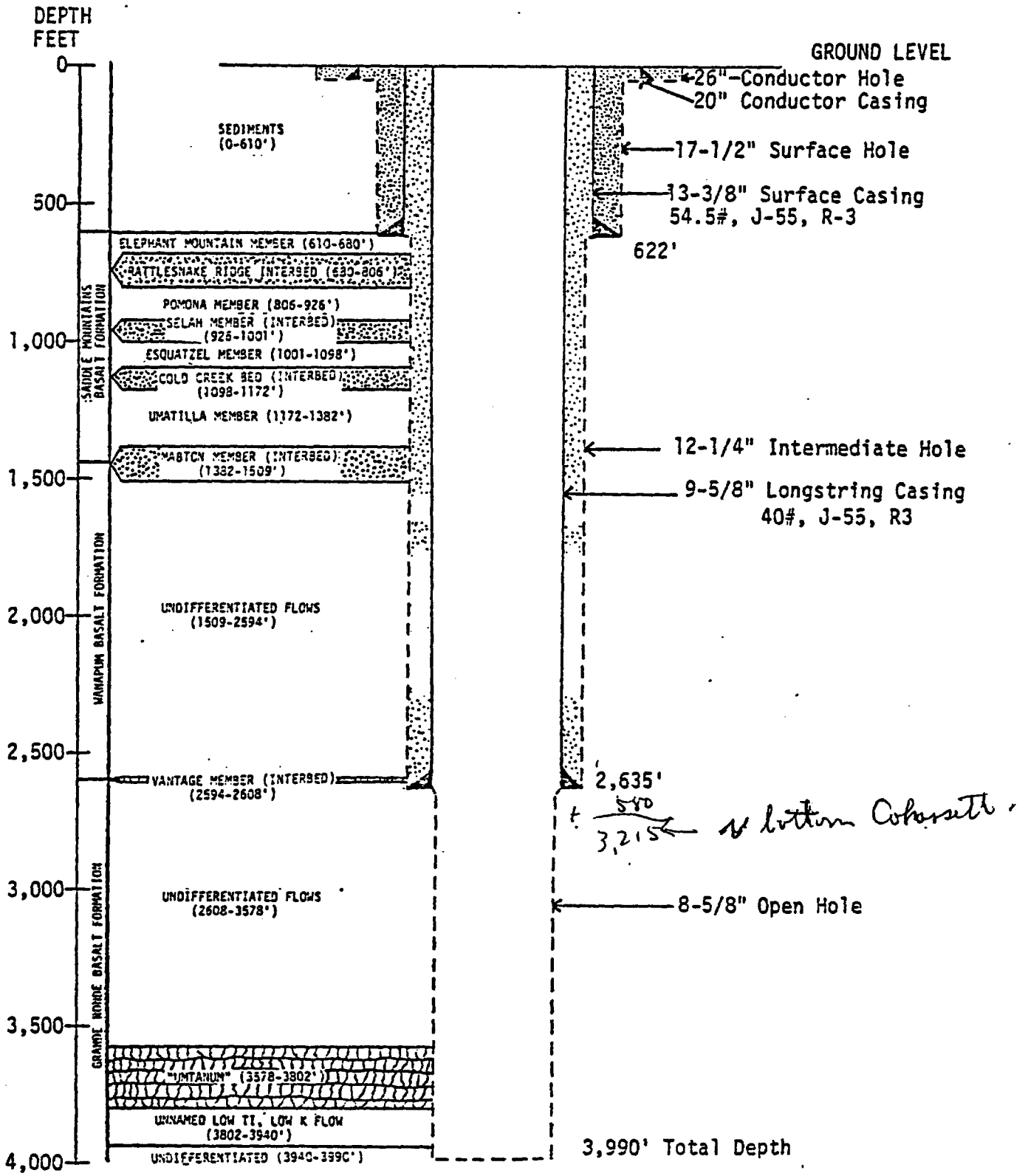

FIGURE 3

AS-BUILT DIAGRAM HOLE DC-5

TABLE I

DEVIATION SURVEYS

DEPTH (feet)	DEVIATION* FROM VERTICAL	DATE	DEPTH (feet)	DEVIATION* FROM VERTICAL	DATE
85	1/2°	12/12/77	2,306	1°	1/17/78
147	1/4°	12/13/77	2,369	3/4°	1/17/78
206	1/4°	12/13/77	2,432	3/4°	1/18/78
268	1/4°	12/14/77	2,494	1°	1/18/78
368	0°	12/14/77	2,555	1°	1/19/78
458	1/2°	12/15/77	2,616	misfire	1/20/78
552	1/2°	12/15/77	2,646	1/2°	1/27/78
663	3/4°	12/19/77	2,740	3/4°	1/27/78
710	3/4°	12/20/77	2,803	1/2°	1/28/78
773	1/2°	12/21/77	2,866	3/4°	1/28/78
867	1/2°	12/21/77	2,929	3/4°	1/28/78
929	1/2°	1/05/78	2,991	1°	1/29/78
992	1°	1/05/78	3,054	1-1/4°	1/29/78
1,023	3/4°	1/06/78	3,115	1-1/4°	1/29/78
1,085	3/4°	1/06/78	3,178	1-3/4°	1/30/78
1,180	0°	1/07/78	3,239	1-3/4°	1/30/78
1,243	1/2°	1/08/78	3,303	1-1/2°	1/31/78
1,305	0°	1/09/78	3,366	2°	1/31/78
1,369	3/4°	1/09/78	3,428	1-3/4°	1/31/78
1,431	1/2°	1/10/78	3,488	1-3/4°	2/01/78
1,494	3/4°	1/10/78	3,551	2-1/4°	2/01/78
1,556	1/2°	1/11/78	3,613	2-1/2°	2/01/78
1,618	3/4°	1/12/78	3,644	2-1/2°	2/02/78
1,711	1-1/4°	1/12/78	3,674	misfire	2/02/78
1,774	1-1/4°	1/13/78	3,706	3-1/2°	2/02/78
1,838	1-1/4°	1/13/78	3,737	4-1/4°	2/02/78
1,901	1-1/4°	1/14/78	3,747	4-1/4°	2/03/78
1,964	1-1/2°	1/14/78	3,778	4-3/4°	2/03/78
2,026	1°	1/15/78	3,809	5-1/2°	2/04/78
2,088	1°	1/15/78	3,838	5°	2/04/78
2,151	misfire	1/16/78	3,869	5-1/4°	2/05/78
2,183	1-1/4°	1/16/78	3,900	5°	2/05/78
2,243	1-1/4°	1/17/78	3,930	4-1/4°	2/05/78

*Deviation survey accuracy is to the nearest one-quarter degree

TABLE II

CASING TALLY - AS-BUILT 13-3/8-INCH SURFACE CASING

JOINT NUMBER	LENGTH (ft)	STRING EQUIPMENT	JOINT NUMBER	LENGTH (ft)	STRING EQUIPMENT
	1.50	Float Shoe			
1	42.10	Stabilizer	9	41.07	
2	41.34		10	40.42	
3	41.10		11	40.88	
4	42.42	Stabilizer	12	41.23	
5	41.96		13	41.34	
6	41.35		14	40.42	
7	42.62		15	40.59	
8	42.14				
			TOTAL	622.48	

TABLE III

DESIGN CRITERIA FOR 13-3/8-INCH SURFACE CASING

SECTION	1
WEIGHT (lb/grade)	54.5/J-55 ST&C
EFFECTIVE COLLAPSE* RESISTANCE (psi)	566
DEPTH OF BOTTOM OF SECTION (ft)	622
LENGTH OF SECTION (ft)	622
CUMULATIVE EFFECTIVE WEIGHT TO TOP OF SECTION (lb)	33,899
USABLE JOINT STRENGTH IN TENSION (lb)	480,101
DEPTH TO TOP OF SECTION (ft)	-0-
BIAXIAL STRESS-COLLAPSE SLOPE	-89.31

*Collapse Criteria - 15.5 pounds per gallon cement external versus normal atmospheric pressure

TABLE IV

CEMENTING DETAILS

	12-11-77	12-18-77	1-21-78	1-25-78	1-26-78
CASING SIZE (in.)	20	13-3/8	9-5/8	9-5/8	9-5/8
CASING DEPTH (ft.)	620	622	2,635	2,635	2,635
CEMENT UTILIZED	Type II	Class B	Class B	Class B	Class B
CEMENT VOLUME (cu.ft.)	81	792	1032	342	660
DISPLACEMENT VOLUME (cu. ft.)	83	610	264	17	645
SLURRY YIELD (cu. ft/sack)	1.18	1.32	1.32	1.32	1.32
SLURRY WEIGHT (lb/gal)	15.6	14.6-15.6	15.2-15.6	15.5	15.2-15.6
ADMIXTURES	2% CaCl	2% CaCl	2% CaCl	2% CaCl	2% CaCl
CEMENT METHOD	Positive Displacement	Plug Bump	(Annular Bridge)	(Annular Bridge)	Positive Plug Displacement
CEMENT STAGES	1	1	1	1	1
WAIT ON CEMENT TIME (hr.)	11.5	15	6	4	7

TABLE V

MUD RECORD

DATE 1977	DEPTH (ft)	WEIGHT (lb/gal)	VISCOSITY Sec API	PV	YP	GELS (10 sec:10 min)	pH	SAND (%)	SOLIDS (%)
12-11	42	8.5	76	--	--	--	--	--	--
12-14	286	8.8	50	16	6	7:12	8.5	2	8
12-16	629	8.7	75	--	--	--	--	--	--
12-19	662	8.5	37	16	10	3:11	9.5	--	--
12-20	674	8.6	37	16	12	4:12	9.7	--	7
12-21	823	8.7	34	16	6	2:8	9.5	--	7
12-22	892	8.8	35	16	12	3:16	9.5	--	7
12-31	912	8.6	45	16	12	5:16	9	.5	7
1- 1	912	8.6	50	21	16	4:12	9	--	--
1- 5	923	8.7	43	--	--	--	--	--	--
1- 6	1050	8.9	38	17	13	6:18	11.5	1.5	9
1- 7	1157	8.8	36	15	12	2:16	9.5	1	7
1-11	1557	9.5	50	20	8	4:10	8.5	7	10
1-12	1654	8.8	42	10	6	3:9	8.5	1.5	4
1-13	1784	8.9	43	10	6	4:11	8.5	1	5
1-15	2045	9.1	46	12	6	6:12	8.5	2	8
1-16	2142	9.1	40	10	6	6:15	8	3	6
1-17	2269	9.2	40	8	6	7:13	8.5	3	7
1-18	2449	9.5	44	12	4	4:11	8.5	4	9
1-19	2523	9.5	45	8	12	4:11	8.5	3	8
1-20	2576	9.4	43	18	4	3:9	8.5	1.5	7
1-22 to 2-9	Fresh Water								

TABLE VI

DESIGN CRITERIA FOR 9-5/8- INCH LONGSTRING CASING

SECTION	1
WEIGHT (lb/grade)	40/J-55 ST&C
EFFECTIVE COLLAPSE* RESISTANCE (psi)	446
DEPTH OF BOTTOM OF SECTION (ft)	2,635
LENGTH OF SECTION (ft)	2,635
CUMULATIVE EFFECTIVE WEIGHT TO TOP OF SECTION (lb)	105,400
USABLE JOINT STRENGTH IN TENSION (lb)	346,600
DEPTH TO TOP OF SECTION (ft)	-0-
BIAXIAL STRESS-COLLAPSE SLOPE	-65.55

*Collapse Criteria - 15.5 pounds per gallon cement external versus normal atmospheric pressure

TABLE VII

CASING TALLY - AS-BUILT 9-5/8-INCH LONGSTRING CASING

JOINT NUMBER	LENGTH (ft)	STRING EQUIPMENT	JOINT NUMBER	LENGTH (ft)	STRING EQUIPMENT
1	43.77		36	41.96	
2	41.94	Centralizer	37	40.38	
3	41.83		38	41.52	
4	41.87		39	37.90	
5	41.26	Centralizer	40	39.86	
6	41.65		41	41.00	
7	42.54		42	40.44	
8	41.44		43	41.61	
9	41.92		44	37.40	
10	35.91		45	40.13	
11	40.94		46	42.09	
12	41.36		47	40.60	
13	41.69		48	41.67	
14	39.29		49	41.90	
15	41.88		50	41.08	
16	39.49		51	41.81	
17	40.18		52	41.85	
18	42.04		53	41.51	
19	41.00		54	42.20	
20	40.18		55	41.68	
21	42.77		56	41.35	
22	41.70		57	42.35	
23	41.75		58	42.24	
24	41.48		59	41.90	
25	41.81		60	41.26	
26	40.04		61	39.95	
27	41.56		62	41.55	
28	42.35		63	42.52	
29	41.10		64	34.15	
30	41.19		65	41.12	
31	40.95				
32	35.60				
33	42.20			-31.62	up on #65
34	41.60				
35	41.15		TOTAL	2634.51	

TABLE VIII

BIT RECORD

NO.	SIZE	MAKE	TYPE	JET 32nd IN	DEPTH	FEET	HOURS	FEET PER HOUR	WT 1,000 LBS	RPM	PUMP PRESS	MUD WT.	MUD VIS.	DULL CONDITION T	DULL CONDITION B	DULL CONDITION G
1	26"	STC	DS	OPEN	42	42	19.5	2.15	29	60	100	8.5	76	4	2	2
2	17.5	STC	4JS	OPEN	635	593	94.75	6.25	10/15	60		8.7	75	6	6	5
3	12.25	STC	F-3	11-16-16	912	319	72.75	4.38	15/35	60	650	8.8	35	6	5	4
4	12.25	STC	F-4	OPEN	1327	415	87.5	4.74	9/35	60	100	9.2	48	7	5	5
5	12.25	STC	F-4	OPEN	2128	801	144.25	5.55	30/35	60	100/200	9.1	40	7	7	7
6	12.25	STC	F-4	22-22-22	2577	449	94	4.77	35/38	60	100/400	9.4	43	7	7	5
7	12.25	STC	F-4	22-22-22	2635	58	12.75	4.54	20/38	60	250/300	9.2	47	3	2	1
8	8.625	REED	4-13	13-13-13	2635	2075	23	90.21	30/38	60	300/900	WATER		DRLG. CEMENT		
9	8.625	REED	FP-72	14-14-14	3226	591	73.75	8.01	20/40	60	700/800	WATER		5	5	4
10	8.625	REED	FP-72	14-14-14	3737	511	63.25	8.07	10/40	60	700	WATER		5	5	6
11	8.625	REED	FP-72	14-14-14	3989	252	79.25	3.17	5/20	60	325/675	WATER		4	3	4

STC=Smith Tool Company

T = Tooth

B = Bearing

G = Gauge

Dull Condition Grading System utilized is that of the International Association of Drilling Contractors.

TABLE IX

SERVICE COMPANIES AND EQUIPMENT SUPPLIERS

Ace Sales & Services, Inc., Richland, Washington - sanitary facilities
Big Chief Water Services, Inc., Shelby, Montana - water transporting
Bill's Casing Tong Service, Marysville, California - tong service
Christensen Diamond Products U.S.A., Inc., Casper, Wyoming - stabilizer and shock-sub
Dahlory, Inc., Santa Fe Springs, California - shale shaker
Drilling Fluid Specialists, Inc., El Segundo, California - mud products and services
Fleet Cementers, Inc., Grand Junction, Colorado - cement products and services
Gulco Industries, Inc., Oklahoma City, Oklahoma - well head equipment
Herman Karst Enterprises, Inc., Casper, Wyoming - conductor casing
J. A. Jones Construction Compnay, Richland, Washington - site construction
Lynes, Inc., Bakersfield, California - PIP packer and circulating head
Monarch Machine Shop, Pasco, Washington - cap plate
National Supply Company, Casper, Wyoming - casing
Redman Pipe and Supply, Inc., Tulsa, Oklahoma - well head equipment
Reed Tool Company, Inc., Houston, Texas - bits
Rucker-Acme Tool Company, Casper Wyoming - blowout preventer and drill collar rental
Schlumberger Well Services, Inc., Cut Bank, Montana - logging and perforating services
Smith Tool Company, Inc., Houston, Texas - bits
Western Building Supply Company, Pasco, Washington - cement admixtures

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