

**APPENDIX B NOMINAL GEOTHERMAL WELL DRILLING AND  
COMPLETION PROGRAM**

**Mammoth Pacific L.P.**

**1500' Production Well**

**Drilling Program**

**6-11-01**

**ThermaSource, Inc.**

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**Louis E. Capuano, Jr.**

**Mammoth Pacific**

**1500' Production Well  
Drilling Program**

**June 11, 2001**

**ThermaSource, Inc.**

<b><u>Time</u></b>	<b><u>Operations in Sequence:</u></b>
	1. Prepare location and install 30" conductor pipe to approximately 20' with backhoe. Install 8' X 8' cellar around conductor and cement floor of cellar.
0.5 days	2. Move in rotary drilling rig and center same over conductor pipe. Rig and prepare to drill. Install flowline on conductor to return mud to pits.
2.5 days	3. Pick up drilling tools and spud well and drill 27" hole to 250' with mud.
0.25 days	4. Rig up and run 22" welded casing to total depth with drill pipe stab in float collar located 40' above bottom. * See attached 22" Casing Running and Cementing Procedure
0.25 days	5. Run into casing with drill pipe and stab into float collar and circulate hole and prepare to cement casing.
0.25 days	6. Cement casing from total depth back up to surface.
0.5 days	7. Wait on cement.
0.5 days	8. Pull out of hole with drill pipe, cut and remove conductor at ground level. Cut 22" casing off and install wellhead. Install and nipple up blow out preventer stack consisting of hydril and flowline.
0.5 days	9. Test blow out preventers and lay down all 27" tools. Make up 20-1/2" tools and run into 22" casing.
4.5 days	10. Drill out 22" casing and drill 20-1/2" hole to 1000' with mud. Maintain hole as straight as possible, taking directional surveys every 100'. Maintain angle in hole less than 4° at total depth of 1000'. Maintain rate of angle change to be less than 1-1/2° per 100'.
0.25 days	11. Upon drilling to 1000', circulate and condition hole and mud to run logs.

- |           |     |  |
|-----------|-----|--|
| 0.25 days | 12. | Log well as directed by geologic staff.  |
| 0.25 days | 13. | Upon completion of logging, run in hole with drill pipe and circulate to condition hole and mud for casing.  |
| 0.25 days | 14. | Pulled out of hole with drill pipe and rig up to run casing to total depth.  |
| 0.25 days | 15. | Run 16" casing to total depth with drill pipe stab in float collar located 40' above bottom of casing. *See attached 16" Casing Running and Cementing Procedure.   |
| 0.25 days | 16. | Run into casing with drill pipe and stab into float collar. Circulate and condition hole and prepare to cement casing.   |
| 0.25 days | 17. | Rig up cementers and cement 16" casing from total depth to surface. Pull out of float collar with drill pipe and pull out of hole with drill pipe.   |
| 0.25 days | 18. | Wait on cement.  |
| 0.5 days  | 19. | Cut and remove 22" casing and blow out preventer stack. Cut off 16" casing and weld on 16" wellhead. Stack up and nipple up blow out preventers. Stack consists of double ram type preventer and rotating head with flowline assembly. |
| 0.5 days  | 20. | Test blow out preventer stack and lay down 20-1/2" tools. Pick up 15" tools and run into 16" casing with same.   |
| 2.5 days  | 21. | Drill out 16" casing with 15" bit and drill 15" hole with aerated water to total depth through production zones to approximately 1500'.  |
| 0.75 days | 22. | Upon completion of hole to 1500' flow, perform short term well test.   |
| 0.25 days | 23. | Log production interval and prepare to complete well with slotted liner.   |
| 0.5 days  | 24. | Rig and run 13-3/8" slotted liner into hole and hang same at 900', 100' above bottom of 16" casing, and extending to total depth of the well.  |
| 0.25 days | 25. | Pull out of hole and lay down all drill pipe and drilling tools.   |

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**1500' Drilling Program**  
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0.5 days	26.	Rig down rig and move off location.
0.5 days	27.	Release rig.
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18 days		Total time on location

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**Procedure for Running and Cementing 22" Casing**

1. Drill 26" to 27" hole to casing depth, 250' with mud.
2. Circulate for 1 to 2 hours to condition hole and mud for casing.
3. Pull out of hole.
4. Rig up and run 22" welded casing to total depth. Casing should be stab-in float shoe on bottom.
5. After casing is on bottom, rig up and run into hole with drill pipe with stab-in stinger on bottom. Stab into float shoe and circulate to condition hole for cement.
6. Rig up to cement casing.
7. Rig up cementers and prepare to cement casing. If lost circulation is a problem, pump 20 bbls of CaCl<sub>2</sub> water followed by 10 bbls of fresh water and then 20 bbls of sodium silicate. This mixture is then spaced with viscous mud prior to mixing and pumping the cement.
8. Mix and pump cement without any additional spacers. Pump cement consisting of Class G cement blended with 40% silica flour, 3% gel and a friction reducer. 3% CaCl<sub>2</sub> may be added to reduced the required setting time. Mix and pump cement until good cement returns are present between the hole and the 22" casing. Pull drill pipe stinger out of float shoe and dump excess from drill pipe on top of the float shoe.
9. Pull out of hole with drill pipe and wait on cement.
10. Observe cement in annulus and fill back to surface as required.
11. Cut off 22" casing and install casing wellhead flange.
12. Install 20" hydril with 20-1/2" bore. Nipple up blow out preventer stack and flow line.
13. Test casing and hydril to 350 psi.
14. Pick up 20-1/2" drilling assembly and run in hole with same. Drill out 22" casing and cement.

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**Procedure for Running and Cementing 16" Casing**

1. Drill 20-1/2" hole to casing depth, 1000' with mud.
2. Circulate for 2 to 3 hours to condition hole and mud for logging.
3. Pull out of hole.
4. Rig up loggers and run logs as indicated by geologic staff.
5. Rig down loggers and run in hole with bit to total depth. Pick up excess drill pipe needed to stab into float collar for cement the 16" casing.
6. Circulate for 1 hour. Make short trip and circulate for casing.
7. Pull out of hole and rig up to run 16" casing.
8. Run 16" casing grades and weights and thread design as indicated on attached detailed sheet with stab-in float collar located 40' above float shoe on bottom of casing. Install centralizers, one in the middle of the bottom two joints and then install on the tool joints. Locate centralizers on every other collar to within 100' of surface.
9. Set casing in elevators on spider. Do not set casing slips. Install return hoses from the 22" wellhead to mud pits for cement returns.
10. Rig up with landing plate on top of the 16" casing. Run drill pipe into 16" with stab-in stinger on bottom. Stab into collar and rig up to circulate. Tie down drill pipe.
11. Circulate for 1 hour, or at least two full circulations, to clean up and cool down hole.
12. Rig up to cement casing.
13. If lost circulation is a problem, pump 20 bbls of CaCl<sub>2</sub> water followed by 10 bbls of fresh water then 20 bbls of sodium silicate and then a 20 bbls of viscous mud to separate the cement slurry.
14. Mix and pump cement with any additional spacers. Pump stage 1 consisting of Class G

cement blended with 1:1 perlite and 40% silica flour, 3% gel and friction reducer and retarders as required. Pump approximately hole volume of this slurry or until cement appears at the surface then change over to Stage 2.

15. Pump 200 cuft of stage 2 cement consisting of Class G cement blended with 40% silica flour, 3% gel with friction reducer and retarders as required. The last 100 cuft of this stage should be staged in to keep the cement at the surface in the annulus. Check of fall back in annulus each shut down during staging. Pull out of stab-in collar and clear drill pipe, dropping all excess cement from drill pipe on top of float collar.
16. Rig down circulating equipment and pull out of hole with drill pipe.
17. Hook up to 16" casing elevators and pick up slightly to remove spider, then center 16" casing in stack.
18. Drain blow out preventer equipment after 30 minutes from the time cement was in place.
19. Wait on cement for 12 hours before landing casing. Check for cement fallback in annulus periodically, bring cement back up to surface using 1" pipe if necessary.
20. Cut off 16" casing and remove same. Remove all 20" blow out preventer equipment and cut and remove 22" casing. Install 16" X 16-3/4" wellhead and then 16-3/4" blow out preventer stack. Nipple up stack with rams and rotating head with flow line assembly.
21. Test blow out preventer equipment to 750 psi.
22. Change out bottom hole drilling assembly for 15" tools and run in hole with same to drill out excess cement.

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**Special Considerations**

**Auxiliary Equipment that should be maintained with the Rig**

1. Six pen drilling recorders with: a. string weight, b. rpm, c. rotary torque, d. rate of penetration, e. pump pressure, f. pump strokes broad.
2. Special rotating head with rubbers, capable of stripping 15" bottom hole assemblies. Complete with spare rotating head stripper drive bushing assembly. Run cold water continuously on head while producing geothermal fluids.
3. Use tong torque assembly for making up collars to API torque requirements.
4. Temperature should be taken with every directional survey by running a maximum recording thermometer in the survey instrument.
5. Catch drill cutting samples (2 sets) every 10', to be cleaned and sacked.
6. In and out temperatures, both of mud, air or aerated water shall be recorded in the tour reports every 30'. All steam/water entries shall be recorded in the tour reports.
7. All lost circulation zones encountered shall be recorded in the tour report book, recording both the depth at which the loss occurred, as well as the amount of fluid lost. Adversely, all flows shall also be recorded giving depth and the amount of the increase.
8. Periodic tests may be conducted to determine well potential. Drilling may be stopped and the hole evacuated to check for flow at lost circulation zones.
9. Upon completion , the well will be shut and the blow out preventer equipment will then be removed.
10. Rotary table will be equipped with a rotary torque gauge with visual display for driller.

**Hydrogen Sulfide Monitoring and Abatement:**

Hydrogen sulfide monitoring should be maintained during the drilling of the well. Detectors should be placed on the rig floor, cellar area, and flowline region to detect and announce (with alarms and

lights) the presence of hydrogen sulfide. These monitors are typically provided by and maintained daily by the geothermal data loggers. Proper functioning of these monitors are essential in maintaining a safe working environment.

Hydrogen sulfide abatement equipment and materials, i.e. pumps, hydrogen peroxide and caustic soda, may be maintained on location when drilling with lighter than water drilling fluids, i.e. air or aerated mud systems.

Escape breathing equipment, as well as resuscitators shall be available on site with mud logging unit. Fans should also be available on the rig floor to clear H<sub>2</sub>S contaminated floor areas, making it safer to work.

### **Pipe and Blow Out Preventer Inspection**

The initial acceptance of drill pipe should be based on an AAODC-API Class II specification inspection. All subsequent inspections should discard pipe with 30% wear or greater; i.e., use 30% where Class II state 20%.

The drill pipe should include:

1. Electromagnetic inspection of tubes (Sonoscope or Scanalog).
2. Wall thickness and cross sectional area (ultrasonic or gamma ray).
3. End area inspection (electronic or magnetic particle).

All drill collar end areas should be magnetic particle inspected every 14 days or 9 days while drilling with production or drilling with air or aerated mud systems.

All BOPs should be inspected for wear by the manufacturer or an authorized agent prior to installation. All BOPs should be tested after installation prior to drilling out cement.

Remind service companies furnishing bottomhole assemblies that their equipment should be magna-fluxed prior to delivery.

### **Air Equipment Requirements**

Sufficient air volumes will be required to aerate a water system to drill the 15" hole from the 16" casing shoe to 1500'+/- through the potential production zone. Available air equipment should be able to supply sufficient air to maintain annular velocities to adequately clear the hole. Critical annular velocity for a 15" hole drilled with water is approximately 50 to 70 FPM. Air/Water ratios should be maintained between 15:1 to 25:1. Air compressors capable of delivering 1000 to 1200 CFM at 600 to 800 psi should be available on location to successfully drill this portion of the hole with an aerated water system. A stand-by compressor may be necessary to successfully operate in this area.

Hook up lines, air meters, scrubber, misting pumps with minimum capacity of 10 gpm, and operating personnel will be furnished by the air contractor. Soap, corrosion inhibitors and pH control agents should be available on location to use with the aerated water system. A drilling muffler or separator shall be installed on the blooie line for air and aerated fluid drilling. The separator chamber shall be large enough to allow the discharged air and water to be contained and separated within. The separating force shall be centrifugal. The discharged air and/or steam shall be vented out the top with the water drain from the bottom into the lined waste sump on location.

### **Blow Out Contingency Plan and Emergency Spill Containment Plan**

Detailed contingency plans for blow out and spill containment are attached as a vital part of this drilling program. Both plans contain detailed procedures for all situations as well as a notification schedule of persons to be contacted in event of emergency. Available and appropriate contractors with addresses, telephone numbers and contact persons are also contained within these plans.

These plans should be posted on location and the Drilling Supervisor and Rig Toolpusher should be familiar with all portions of these plans.

**CASING, CEMENTING AND BOP PROGRAMS**

<b>CASING PROGRAM</b>		SIZE 16"	DEPTH 1000'	6-11-01	WELL Mammoth		
INTERVAL	WEIGHT LB/FT	GRADE	JOINT TYPE	CALCULATED SAFETY FACTORS			
				TOP BURST	BOT. BURST	COLL.	TENSION
0 to 1000'	75	K-55	Buttress	2.74		2.07	17.75
<b>DESIGN CONDITIONS</b>							
SURFACE BURST PRESSURE	-	960	PSI	OUTSIDE MUD WT. (COLLAPSE)	-	9.5	PPG
INSIDE MUD WEIGHT (BURST)	-	9.5	PPG	INSIDE MUD WT. (COLLAPSE)	-	0	PPG
OUTSIDE MUD WEIGHT (BURST)	-	9.5	PPG	FORM. PRESS. GRAD. AT SHOE (COLLAPSE)	-	9.5	PPG
FRAC. GRAD. AT SHOE (BURST)	-	14.5	PPG	BIAXIAL LOAD: COLL. <input checked="" type="checkbox"/>	BURST <input checked="" type="checkbox"/>	BOUYANCY: YES <input type="checkbox"/>	NO <input checked="" type="checkbox"/>

**CEMENTING PROGRAM**

SLURRY DESCRIPTION AND PROPERTIES			
SLURRY DESCRIPTION (AND NUMBER)			
1600 cuft (755 sacks) of Class G cement blended 1:1 with perlite and 40% silica flour and 3-4% gel as well as friction reducer and retarder as required			
Tailed with 200 cuft (123 sacks) of Class G cement blended with 40% silica flour and friction reducer and retarder as required			
			DESIRED TOP SURFACE
			EXCESS 100%
SLURRY VOL. - CU FT / (SLURRY NO.)	1600 cuft	200 cuft	
SLURRY YIELD - CUBIC FEET/SACK	2.12	1.62	
SLURRY DENSITY - PPG	106 #/cuft (14.2 ppg)	116 #/cuft (15.5 ppg)	
THICKENING TIME - DEPTH SCH/HRS, MIN.	2-3 hours	2-3 hours	
COMPRESSIVE STRENGTH - PSI/HOURS			
RUNNING AND CEMENTING INSTRUCTIONS			
SHOE, COLLAR(S) AND JOINT STRENGTHENING			
<ul style="list-style-type: none"> <li>* Float collar run 1 joint (40') above float shoe on bottom</li> <li>* Weld collars on bottom joint</li> <li>* Threadlock threads on bottom 4 joints</li> </ul>			
CENTRALIZERS AND SCRATCHERS - NUMBER, TYPE AND SPACING			
<ul style="list-style-type: none"> <li>* 1 centralizer in the middle of the bottom joint</li> <li>* 1 centralizer on every other casing collar to within 100' of surface</li> <li>* No scratchers run</li> </ul>			
PREFLUSH, DISPLACEMENT RATE, PLUGS, RECIPROCATION, ETC.			
<ul style="list-style-type: none"> <li>* 20 bbls of CaCl<sub>2</sub> water</li> <li>* 10 bbls of freshwater</li> <li>* 20 bbls of sodium silicate</li> <li>* 20 bbls of mud spacer ahead of cement</li> </ul>			
PRESSURE TESTING AND LANDING			
<ul style="list-style-type: none"> <li>* Bump plug with 500 psi</li> <li>* Wait on cement for 12 hours. Nipple up and test BOPs to 750 psi</li> </ul>			

**BOP PROGRAM**

API STACK ARRANGEMENT CODE	WORKING PRESSURE PSI	MINIMUM BORE INCHES	TYPE	TEST PRESSURES - PSI		
				RAM TYPE	ANNULAR TYPE	ROTATING HEAD
	3000 psi	16"	16" Double Ram type	CSO & Pipe		1000

**GROUND  
LEVEL**

**250'**

**500'**

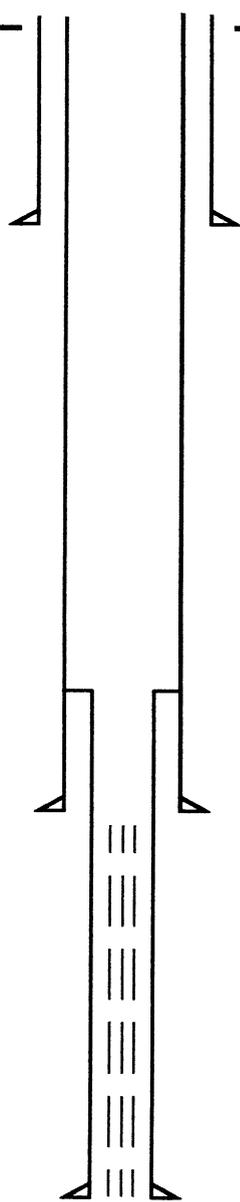
**750'**

**1000'**

**1250'**

**1500'**

**1750'**



22" CASING SET IN 27"  
HOLE AT 250'.

16" CASING SET IN 20 1/2"  
HOLE AT 1000'.

13 5/8" SLOTTED LINER SET  
IN A 15" HOLE FROM 800' TO 1500'

**DRAWING  
NUMBER**

001

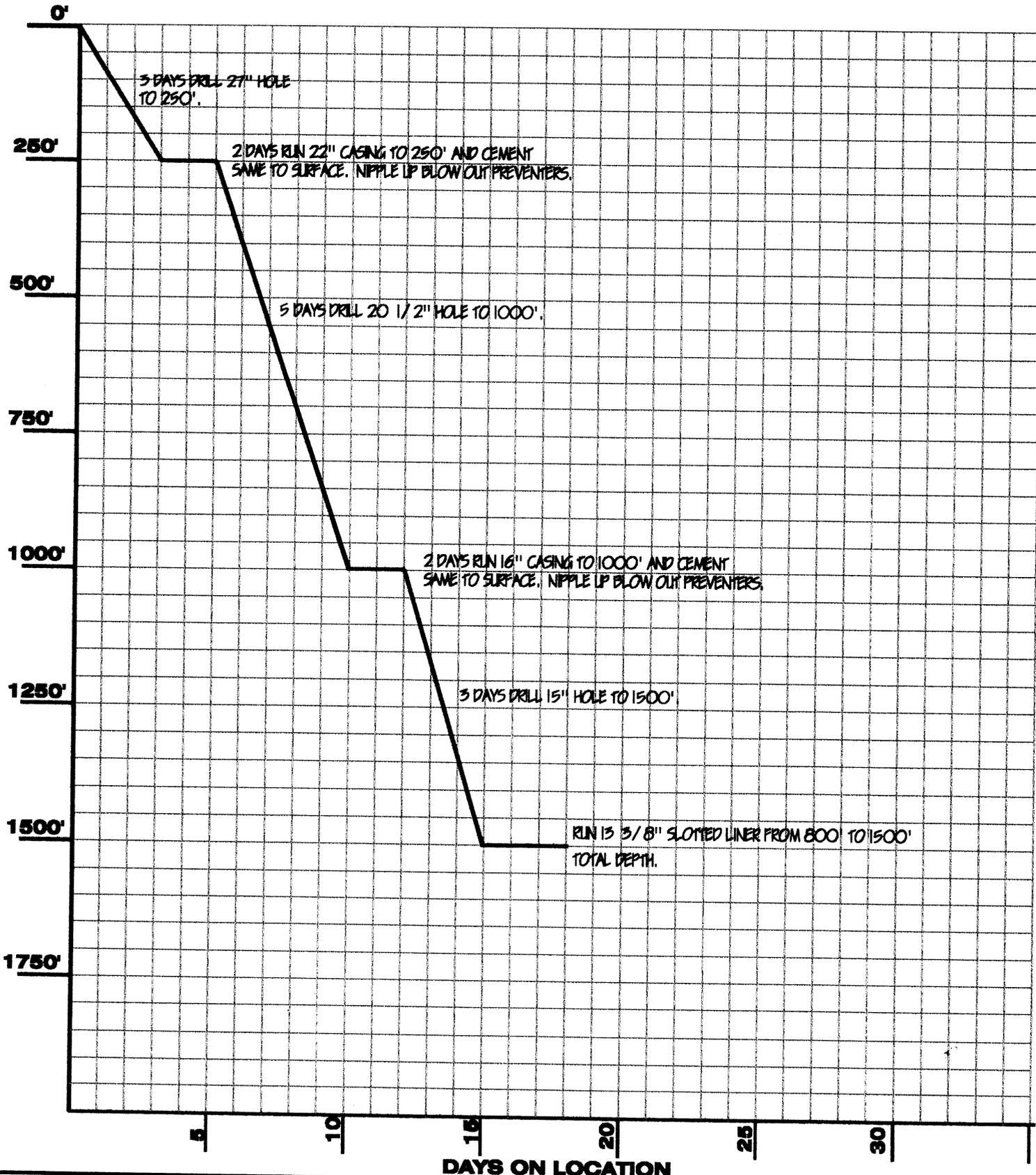
**THERMASOURCE, INC.**

MAMMOTH PACIFIC L.P.  
COMPLETED WELL PROFILE  
1500' PRODUCTION WELL

**DATE**

6-1-01

DEPTH



DAYS ON LOCATION

DRAWING NUMBER  
002

# THERMASOURCE, INC.

MAMMOTH PACIFIC L.P.  
DRILLING CURVE  
1500' PRODUCTION WELL

DATE  
6-1-01

DRILLING NIPPLE

FLOWLINE FOR MUD DRILLING

20" 2000 PSI HYDRIL WITH 21-1/4" BORE

20" 2000 PSI SINGLE RAM TYPE PREVENTER WITH CSO RAM 21-1/4" BORE

20" 2000 X 22" S.O.W. RENTAL WELLHEAD WITH 2-3" VALVED OUTLETS

2-3" VALVED OUTLETS WITH 3" STEEL LINE ONE TO BLOW DOWN & ONE FOR FILL UP TO PUMPS

GROUND LEVEL

22" Casing

3' DEEP CELLAR



ThermaSource Inc.

P.O. Box 1236 • Santa Rosa, California 95402 • (707) 523-2960

DRAWN

FOR: MP

BY: LEC

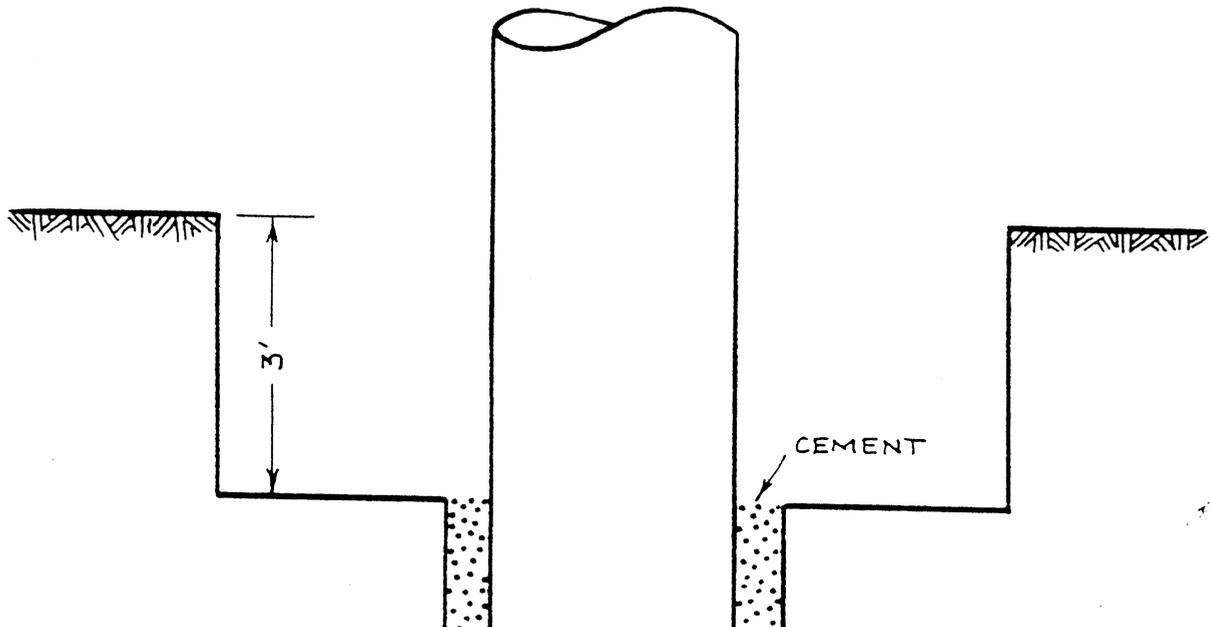
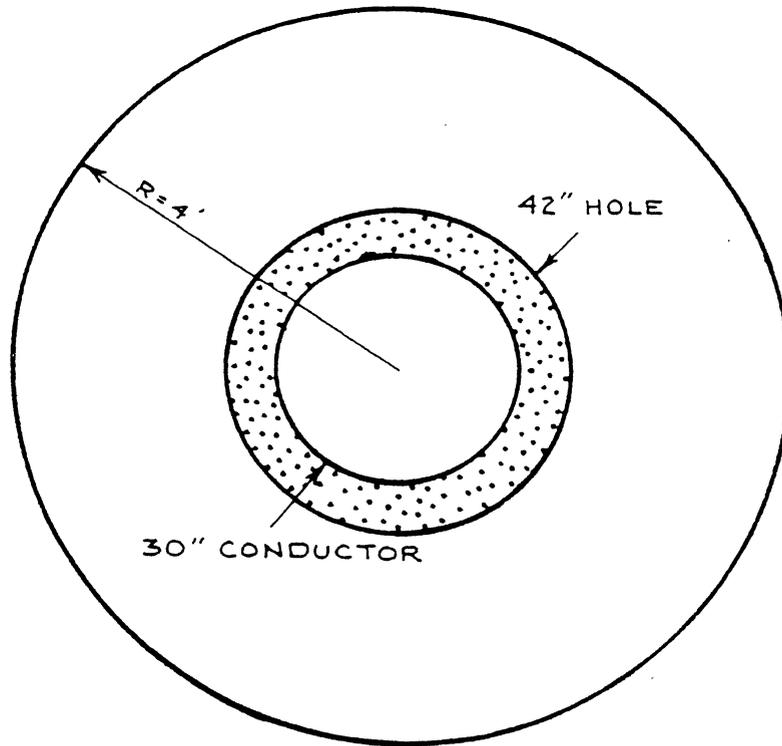
DATE: 6-11-01

SCALE:

DRAWING No.

003

Mammoth Pacific  
1500' Production Well  
22" Casing and Blow Out Preventers



**TSI**

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**FOR:** MP

**BY:** LEC

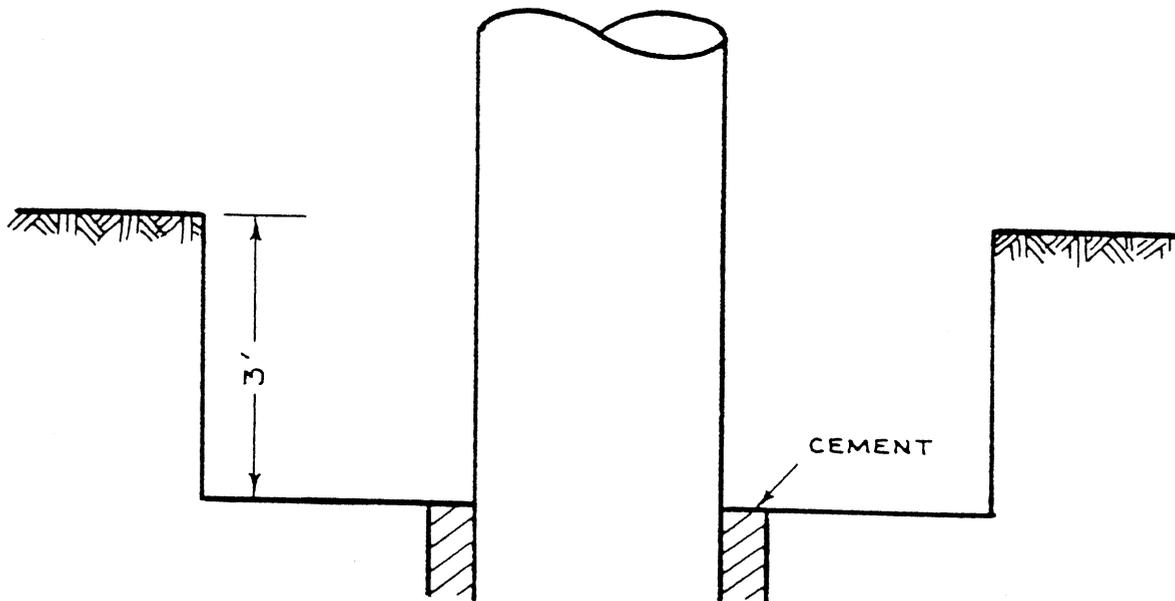
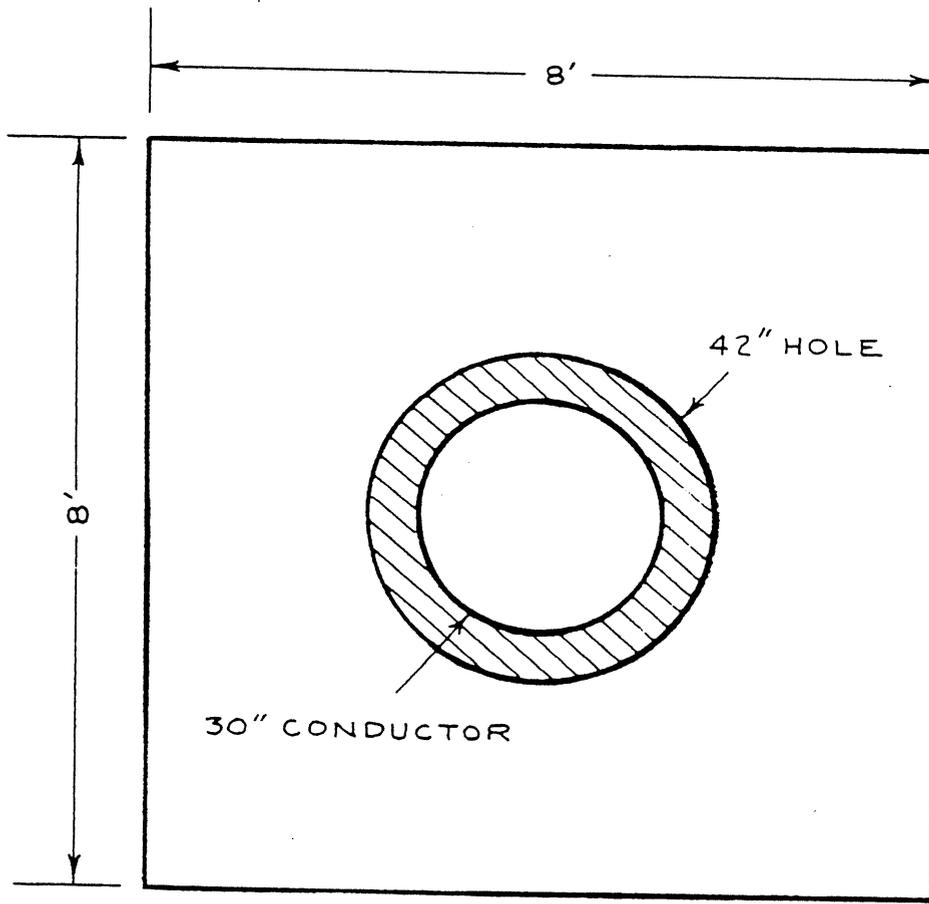
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004

Mammoth Pacific  
30" Conductor with Round Cellar  
1500' Production Well



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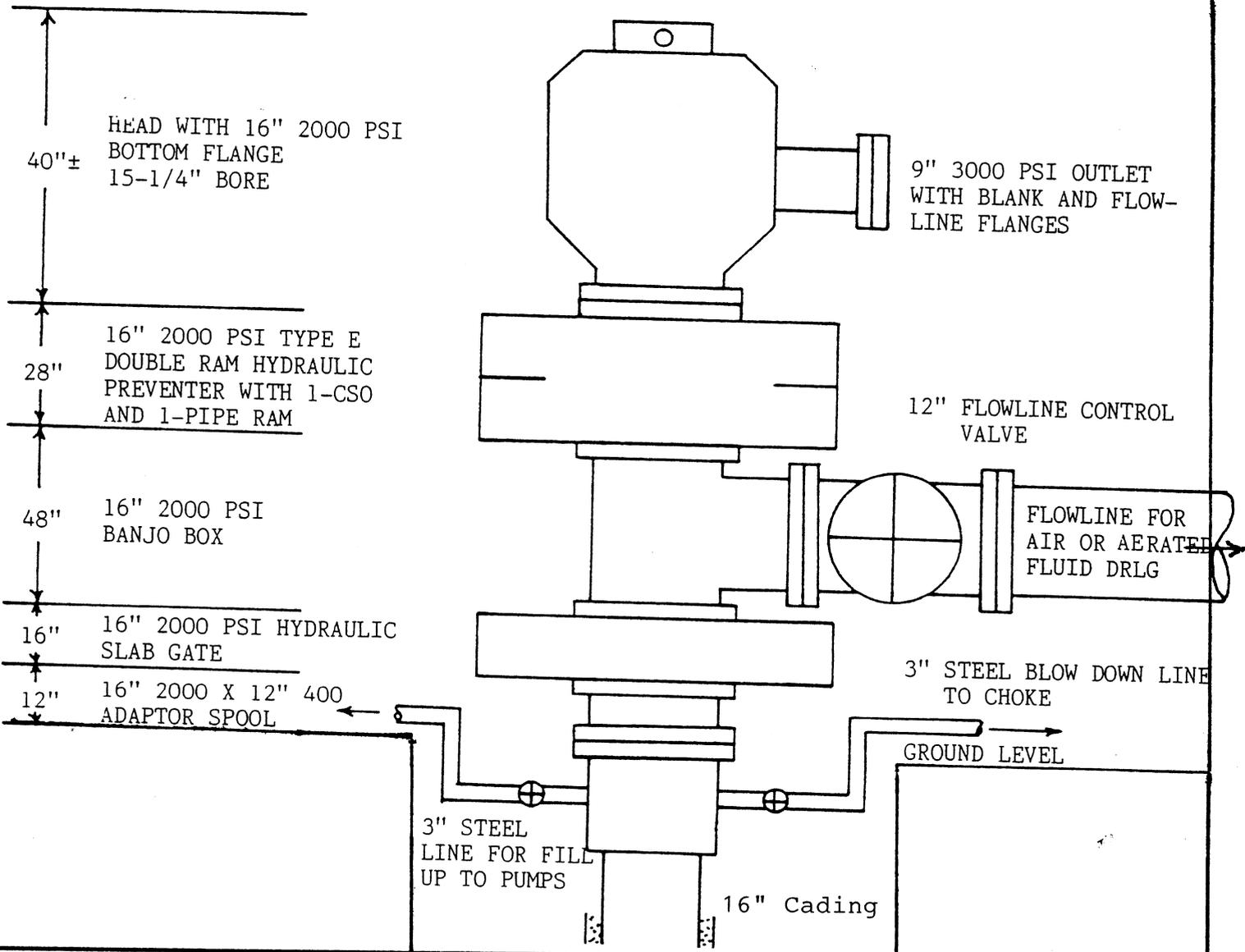
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005

Mammoth Pacific  
30" Conductor with Box Cellar  
1500' Production Well



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006

Mammoth Pacific  
 16" Casing and Blow Out Preventers  
 1500' Production Well