GL00551

Appendix E

Drilling and Completion Program Plan

Appendix E

DRILLING AND COMPLETION PROGRAM

The drilling and completion program for the 10,000 ft deep well was expected to take approximately 195 days. This time included total time for drilling and coring, placement and cementing of all casing strings, all logging and other test activities including 15 days for scientists, and a short-term cleanout of the well while the drilling rig was on site.

This section restates the complete drilling and completion program for the deep well, in the format typically used by the drilling industry. A summary of this program is given in Table E-1.

Table E-1

STATE 2-14: DRILLING AND COMPLETION PROGRAM

Location	The east half of the southeast quarter of Section 14, Township 11 South, Range B East SBB&M, County of Imperial, State of California
Elevation	230± ft below sea level. All depths measured from K.B. ± 25 ft above ground level
Proposed total depth	10,000 ± ft
Anticipated producing interval	6,000 to 10,000 ft

E.1 DRILLING PROCEDURES

The procedures are as follows:

- Move in and rig up over 30 in. preset conductor pipe
- Drill 26 in. hole from bottom of 30 in. conductor pipe to 700 ft with mud. Wait on cement (WOC). Install mud cooling equipment.
- Run 20 in. surface casing to 700 ft and cement to surface.
- Weld on 20 in. casing flange and install 20 in. 3,000 psi working pressure BOPE. Pressure test BOP and casing to 500 psi in the presence of a California Division of Oil and Gas (CDOG) representative
- Drill out cement and drill 17-1/2 in. hole to 3,020 ft with mud. Take two cores in this section as prescribed in the detailed daily drilling schedule
- Circulate, condition mud, and cool hole for open hole geophysical logs. Take SIM and multishot survey on trip out of hole. Run logs from 3,020 ft up to surface casing. If hole becomes too hot, circulate and cool hole as required for logs
- Pump sweep plug, and circulate and condition hole for casing. Run and cement 13-3/8 in. casing to surface.

  Note: Casing running speed should not to exceed 1 min per joint. When ±1,000 ft and ±2,000 ft of casing has been run, circulate hole for 30 min. When casing has reached bottom, circulate until returns are clean (minimum circulation - two hole volumes)
- Install 13-3/8 in. casing head and nipple up 13-5/8 in. 3,000 psi BOPE. Pressure-test BOPE and casing to 1,000 psi in the presence of a CDOG representative
- Drill 12-1/4 in. hole with mud from 3,000 to 6,000 ft, taking logs and cores as prescribed in detailed drilling schedule
- Pump sweep plug, circulate, condition mud, and cool hole for open hole logging. Run logs from 6,000 ft back to 3,000 ft. If hole becomes too hot, circulate and cool hole as required for logs

  Note: Hole temperatures may be too high at this depth to run geophysical logs, and only production logs will be obtained

- Circulate and condition hole for casing. Run and cement 9-5/8 in. casing to surface

  Note: Casing running speed not to exceed 2 min per joint. When ±2,000 ft and ±4,000 ft of casing has been run, circulate hole for 30 min. When casing has reached bottom, circulate until returns are clean (minimum circulation - two hole volumes)

- Cut off 9-5/8 in. casing and install expansion spool master valve and BOPE. Pressure test BOPE and casing to 1,000 psi in the presence of a CDOG representative

- Drill 8-1/2 in. hole with mud from 6,000 to 10,000 ft total depth, taking cores and logs as described in detailed coring schedule

- Circulate and condition hole for 7 in. slotted liner. Run slotted liner with polished bore receptacle from 5,800 to 10,000 ft. Pull out of hole and lay down drill pipe. Perform logs including casing caliper

  Note: Liner running speed not to exceed 1 min per joint. At 3,000 and 6,000 ft, liner is to be circulated for 30 min. On bottom, liner is to be circulated until returns are clean (minimum circulation - two hole volumes)

- Replace BOPE equipment with wellhead flow assembly and flow well for cleanup as directed. Initiate flow

- Nipple down flowline

- Release rig

E.2 CASING PROGRAM

E.2.1 Conductor Casing

The 30-inch, 118 lb/ft plain end casing is to be set at 60 feet.

E.2.2 Surface Casing

Size	Section	Length	Weight	Grade	Coupling	Range
20 in.	0-700 ft	700 ft	94 lb/ft	K-55	Buttress	3

The surface casing is to be run as follows:

- Thread-lock or tack-weld 20-in. float shoe on bottom joint
- Thread-lock or tack-weld 20 in. stab-in float collar on top of first joint
- Thread-lock or tack-weld first three joints
- Install centralizers on first and third joints, then as needed to bridge sloughing zones
- Clean all threads and dope with Copper-Kote Geothermal thread dope
- Tag bottom and hang casing in full tension
- Run in hole with latch-in assembly and stab in to collar
- Circulate hole two hole volumes prior to cementing

Note: If a sudden increase in flow line temperature is noted before 700 ft, the surface casing will be set immediately.

E.2.3 Protective Casing

The 13-3/8 in. casing will require the following inspections:

- Longitudinal defects
- Wall thickness and eccentricity
- Transverse defects
- API special drift for 12-1/4 in. bit
- API thread
- Wall thickness spot tests
- Coupling
- Special end area

Size	Section	Length	Weight	Grade	Coupling	Range
13-3/8 in.	0-3,000 ft	3,000 ft	68 lb/ft	C-95	Buttress	3

The protective casing is to be run as follows:

- o Tack-weld 13-3/8 in. float shoe
- o Stab-in float collar on top of second joint (± 80 ft)
- o Clean all threads and dope with Copper-Kote high temperature dope
- o Install centralizers in middle of first and second joint, then as needed to bridge sloughing zones. No centralizers to be set in top 200 ft of hole
- o Fill casing with mud as required during running operations
- o Tag bottom and hang casing in full tension
- o Circulate hole two hole volumes prior to cementing or until mud clears up prior to cementing

E.2.4 Production Casing

The 9-5/8 in. casing is to be inspected in the same manner as the 13-3/8 in. protective casing.

Size	Section	Length	Weight	Grade	Coupling	Range
9-5/8 in.	0-6,000 ft	6,000 ft	47 lb/ft	C-95	Buttress	3

The production casing is to be run as follows:

- o Tack-weld 9-5/8 in. float shoe on bottom
- o Place float collar two joints above shoe and tack-weld
- o Tack-weld bottom three joints
- o Install centralizers in middle of bottom two joints and then as required to bridge sloughing zones
- o Clean threads and dope with Copper Kote high temperature thread dope
- o Tag bottom and hand casing in full tension
- o Circulate hole at least two hole volumes or until mud clears up prior to cementing

E.2.5 Production Liner

The 7 in. liner is to be inspected in the same manner as the 13-3/8 in. protective casing. In addition, the liner will be machined-slotted with 2 in. x 1/4 in. slots on 6 in. center with 20 slots per foot. Slot open hole section only.

Size	Section	Length	Weight	Grade	Coupling	Range
7 in.	5,800-10,000 ft	4,200 ft	29 lb/ft	N-80	LTC	3

The production liner is to be run as follows:

- o Install guide shoe on bottom
- o Clean all threads and dope with Copper-Kote high temperature thread dope
- o Install 7 in. x 9-5/8 in. liner hanger
- o Tag bottom, then pull up and set liner

E.3 CEMENTING PROGRAM

E.3.1 Surface Casing - 20 In.

Preflush	40 bbl water 50 bbl $CaCl_2$ 30 bbl water 50 bbl FLOWCHEK 30 bbl water
Slurry	1,600 ft^3 API Class G cement, Spherelite (50 lbs per sack of cement), 40% silica flour. Retarder to be added if required by hole temperatures. Note: Slurry volume based on 50% excess over theoretical.

E.3.2 Protective Casing - 13-3/8 In.

Preflush	Same as surface casing
Lead slurry	3,000 ft^3 API Class G cement and Spherelite (50 lbs per sack of cement), 3% gel, and 0.5% friction reducer

Tail slurry	500 ft^3 API Class G cement, 40% silica flour, and 0.5% friction reducer. Retard all cements as dictated by hole temperatures

E.3.3 Production String - 9 5/8 In.

Preflush	Same as surface casing
Lead slurry	2,500 ft^3 API Class G cement and Spherelite (50 lbs per sack of cement), 40% silica flour, 3% gel, and 0.5% friction reducer
Tail slurry	400 ft^3 API Class G cement, 40% silica flour, 3% gel, and 0.5% friction reducer. Retard all cements as dictated by hole temperatures

E.4 DRILLING FLUIDS PROGRAM

E.4.1 Surface to 700 Ft (Gel/Weighted System)

Properties are as follows:

o	Density, lb/gal	8.5-9.2 - normal 11-12 - if shallow CO_2 is expected
o	Funnel viscosity, sec	40-50
o	Fluid loss, cm^3	15-20
o	Plastic viscosity, cp	6-13
o	Yield, lb/100 ft^2	15-25
o	pH	9.5-11
o	Solid, %	4-6

E.4.2 700 to 3,000 Ft (Gel/Lignite System)

Properties are as follows:

o	Density, lb/gal	8.5-9.3
o	Funnel viscosity, sec	40-50
o	Fluid loss, cm^3	12-15
o	Plastic viscosity, cp	8-15

- Yield, lb/100 ft^2 8-14
- pH 9.5-11
- Solids, % 4-6

Mud weight and solids content should be maintained as low as practicable with mechanical equipment and the addition of water.

E.4.3 3,000 to 6,000 Ft (Sepiolite/Polymer System)

Properties are as follows:

- Density, lb/gal 8.6-9.2
- Funnel viscosity, sec 35-42
- Fluid loss, cm^3 12-15
- HT-HP fluid loss, cm^3 25-30 max.
- Plastic viscosity, cp 8-16
- Yield, lb/100 ft^2 6-10
- pH 9.5-11.0
- Solids, % 5-7

As in the preceding interval, mud weight and solids content are to be maintained as low as practicable. This mud formulation may be required earlier, depending on borehole temperatures actually encountered.

E.4.4 6,000 to 10,000 Ft (Sepiolite/Polymer System)

Properties are as follows:

- Density, lb/gal 8.6-9.2
- Funnel viscosity, sec 35-40
- Fluid loss, cm^3 10-12
- HT-HP fluid loss, cm^3 20-25 max.
- Plastic viscosity, cp 8-15

- o Yield, lb/100 ft^2 6-10
- o pH 9.5-11.0
- o Solids, % 5-7

The basic water source will be canal water treated for sulfate control. pH control will be through the addition of caustic soda.

E.5 HYDRAULICS PROGRAM

The preliminary hydraulics program is shown in Table E-2. This program has been devised to provide good cuttings removal without damage to the well bore by turbulent flow. It should be noted that the actual hydraulics operation will have to be fine-tuned in the field.

E.6 BLOWOUT PREVENTION EQUIPMENT (BOPE) REQUIREMENTS

Kelly cock, standpipe, valve, and drill-pipe float will be maintained on the rig floor. Dual-station controls, one on the rig floor, the other at least 50 feet from the wellhead, will be provided for all BOPE. Accumulator capacity will be 160 gallons minimum with 3,000 psi charge pressure.

E.6.1 Surface to 700 Ft

Annular BOP will be located on the 30 in. casing above the diverter. BOPE is not designed to hold pressure, but to protect rig crew against shallow gas pockets or hot artesian water flows.

E.6.2 700 to 3,000 Ft

Two 20 in., API Class 3M single gates with blind and pipe rams, and a 20-inch, 3,000 psi WP annular preventer with a pitcher nipple on top.

Table E-2

SCIENTIFIC WELL HYDRAULICS PROGRAM

	Casing interval, ft			
	60-700	700-3,000	3,000-6,000	6,000-10,000
Casing size, in.	20	13-3/8	9-5/8	7
Drilling fluid properties				
Mud weight, lb/gal	9.0	9.1	9.2	9.2
Plastic viscosity, cp	15	11	12	11
Yield point, lb/100 ft^2	20	10	8	7
Boundary conditions				
Maximum surface pressure, psig	2,800	2,800	2,800	2,800
Maximum flow rate, gpm	875	875	610	425
Minimum flow rate, gpm	525	525	368	255
Minimum jet size, in.	14/32	14/32	14/32	14/32

E.6.3 3,000 to 10,000 Ft

13-5/8-inch, API Class 3M single gates with pipe and blind rams, and a 13-5/8-inch, 3,000 psi WP annular preventer. Kelly cock and standpipe valve will be maintained on the rig floor. A rotating head will be installed above the top preventer.

E.6.4 BOP Safety

- Tighten all bolts after heat up
- Loosen and/or tighten turn buckles as well heats up
- Work all BOPE when out of hole for bit changes
- Check pipe and blind ram rubbers often as temperature increases
- Scaffolding should be built around BOPE for ease of access and safety

- When loss of circulation occurs, ensure that cool drilling fluid is pumped into well periodically while mixing loss circulation material to keep well from heating up

- Flow line should be manifolded so that flow can be directed either through the flash cylinder or can bypass the flash cylinder before entering the possum belly

E.7 DIRECTIONAL REQUIREMENTS

This well will be drilled as an essentially straight hole with the following drift limitations:

Interval	Max. Dogleg Severity	Max Deviation From/Vertical
Surface to 3,000 ft	1.5/100 ft	6°
3,000 to 6,000 ft	1.5/100 ft	6°
6,000 to 10,000 ft	1.5/100 ft	6°

Single-shot directional surveys will be taken at no more than 200-foot intervals. Run multishot survey in drill pipe on last trip out before logging at casing points.

E.8 COMMERCIAL LOGGING IN WELL

Logging in the well will consist of geophysical, caliper, temperature, and pressure, cement bond, and spinner/trigger logs.

E.8.1 Outline of Deep Well Logging Program

Table E-3 shows when in the program each well log will be taken.

E.8.2 Mud Logging

The mud loggers will be responsible for the operation of the drilling data terminal and performing mud logging services as follows:

- Take 10 ft samples from bottom of conductor pipe to 6,000 ft, then take 5 ft samples from 6,000 to 10,000 ft

Table E-3

OUTLINE OF WELL LOGGING PROGRAM

Logging Point Deep Well	Number of Runs: Geophysical Log Suite	Caliper of Casing	Temperature/pressure: Continuous	Temperature/pressure: Wireline	Cement Bond-Gamma Ray	Spinner/Tracer
DB, @1,000ft			1			
DB, @2,000ft			1			
13-3/8 in. casing point	1		4		1	
DB, @4,000ft			1			
DB, @5,000ft			1			
9-5/8 in. casing point	1		4		1	
DB, @7,000ft				1		
DB, @8,000ft				1		
DB, @9,000ft				1		
TD, before liner set				1		
TP, after liner set		1		1		
TP, rate step 1				1		1
TP, rate step 2				1		1
TP, rate step 3				1		1
RP 1 day post-test				1		
RP 5 days post-test				1		
RP 2 weeks post-test				1		
RP 5 weeks post-test				1		
RP after pressure recovery		1		1		
RP 6 months post-test				1		
Total	2	2	12	14	2	3

DB = drilling break
TD = total depth
TP = test period
RP = recording period

- o Wash, dry, and bag samples, six bags from each interval
- o Prepare detailed lithological log from cuttings
- o Maintain records of bit changes, directional surveys, casing points, and cement jobs
- o Assist wellsite geologist in core handling
- o Install drilling data terminal and monitor following drilling parameters
  - Penetration rates
  - Weight on bit
  - Rotary speed
  - Mud temperature in and out
  - CO_2 and H_2S
  - Mud pit levels
  - Resistivity of fluids
  - Pump strokes
  - Flow rate out
  - Mud density

E.9 DRILLING ASSEMBLIES

Drilling assemblies needed for the well are shown schematically in Figures E-1 and E-2. Variations of these configurations will be used, with the possible use of an additional string stabilizer to maintain hole straightness.

E.9.1 Bits

Standard bits will be used where appropriate, while sealed journal bearing bits will be used in the deep portion of the well. The bit weights for geothermal drilling are in the order of 25,000 to 40,000 pounds, with rotary speeds of 60 to 100 rpm. Jet sizes will be the same as those cited in Table E-2.

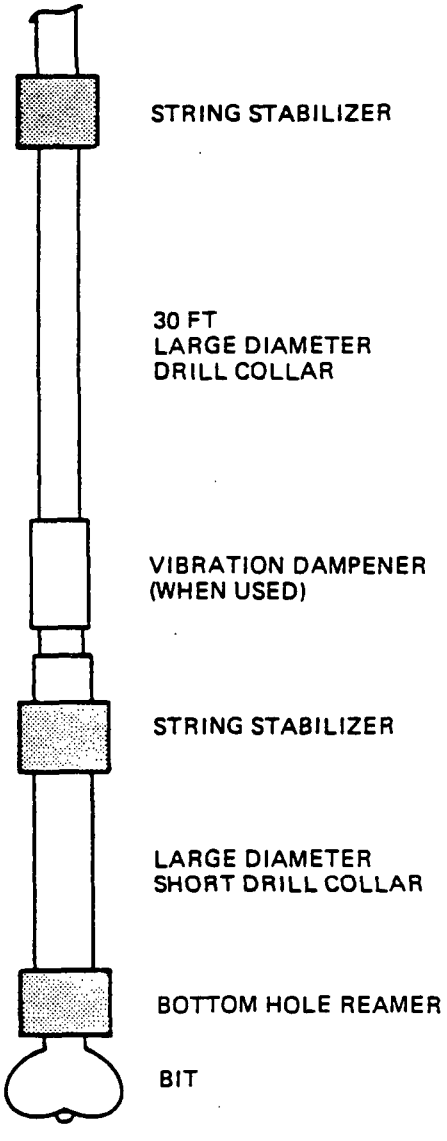

Figure E-1 DRILL ASSEMBLY 17-1/2-INCH – 12-1/4-INCH BHA

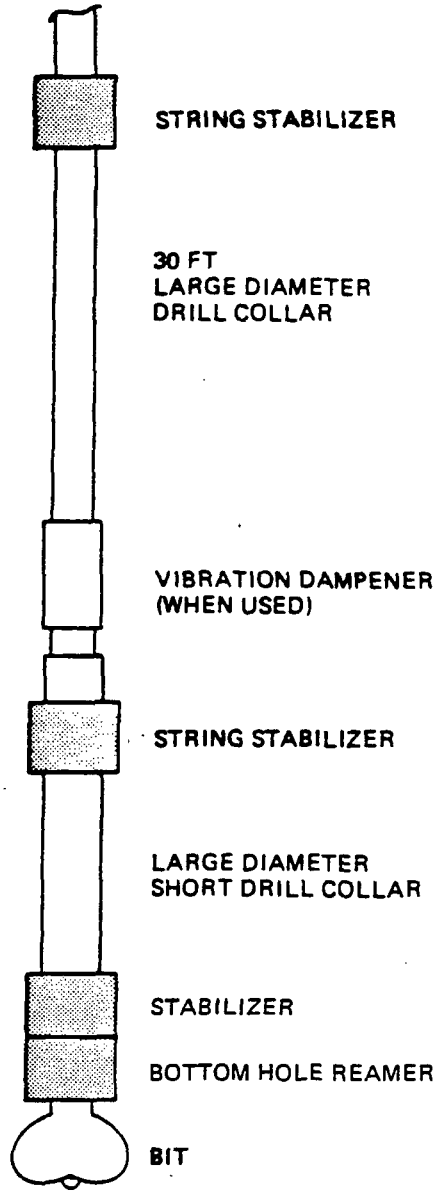

Figure E-2 DRILL ASSEMBLY 8-1/2-INCH BHA

E.9.2 Reamers

Near-bit roller reamers are used with packed hole assemblies for reaming in hard rock formations. The reamers are used for both stabilization and reaming of the hole when bit gauge (outside diameter) is reduced during the drilling operation. Three-point type roller-cutter reamers should be used with chert-type cutters (if formation is extremely hard) or standard cutters.

E.9.3 Stabilizers

Spiral type stabilizers with welded blades should be used. Long or short stabilizer wings are available. The number of stabilizers in the contact area will depend upon the deviation control needed during the operation. In hard rock, short stabilizers are used; in soft rock, long-bladed stabilizers are appropriate. Short stabilizers should normally be used.

E.9.4 Drill Collars

Drill collars provide weight for drilling and stiffness needed to maintain the hole as close as possible to vertical. The required weight on the bit will determine how many collars are used. Eight in. collars will suffice in the larger diameter holes; 6-1/2 in. collars should be used on the 8-1/2-in. hole.

E.10 BIT GUIDE

Bit performance assumptions are shown in Table E-4 and a bit guide is given in Table E-5.

Table E-4

DESIGN ASSUMPTIONS FOR SALTON SEA SCIENTIFIC WELL

Depth (ft)	Bit Life (hours)	Drilling Rate (ft/hr)	No. of Cores	Core Rate (ft/hr)	No. of Bits	No. of Core Bits
0 - 700	45	15	0	0	1	0
700 - 3,000	80	12.5	4	5	2	2
3,000 - 6,000	48	10	18	5	5	3
6,000 - 10,000	45	8	27	5	9	6

Table E-5

BIT GUIDE

Depth (ft)	Bit Size (in.)	Bit Type[a]	Weight on Bit (1000's of lbs)	Bit Speed (rpm)
Surface-700	26	OSC3AJ	25-40	60-100
700-3,000 (see Figure D-1)	17-1/2	J-3 J-4 X3-A	25-40	60-100
3,000-6,000 (see Figure D-1)	12-1/4	J-3 J-22 J-33	25-40	60-100
6,000-10,000 (see Figure D-2)	8-1/2	J-11 J-22 J-33 J-44	25-40	60-100

(a) Hughes Tool Company designation or comparable equivalent.

E.11 CORING PROCEDURE

The procedure is as follows:

- Run hole sweep and circulate 1 to 1-1/2 hole volumes before pulling out of hole
- Pull out of hole and stand back bit assembly
- Pick up core bit and core barrel assembly and run in hole to core interval
- Circulate to condition mud before coring
- While coring, control bit weight, circulating speed, and rotary table speed (rpm) as recommended by core engineer
- Pull out of hole, retrieve core, and lay down core barrel and bottomhole coring assembly. Cores to be handled as directed by on-site geologist
- Pick up bottom hole assembly, run in hole, and drill to next coring point

E.12 SCIENTIFIC WELL DRILL RIG SPECIFICATIONS

Mast or derrick	Height 152 ft, 1,000,000 lb GNC
Substructure	30 ft clearance to rotary beams, 8000,000 lb GNC
Drawworks	1,700 hp rated input
Drawworks power	see above
Rotary table	27-1/2-in. or bigger with split bushings
Crown block	300-500 ton
Traveling block and hook	300-500 ton
Swivel	300 ton
Drilling line	1-1/2 in. or 1-5/8 in.
Drill collars	Four 10 in. x 3 in. ID with 7-5/8 reg. connections, eighteen 8 in. x 2-13/16 in. ID with 6-5/8 reg. connections, twenty one 6-1/2 in. x 2-1/4 in ID with 4-1/2 XH connections
Drill pipe	15,000 ft 4-1/2 in., 20 lb/ft, E, XH or 5 in., 19.50 lb/ft, E, XH drill pipe
Hevi-Wate	21 joints, 5 in. x 3-1/16 ID, 50 lb/ft with 4-1/2 IF connections
Mud pumps and power	Two 1,300 hp triplex with rig mats for pumps
Light plants	Three 1,000 kW generators
Doghouse and trailer house	Large trailer for tool pusher
Subs	As required for all drilling assemblies

Steel mud pits	Four-pit system with 1,500 bbl capacity and completely covered with expanded metal. Mixing and stirring equipment, flowline flash tank, pump or jet system to facilitate dumping solids and cleaning. Two 6-in. x 8-in. or larger centrifugal pumps
Shale shaker, desander and desilter	Dual-tandem shaker. Desander with 2-12 in. cones. Mud cleaner
Kelly	Square Kelly & Kelly spinner with reverse
Weight indicator	Martin Decker or equivalent
Lighting system for rig	So that entire site and working areas are well lighted including under the substructure. Lighting to be vapor-proof UL approved
Core boxes and sample containers	Not required
Drilling recorder	Six-pen. Rate of penetration, hookload, pump pressure, pump strokes, torque, and rotary speed
Directional survey instrument	Single shot kit and peewee unit with heat shield kit
Handling tools	Slips, lifting subs, elevators, tongs, bit breakers for all drill pipe, collars and bit sizes
LPG, fuel, and lubricants	One 250 gal fuel tank with gauge and pump
Mud-testing equipment	Marsh funnel and mud balance
Portable water pump	Duplex pump with minimum 100 gpm at 100 psi
Tool joint and casing thread lubricant	Lubricant to be Copper-Kote Geothermal pipe dope for all tubular goods
Chemical toilet facilities for contractor personnel	Three chemical toilets and maintenance
Fishing tools	Overshots, jars, accelerators, for all sizes of drilling tools

Containment services, Kelly Stopcock and float subs	For all drilling sizes
Blowout prevention for 30 in. casing	Hydril diverter
Blowout prevention equipment for 20 in. casing	Single gate, 3M, blind rams Single gate, 3M, pipe rams 3M annular BOP
Blowout prevention equipment for 13-3/8 in. casing	Single gate, 3M, blind rams Single gate, 3M, pipe rams 3M annular BOP
Blowout prevention equipment for 9-5/8 in. casing	Single gate, 3M, blind rams Single gate, 3M, pipe rams 3M annular BOP Rotating head
Automatic driller and torque limiter	
Independent wireline depth measuring unit	Hydraulic unit with 18,000 ft reel of .092 nickel-plated wireline
Water storage	Four 500 bbl tanks manifolded together. Also potable water for crews