GTLT - 9

(6-30)-18N-3E
Sunoco Energy Development Corporation (Sandoval County)

9-76-1-M(PA); 2-P(PA); 4-A(PA) & 3-L(PA)

Form G-103
Adopted 10/1/74

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Operator	1	
Land Office		

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. Box 2088, Santa Fe 87501

SUNDRY NOTICES AND REPORTS ON GEOTHERMAL RESOURCES WELLS

5. Indicate Type of Lease: State ☐ Fee ☒
5.a State Lease No.: ------

Do Not Use This Form for Proposals to Drill or to Deepen or Plug Back to a Different Reservoir. Use "Application For Permit —" (Form G-101) for Such Proposals.)

1. Type of well: Geothermal Producer ☐ Temp. Observation ☐ Low-Temp Thermal ☐ Injection/Disposal ☐
7. Unit Agreement Name: None
2. Name of Operator: Sunoco Energy Development Corporation
8. Farm or Lease Name: San Diego Grant
3. Address of Operator: 12700 Park Central Pl., Suite 1500, Dallas, TX 75251
9. Well No.: 9-76-1
4. Location of Well: Unit Letter M, 1200 Feet From The S. Line and 200 Feet From The W. Line, Section 6 Township 18 N. Range 3E. NMPM.
10. Field and Pool, or Wildcat: None
15. Elevation (Show whether DF, RT, GR, etc.): 6600' G.L.
12. County: Sandoval

16. Check Appropriate Box To Indicate Nature of Notice, Report or Other Data

NOTICE OF INTENTION TO:		SUBSEQUENT REPORT OF:	
PERFORM REMEDIAL WORK ☐	PLUG AND ABANDON ☒	REMEDIAL WORK ☐	ALTERING CASING ☐
TEMPORARILY ABANDON ☐		COMMENCE DRILLING OPNS. ☐	PLUG & ABANDONMENT ☒
PULL OR ALTER CASING ☐	CHANGE PLANS ☐	CASING TEST AND CEMENT JOB ☐	
OTHER ☐		OTHER Per verbal permission. ☐	

17. Describe Proposed or completed Operations *(Clearly state all pertinent details, and give pertinenet dates, including estimated date of starting any proposed work)* SEE RULE 203.

Hole was abandoned by: a) cutting off 3/4" iron pipe 6" below ground level; b) filling top 10' of pipe with cement; c) covering the pipe with dirt; d) clearing site of all trash and debris and e) restoring site as nearly as practical to original condition. Abandonment operations commenced on 9/24/77 and were completed on 9/24/77.

This conforms with abandonment method prescribed by U.S. Geological Survey's Revised Special Stipulations for Shallow Temperature Gradient Holes.

OCT 31 1977
OIL CONSERVATION COMM.
Santa Fe

18. I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNED [signature] TITLE Vice President, Operations GeoThermal Services, Inc. DATE 10/24/77

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 12/12/77

CONDITIONS OF APPROVAL, IF ANY:

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NEW MEXICO OIL CONSERVATION COMMISSION
P. O. Box 2088, Santa Fe 87501

Form G-103
Adopted 10/1/74

JAN 17 1977
OIL CONSERVATION COMM.
Santa Fe

SUNDRY NOTICES AND REPORTS ON GEOTHERMAL RESOURCES WELLS

5. Indicate Type of Lease: State ☐ Fee ☒
5.a State Lease No.

Do Not Use This Form for Proposals to Drill or to Deepen or Plug Back to a Different Reservoir. Use "Application For Permit —" (Form G-101) for Such Proposals.)

1. Type of well: Geothermal Producer ☐ Temp. Observation ☒ Low-Temp Thermal ☐ Injection/Disposal ☐
7. Unit Agreement Name: None
2. Name of Operator: Sunoco Energy Development Corporation
8. Farm or Lease Name: San Diego Grant
3. Address of Operator: 12700 Park Central Pl., Suite 1500, Dallas, TX 75251
9. Well No.: 9-76-1
4. Location of Well: Unit Letter M, 1200 Feet From The S Line and 200 Feet From The W Line, Section 6 Township 18N. Range 3E. NMPM.
10. Field and Pool, or Wildcat: None
15. Elevation (*Show whether DF, RT, GR, etc.*): 6600' G.L.
12. County: Sandoval

16. Check Appropriate Box To Indicate Nature of Notice, Report or Other Data

NOTICE OF INTENTION TO:				SUBSEQUENT REPORT OF:			
PERFORM REMEDIAL WORK	☐	PLUG AND ABANDON	☐	REMEDIAL WORK	☐	ALTERING CASING	☐
TEMPORARILY ABANDON	☐			COMMENCE DRILLING OPNS.	☒	PLUG & ABANDONMENT	☐
PULL OR ALTER CASING	☐	CHANGE PLANS	☐	CASING TEST AND CEMENT JOB	☐		
OTHER	☐			OTHER			☐

17. Describe Proposed or completed Operations *(Clearly state all pertinent details, and give pertinenet dates, including estimated date of starting any proposed work)* SEE RULE 203.

On 1/4/77 Hole No. 9-76-1 was spudded at 11:00 (AM) PM

The hole was T.D.'d on 1/9/77 @ 95 ' BGL

Trouble - LC - 30'-35'
OK - Inspected

18. I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNED [signature] TITLE Chief Geologist Geothermal Services, Inc. DATE 1/13/78

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 1/18/77

CONDITIONS OF APPROVAL, IF ANY:

Form G-101
Adopted 10/1/74

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U.S.G.S.		
Operator	1	
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NEW MEXICO OIL CONSERVATION COMMISSION

P. O. Box 2088, Santa Fe 87501

APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK---GEOTHERMAL RESOURCES WELL

5. Indicate Type of Lease: STATE ☐ FEE ☒

5.a State Lease No.:

1a. Type of Work: Drill ☒ Deepen ☐ Plug Back ☐

b. Type of Well: Geothermal Producer ☐ Low-Temp Thermal ☐ Temp Observation ☒ Injection/Disposal ☐

7. Unit Agreement Name: none

8. Farm or Lease Name: San Diego Grant

2. Name of Operator: Sunoco Energy Development Corporation

9. Well No.: 9-76-1

3. Address of Operator: 12700 Park Central Pl., Suite 1500, Dallas, TX 75251

10. Field and Pool, or Wildcat: none

4. Location of Well ** UNIT LETTER M LOCATED 1200 FEET FROM THE South LINE AND 200 FEET FROM THE West LINE OF SEC. 6 TWP. 18 N. RGE. 3 E. NMPM

12. County: Sandoval

19. Proposed Depth	19A. Formation	20. Rotary or C.T.
500 ft.	unknown	rotary

21. Elevations (Show whether DF, RT, etc.)	21A. Kind & Status Plug. Bond	21B. Drilling Contractor	22. Approx. Date Work will start
6600 ft. (GL)	see note "A"	Geothermal Services	Oct. 1, 1976

PROPOSED CASING AND CEMENT PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	SACKS OF CEMENT	EST. TOP
5-1/8"	3/4"	1.14 lbs.	500'	1.5	6" BGL

Program- See attached "Standard Shallow Temperature Gradient Hole Drilling Program"

**- All section lines projected

Note A- Type of bond will be $10,000 multiple-well low-temperature well or geothermal observation well bond. The bond is in the process of being filed, and a bond number will be furnished as soon as available before operations commence.

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OIL CONSERVATION COMM.
Santa Fe

Quad 29

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: If proposal is to deepen or plug back, give data on present productive zone and proposed new productive zone. Give blowout preventer program, if any.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

Signed [signature] Title Chief Geologist, Geothermal Services, Inc. Date July 21, 1976

(This space for State Use)

APPROVED BY Carl Uvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 9/9/76

CONDITIONS OF APPROVAL, IF ANY:

GEOTHERMAL SERVICES, INC.
7860 CONVOY COURT, SAN DIEGO, CALIFORNIA 92111 • (714) 565-4712

STANDARD SHALLOW TEMPERATURE GRADIENT HOLE DRILLING PROGRAM
(500'/150m; Rubber Tired Equipment; Rotary/Mud)

1. Coordinate "Special Stipulations" or other unusual requirements with the Project Geologist prior to set-up and spud.

2. Choose location and orientation of drilling rig so as to minimize surface disturbance.

3. Drill 4" to 6" hole to maximum depth of 500'/150m. Take cuttings samples, cores, etc. at direction of Project Geologist.

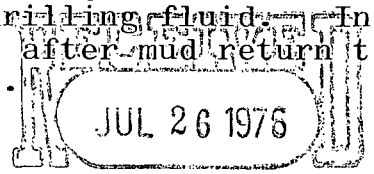
4. If drilling with mud, use regular Bentonite drilling mud. No toxic additives are to be used in drilling fluids without permission of Project Geologist. Have supply of lost circulation material available. Use portable mud pits unless specifically directed otherwise.

5. Have a supply of Barite available in case of artesian flow. If artesian flow is enccountered, comply with United States Geological Survey's Stipulations.

6. Mud return temperature shall be measured and recorded on "Drilling History" every 10'/3m.

   a. If temperature reaches 120°F/50°C, STOP DRILLING and circulate for 30 minutes, monitoring mud temperature and pit volume for possible hot artesian flow. If no flow, run pipe at this depth after logging is completed.

   b. If there is a sudden increase in temperature of the drilling mud (several degrees in only a few feet) STOP DRILLING and circulate for 30 minutes, monitoring mud temperature and pit volume for possible hot artesian flow. If no flow, continue drilling CAUTIOUSLY, keeping a careful watch on return temperature of drilling fluid. In no case shall drilling continue after mud return temperature reaches 120°F/50°C.



7. Run pipe immediately after running electric logs or reaching T.D. (if hole is not logged).

   a. Install cap on bottom of first length of pipe. (If using steel pipe, seal each joint with teflon tape to ensure watertight).

   b. Steel pipe must be used when air temperature is 40°F or below, as PVC cement will not adhere.

   c. Steel pipe must be used if drilling fluid temperature exceeds 100°F/40°C.

   d. When pipe is landed, top must be 6" to 12"/ 15cm to 30cm below ground level. (Cut and thread as necessary).

   e. Fill pipe with CLEAN WATER (water that is oily or contains solvents such as gasoline MUST NOT be used) and install cap. Do not seal.

   f. Set paper, rag or dirt bridge down open annulus at least 10'/3m below ground level. Fill annulus with cement up to base of cap on pipe.

8. Clean up location THOROUGHLY.

9. Any excavated pits or sumps must be backfilled to conform to the original topography.

10. When temperature surveys are completed, fill pipe with cement from 10'/3m to top of pipe, fill excavation to original ground topography and restore location as nearly as possible to original condition.

GEOTHERMAL SERVICES, INC.
San Diego, California
December, 1975

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. BOX 2088 SANTA FE 87501

Form G-102
Adopted 10/1/74

GEOTHERMAL RESOURCES WELL LOCATION AND ACREAGE DEDICATION PLAT

All distances must be from the outer boundaries of the Section.

Operator	Lease	Well No.
Sunoco Energy Development Corp.	San Diego Grant	9-76-1

Unit Letter	Section	Township	Range	County
M	6	18 N.	3 E.	Sandoval

Actual Footage Location of Well:
1200 feet from the projected S. line and 200 feet from the W. line (projected)

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
6600 ft.	none	none	none Acres

1. Outline the acreage dedicated to the subject well by colored pencil or hachure marks on the plat below.

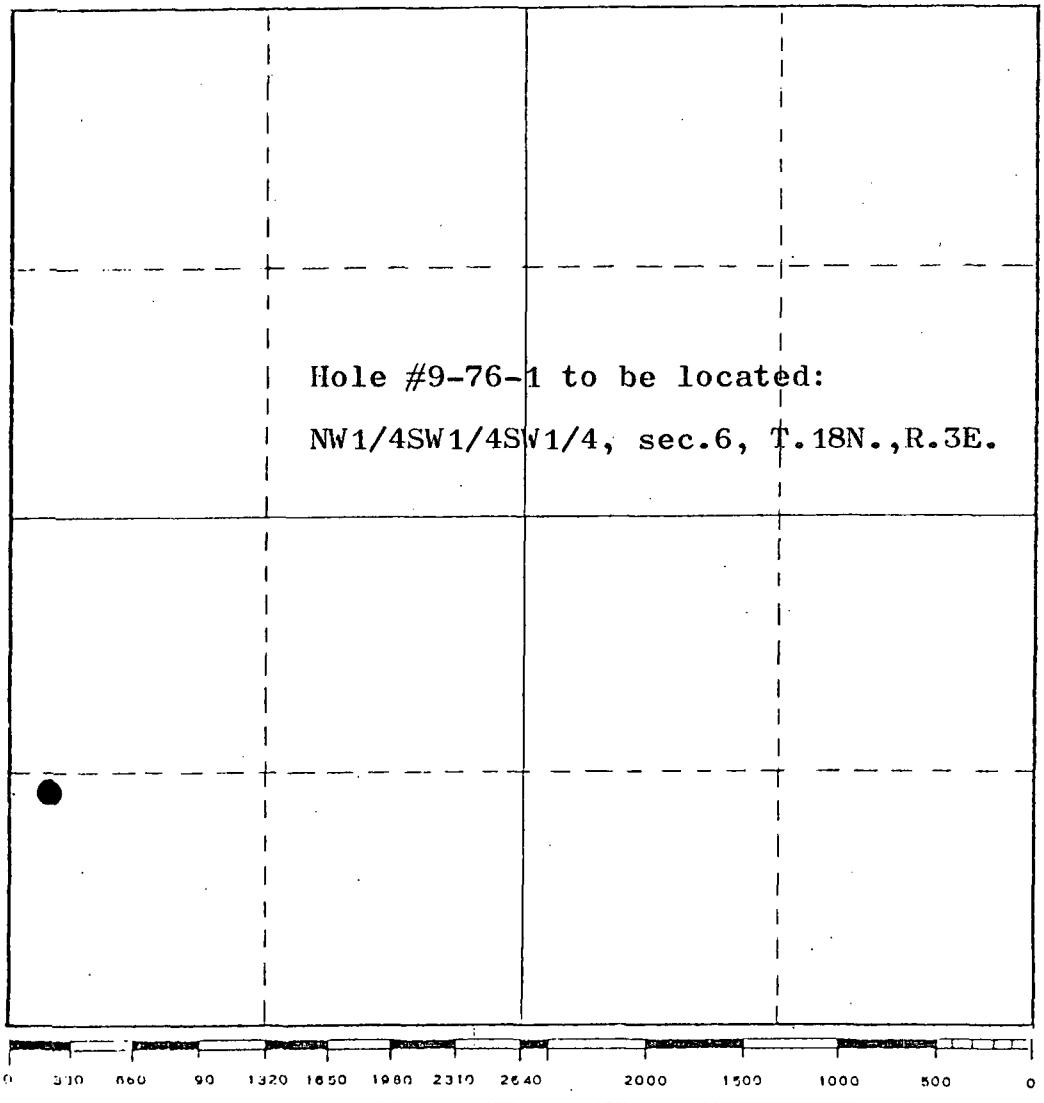
2. If more than one lease is dedicated to the well, outline each and identify the ownership thereof (both as to working interest and royalty).

3. If more than one lease of different ownersip is dedicated to the well, have the interests of all owners been consolidated by communitization, unitization, force-pooling, etc?

☐ Yes ☐ No If answer is "yes," type of consolidation _____

If answer is "no," list the owners and tract descriptions which have actually been consolidated. (Use reverse side of this form if necessary.) _____

No allowable will be assigned to the well until all interests have been consolidated (by communitization, unitization, forced-pooling, or otherwise) or until a non-standard unit, eliminating such interests, has been approved by the Commission.



CERTIFICATION

I hereby certify that the information contained herein is true and complete to the best of my knowledge and belief.

Name: Steve Quiett

Position: Chief Geologist

Company: Geothermal Services, Inc.

Date: July 21, 1976

I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

RECEIVED JUL 26 1976 OIL CONSERVATION COMM. Santa Fe

Date Surveyed

Registered Professional Engineer and/or Land Surveyor

Certificate No.

Form G-101
Adopted 10/1/

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NEW MEXICO OIL CONSERVATION COMMISSION

P. O. Box 2088, Santa Fe 87501

APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK---GEOTHERMAL RESOURCES WELL

5. Indicate Type of Lease: STATE ☐ FEE ☒

5.a State Lease No.:

1a. Type of Work: Drill ☒ Deepen ☐ Plug Back ☐

b. Type of Well: Geothermal Producer ☐ Low-Temp Thermal ☐ Temp Observation ☒ Injection/Disposal ☐

7. Unit Agreement Name: none

8. Farm or Lease Name: San Diego Grant

2. Name of Operator: Sunoco Energy Development Corporation

9. Well No.: 9-76-1

3. Address of Operator: 12700 Park Central Pl., Suite 1500, Dallas, TX 75251

10. Field and Pool, or Wildcat: none

4. Location of Well ** UNIT LETTER M LOCATED 1200 FEET FROM THE South LINE AND 200 FEET FROM THE West LINE OF SEC. 6 TWP. 18 N. RGE. 3 E. NMPM

12. County: Sandoval

19. Proposed Depth	19A. Formation	20. Rotary or C.T.
500 ft.	unknown	rotary

21. Elevations (Show whether DF, RT, etc.)	21A. Kind & Status Plug. Bond	21B. Drilling Contractor	22. Approx. Date Work will start
6600 ft. (GL)	see note "A"	Geothermal Services	Oct. 1, 1976

PROPOSED CASING AND CEMENT PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	SACKS OF CEMENT	EST. TOP
5-1/8"	3/4"	1.14 lbs.	500'	1.5	6" BGL

Program- See attached "Standard Shallow Temperature Gradient Hole Drilling Program"

**- All section lines projected

Note A- Type of bond will be $10,000 multiple-well low-temperature well or geothermal observation well bond. The bond is in the process of being filed, and a bond number will be furnished as soon as available before operations commence.

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Santa Fe

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: If proposal is to deepen or plug back, give data on present productive zone and proposed new productive zone. Give blowout preventer program, if any.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

Signed [signature] Title Chief Geologist, Geothermal Services, Inc. Date July 21, 1976

(This space for State Use)

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 9/9/76

CONDITIONS OF APPROVAL, IF ANY:

GEOTHERMAL SERVICES, INC.
7860 CONVOY COURT, SAN DIEGO, CALIFORNIA 92111 • (714) 565-4712

STANDARD SHALLOW TEMPERATURE GRADIENT HOLE DRILLING PROGRAM
(500'/150m; Rubber Tired Equipment; Rotary/Mud)

1. Coordinate "Special Stipulations" or other unusual requirements with the Project Geologist prior to set-up and spud.

2. Choose location and orientation of drilling rig so as to minimize surface disturbance.

3. Drill 4" to 6" hole to maximum depth of 500'/150m. Take cuttings samples, cores, etc. at direction of Project Geologist.

4. If drilling with mud, use regular Bentonite drilling mud. No toxic additives are to be used in drilling fluids without permission of Project Geologist. Have supply of lost circulation material available. Use portable mud pits unless specifically directed otherwise.

5. Have a supply of Barite available in case of artesian flow. If artesian flow is encountered, comply with United States Geological Survey's Stipulations.

6. Mud return temperature shall be measured and recorded on "Drilling History" every 10'/3m.

   a. If temperature reaches 120°F/50°C, STOP DRILLING and circulate for 30 minutes, monitoring mud temperature and pit volume for possible hot artesian flow. If no flow, run pipe at this depth after logging is completed.

   b. If there is a sudden increase in temperature of the drilling mud (several degrees in only a few feet) STOP DRILLING and circulate for 30 minutes, monitoring mud temperature and pit volume for possible hot artesian flow. If no flow, continue drilling CAUTIOUSLY, keeping a careful watch on return temperature of drilling fluid. In no case shall drilling continue after mud return temperature reaches 120°F/50°C.

7. Run pipe immediately after running electric logs or reaching T.D. (if hole is not logged).

   a. Install cap on bottom of first length of pipe. (If using steel pipe, seal each joint with teflon tape to ensure watertight).

   b. Steel pipe must be used when air temperature is 40°F or below, as PVC cement will not adhere.

   c. Steel pipe must be used if drilling fluid temperature exceeds 100°F/40°C.

   d. When pipe is landed, top must be 6" to 12"/ 15cm to 30cm below ground level. (Cut and thread as necessary).

   e. Fill pipe with CLEAN WATER (water that is oily or contains solvents such as gasoline MUST NOT be used) and install cap. Do not seal.

   f. Set paper, rag or dirt bridge down open annulus at least 10'/3m below ground level. Fill annulus with cement up to base of cap on pipe.

8. Clean up location THOROUGHLY.

9. Any excavated pits or sumps must be backfilled to conform to the original topography.

10. When temperature surveys are completed, fill pipe with cement from 10'/3m to top of pipe, fill excavation to original ground topography and restore location as nearly as possible to original condition.

GEOTHERMAL SERVICES, INC.
San Diego, California
December, 1975

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. BOX 2088 SANTA FE 87501

Form G-102
Adopted 10/1/74

GEOTHERMAL RESOURCES WELL LOCATION AND ACREAGE DEDICATION PLAT

All distances must be from the outer boundaries of the Section.

Operator	Lease	Well No.
Sunoco Energy Development Corp.	San Diego Grant	9-76-1

Unit Letter	Section	Township	Range	County
M	6	18 N.	3 E.	Sandoval

Actual Footage Location of Well:
1200 feet from the projected S. line and 200 feet from the W. line (projected)

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
6600 ft.	none	none	none Acres

1. Outline the acreage dedicated to the subject well by colored pencil or hachure marks on the plat below.

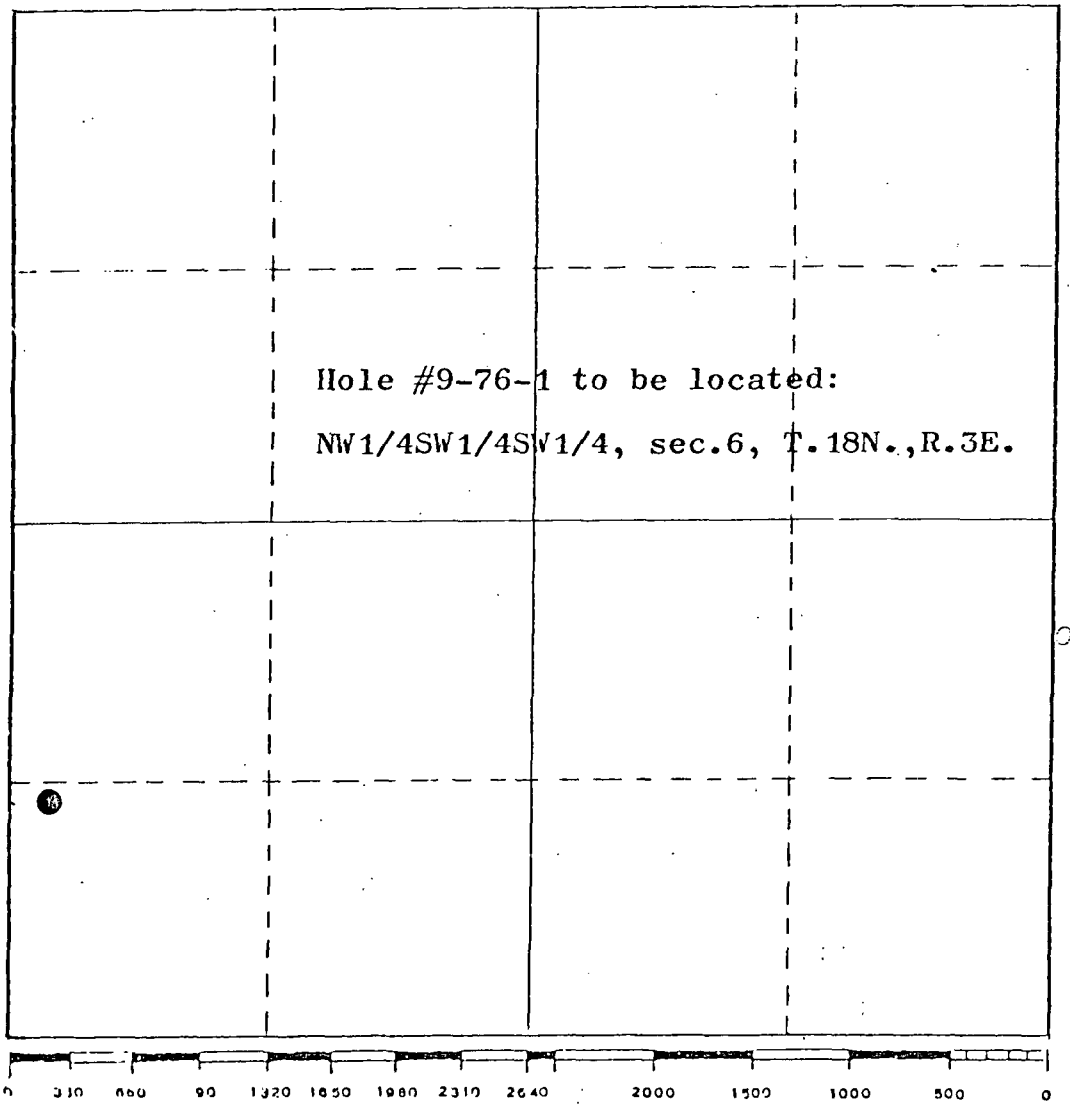
2. If more than one lease is dedicated to the well, outline each and identify the ownership thereof (both as to working interest and royalty).

3. If more than one lease of different ownersip is dedicated to the well, have the interests of all owners been consolidated by communitization, unitization, force-pooling, etc?

☐ Yes ☐ No If answer is "yes," type of consolidation _____

If answer is "no," list the owners and tract descriptions which have actually been consolidated. (Use reverse side of this form if necessary.) _____

No allowable will be assigned to the well until all interests have been consolidated (by communitization, unitization, forced-pooling, or otherwise) or until a non-standard unit, eliminating such interests, has been approved by the Commission.



CERTIFICATION

I hereby certify that the information contained herein is true and complete to the best of my knowledge and belief.

Name: Steve Quiett

Position: Chief Geologist

Company: Geothermal Services, Inc.

Date: July 21, 1976

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OIL CONSERVATION COMM.
Santa Fe

I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

Date Surveyed

Registered Professional Engineer and/or Land Surveyor

Certificate No.

Form G-103
Adopted 10/1/74

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Operator	1	
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NEW MEXICO OIL CONSERVATION COMMISSION
P. O. Box 2088, Santa Fe 87501

SEP 18 19??

SUNDRY NOTICES AND REPORTS ON GEOTHERMAL RESOURCES WELLS

5. Indicate Type of Lease: State ☐ Fee ☒
5.a State Lease No.:

Do Not Use This Form for Proposals to Drill or to Deepen or Plug Back to a Different Reservoir. Use "Application For Permit —" (Form G-101) for Such Proposals.)

1. Type of well: Geothermal Producer ☐ Temp. Observation ☒ Low-Temp Thermal ☐ Injection/Disposal ☐
7. Unit Agreement Name: NONE
2. Name of Operator: SUNOCO ENERGY DEVELOPMENT CORPORATION
8. Farm or Lease Name: SAN DIEGO GRANT
3. Address of Operator: 12700 PARK CENTRAL PL., STE. 1500, DALLAS, TX 75251
9. Well No.: 2
4. Location of Well: Unit Letter P 100 Feet From The EAST Line and 300 Feet From The S Line, Section 7 Township 18N Range 3E NMPM.
10. Field and Pool, or Wildcat: NONE
15. Elevation *(Show whether DF, RT, GR, etc.)*: 8100 (G.L.)
12. County: SANDOVAL

16. Check Appropriate Box To Indicate Nature of Notice, Report or Other Data

NOTICE OF INTENTION TO:		SUBSEQUENT REPORT OF:	
PERFORM REMEDIAL WORK ☐	PLUG AND ABANDON ☒	REMEDIAL WORK ☐	ALTERING CASING ☐
TEMPORARILY ABANDON ☐		COMMENCE DRILLING OPNS. ☐	PLUG & ABANDONMENT ☐
PULL OR ALTER CASING ☐	CHANGE PLANS ☐	CASING TEST AND CEMENT JOB ☐	
OTHER ☐		OTHER ☐	

17. Describe Proposed or completed Operations *(Clearly state all pertinent details, and give pertinenet dates, including estimated date of starting any proposed work)* SEE RULE 203.

This hole was abandoned by: a) cutting off the 13/4" pipe below ground level; b) cementing the top 10' of the pipe and annulus; c) covering the hole with soil and; d) restoring the site as nearly as possible to its original condition.

18. I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNED Barry R. Williams TITLE PROJECT SUPERVISOR GEOTHERMAL SERVICES, INC. DATE 9/10/78

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 9/20/78

CONDITIONS OF APPROVAL, IF ANY:

Form G-101
Adopted 10/1/7

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U.S.G.S.	1	
Operator	1	
Land Office		
BLM	1	

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P. O. Box 2088, Santa Fe 87501

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APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK---GEOTHERMAL RESOURCES WELL

5. Indicate Type of Lease: STATE ☐ FEE ☒
5.a State Lease No.

1a. Type of Work: Drill ☒ Deepen ☐ Plug Back ☐

b. Type of Well: Geothermal Producer ☐ Low-Temp Thermal ☐ Temp Observation ☒ Injection/Disposal ☐

7. Unit Agreement Name: None

8. Farm or Lease Name: San Diego Grant

2. Name of Operator: SUNOCO ENERGY DEVELOPMENT CORPORATION

9. Well No.: 3-77-2

3. Address of Operator: 12700 Park Central Pl., Suite 1500, Dallas, TX 75251

10. Field and Pool, or Wildcat: None

4. Location of Well ** UNIT LETTER P LOCATED 100 FEET FROM THE East LINE AND 300 FEET FROM THE S LINE OF SEC. 7 TWP. 18N RGE. 3E NMPM

projected

12. County: Sandoval

19. Proposed Depth	19A. Formation	20. Rotary or C.T.
500 ft.	unknown	rotary

21. Elevations (Show whether DF, RT, etc.)	21A. Kind & Status Plug. Bond	21B. Drilling Contractor	22. Approx. Date Work will start
8100' (GL)	see note "A"	Geothermal Services	June 15, 1977

PROPOSED CASING AND CEMENT PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	SACKS OF CEMENT	EST. TOP
5-1/8"	3/4"	1.14 lbs.	500'	1.5	6" BGL

Program- See attached "Standard Shallow Temperature Gradient Hole Drilling Program"

**- All section lines projected

Note A- Type of bond will be $10,000 multiple-well low-temperature well or geothermal observation well bond. The bond is in the process of being filed, and a bond number will be furnished as soon as available before operations commence.

Active - 12/12

APPROVAL VALID FOR 90 DAYS UNLESS DRILLING COMMENCED.

EXPIRES 8/11/77

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: If proposal is to deepen or plug back, give data on present productive zone and proposed new productive zone. Give blowout preventer program, if any.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

Signed [signature] Title Chief Geologist, Geothermal Services, Inc. Date April 26, 1977

(This space for State Use)

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 5/13/77

CONDITIONS OF APPROVAL, IF ANY:

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. BOX 2088 SANTA FE 87501

Form G-102
Adopted 10/1/74

GEOTHERMAL RESOURCES WELL LOCATION AND ACREAGE DEDICATION PLAT

All distances must be from the outer boundaries of the Section.

Operator	Lease	Well No.
Sunoco Energy Development Corp.	San Diego Grant	3-77-2

Unit Letter	Section	Township	Range	County
P	7	18N	3E	Sandoval

Actual Footage Location of Well:
100 feet from the projected E line and 300 feet from the S line (projected)

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
8100'	None	None	None Acres

1. Outline the acreage dedicated to the subject well by colored pencil or hachure marks on the plat below.

2. If more than one lease is dedicated to the well, outline each and identify the ownership thereof (both as to working interest and royalty).

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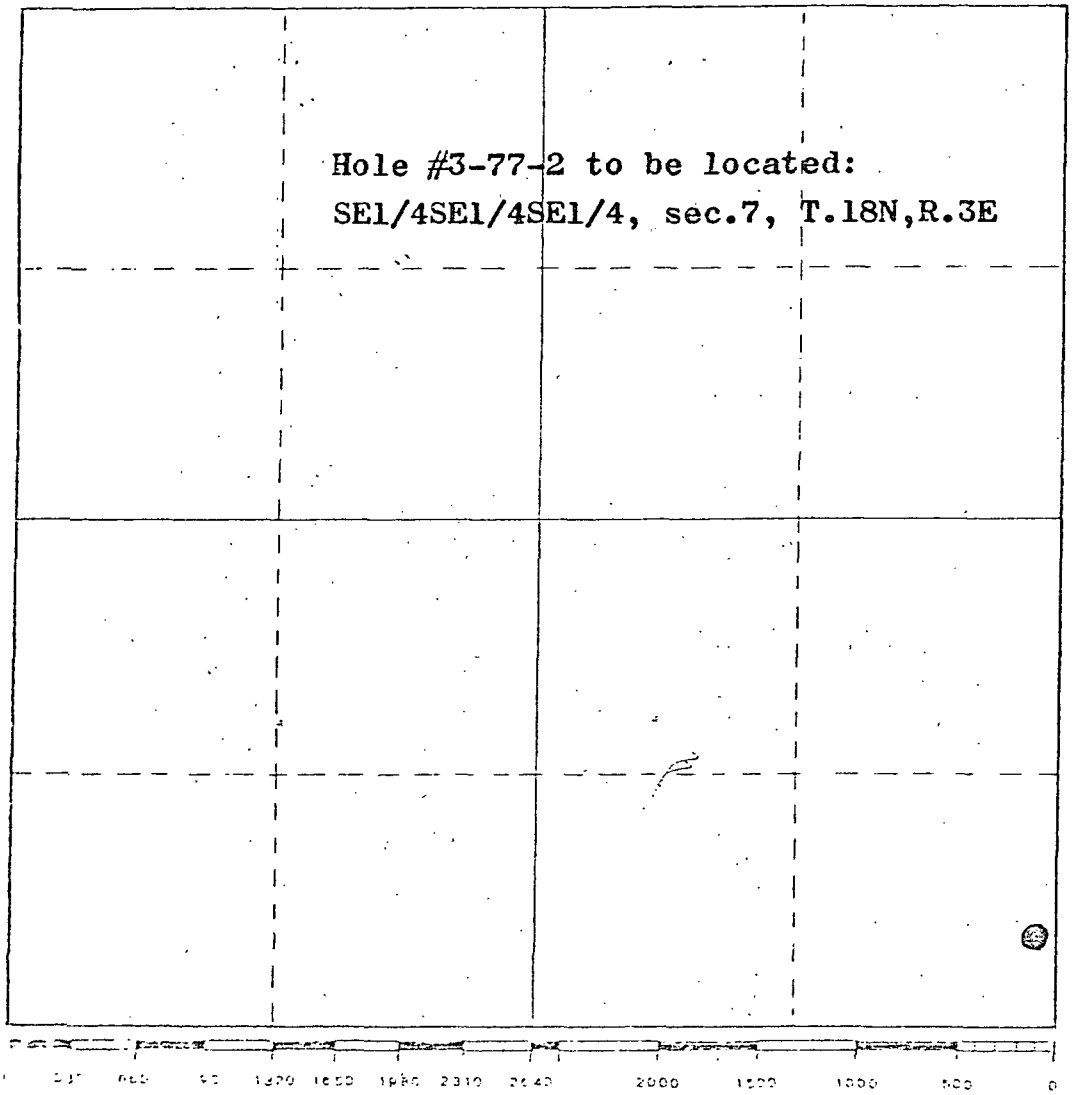

CERTIFICATION

I hereby certify that the information contained herein is true and complete to the best of my knowledge and belief.

Name: Steve Quiett

Position: Chief Geologist

Company: Geothermal Services, Inc.

Date: April 26, 1977

I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

Date Surveyed

Registered Professional Engineer and/or Land Surveyor

Certificate No.

GEOTHERMAL SERVICES, INC.
7860 CONVOY COURT, SAN DIEGO, CALIFORNIA 92111 • (714) 565-4712

STANDARD SHALLOW TEMPERATURE GRADIENT HOLE DRILLING PROGRAM
(500'/150m; Rubber Tired Equipment; Rotary/Mud)

1. Coordinate "Special Stipulations" or other unusual requirements with the Project Geologist prior to set-up and spud.

2. Choose location and orientation of drilling rig so as to minimize surface disturbance.

3. Drill 4" to 6" hole to maximum depth of 500'/150m. Take cuttings samples, cores, etc. at direction of Project Geologist.

4. If drilling with mud, use regular Bentonite drilling mud. No toxic additives are to be used in drilling fluids without permission of Project Geologist. Have supply of lost circulation material available. Use portable mud pits unless specifically directed otherwise.

5. Have a supply of Barite available in case of artesian flow. If artesian flow is encountered, comply with United States Geological Survey's Stipulations.

6. Mud return temperature shall be measured and recorded on "Drilling History" every 10'/3m.

    a. If temperature reaches 120°F/50°C, STOP DRILLING and circulate for 30 minutes, monitoring mud temperature and pit volume for possible hot artesian flow. If no flow, run pipe at this depth after logging is completed.

    b. If there is a sudden increase in temperature of the drilling mud (several degrees in only a few feet) STOP DRILLING and circulate for 30 minutes, monitoring mud temperature and pit volume for possible hot artesian flow. If no flow, continue drilling CAUTIOUSLY, keeping a careful watch on return temperature of drilling fluid. In no case shall drilling continue after mud return temperature reaches 120°F/50°C.

7. Run pipe immediately after running electric logs or reaching T.D. (if hole is not logged).

   a. Install cap on bottom of first length of pipe. (If using steel pipe, seal each joint with teflon tape to ensure watertight).

   b. Steel pipe must be used when air temperature is 40°F or below, as PVC cement will not adhere.

   c. Steel pipe must be used if drilling fluid temperature exceeds 100°F/40°C.

   d. When pipe is landed, top must be 6" to 12"/ 15cm to 30cm below ground level. (Cut and thread as necessary).

   e. Fill pipe with CLEAN WATER (water that is oily or contains solvents such as gasoline MUST NOT be used) and install cap. Do not seal.

   f. Set paper, rag or dirt bridge down open annulus at least 10'/3m below ground level. Fill annulus with cement up to base of cap on pipe.

8. Clean up location THOROUGHLY.

9. Any excavated pits or sumps must be backfilled to conform to the original topography.

10. When temperature surveys are completed, fill pipe with cement from 10'/3m to top of pipe, fill excavation to original ground topography and restore location as nearly as possible to original condition.

GEOTHERMAL SERVICES, INC.
San Diego, California
December, 1975

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT

OIL CONSERVATION DIVISION

P. O. BOX 2088
SANTA FE, NEW MEXICO 87501

Form G-103
Adopted 10-1-74
Revised 10-1-78

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SANTA FE

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SUNDRY NOTICES AND REPORTS ON GEOTHERMAL RESOURCES WELLS

5. Indicate Type of Lease: State ☐ Fee ☒
6. State Lease No.

Do Not Use This Form for Proposals to Drill or to Deepen or Plug Back to a Different Reservoir. Use "Application For Permit —" (Form G-101) for Such Proposals.)

1. Type of well: Geothermal Producer ☒ Temp. Observation ☐ Low-Temp Thermal ☐ Injection/Disposal ☐
7. Unit Agreement Name: N/A
2. Name of Operator: Sunoco Energy Development Co.
8. Farm or Lease Name: #800323 A. E. Thomas et al.
3. Address of Operator: 12700 Park Central Place, Suite 1500, Dallas, Texas 75251
9. Well No.: 4
4. Location of Well: Unit Letter A 250 Feet From The North Line and 860 Feet From The East Line, Section 18 Township 18N Range 3E NMPM.
10. Field and Pool, or Wildcat: Wildcat
15. Elevation (Show whether DF, RT, GR, etc.): 8,012.30 GR
12. County: Sandoval

16. Check Appropriate Box To Indicate Nature of Notice, Report or Other Data

NOTICE OF INTENTION TO:		SUBSEQUENT REPORT OF:	
PERFORM REMEDIAL WORK ☐	PLUG AND ABANDON ☐	REMEDIAL WORK ☐	ALTERING CASING ☐
TEMPORARILY ABANDON ☐		COMMENCE DRILLING OPNS. ☐	PLUG & ABANDONMENT ☐
PULL OR ALTER CASING ☐	CHANGE PLANS ☐	CASING TEST AND CEMENT JOB ☐	
OTHER Drill ☒		OTHER ☐	

17. Describe Proposed or completed Operations (*Clearly state all pertinent details, and give pertinenet dates, including estimated date of starting any proposed work*) SEE RULE 203.

1. Request six-month extension and application for permit to drill due to delay of approval from U. S. Forest Service.

2. Request name change from "San Diego Grant #4" to "A. E. Thomas et al. #4."

APPROVAL VALID FOR 197 DAYS
PERMIT EXPIRES 2-16-82
UNLESS DRILLING UNDERWAY

Extension
APPROVAL VALID FOR 250 DAYS
PERMIT EXPIRES 10-24-82
UNLESS DRILLING UNDERWAY
C.L.

18. I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNED John F. Williamson TITLE Environmental Coordinator DATE July 27, 1981

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 7/30/81

CONDITIONS OF APPROVAL, IF ANY:

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT

OIL CONSERVATION DIVISION

P. O. BOX 2088
SANTA FE, NEW MEXICO 87501

Form G-103
Adopted 10-1-74
Revised 10-1-78

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SUNDRY NOTICES AND REPORTS ON GEOTHERMAL RESOURCES WELLS

5. Indicate Type of Lease: State ☐ Fee ☒
6. State Lease No.

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1. Type of well: Geothermal Producer ☒ Temp. Observation ☐ Low-Temp Thermal ☐ Injection/Disposal ☐
7. Unit Agreement Name: N/A
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SIGNED John F. Williams Jr. TITLE Environmental Coordinator DATE July 27, 1981

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 7/30/81

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NEW MEXICO OIL CONSERVATION COMMISSION
P. O. Box 2088, Santa Fe 87501

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SANTA FE

Form G-101
Adopted 10/1/74

APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK--GEOTHERMAL RESOURCES WELL

5. Indicate Type of Lease: STATE ☐ FEE ☒

5.a State Lease No.:

1a. Type of Work: Drill ☒ Deepen ☐ Plug Back ☐

b. Type of Well: Geothermal Producer ☒ Temp Observation ☐ Low-Temp Thermal ☐ Injection/Disposal ☐

7. Unit Agreement Name: NA

8. Farm or Lease Name: #800323 San Diego Grant

2. Name of Operator: Sunoco Energy Development Co.

9. Well No.: 4

3. Address of Operator: 12700 Park Central Place, Suite 1500, Dallas, Texas 75251

10. Field and Pool, or Wildcat: Wildcat

4. Location of Well: UNIT LETTER A LOCATED 250 FEET FROM THE North LINE AND 860 FEET FROM THE East LINE OF SEC. 18 TWP. 18N RGE. 3E NMPM

12. County: Sandoval

19. Proposed Depth	19A. Formation	20. Rotary or C.T.
9,000'	Precambrian	Rotary

21. Elevations (Show whether DF, RT, etc.)	21A. Kind & Status Plug. Bond	21B. Drilling Contractor	22. Approx. Date Work will start
8012.30 ground		Not yet determined	June 1, 1981

PROPOSED CASING AND CEMENT PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	SACKS OF CEMENT	EST. TOP
26"	20"	94	300'	590	Surface
17 1/2"	13 3/8"	61	2,000'	1,280	Surface
12 1/4"	9 5/8"	40 - 43 1/2	6,000'	1,275	1,800'
8 3/4"	Open hole or 7" slotted liner		9,000'		

Plan of operation on file in Oil Conservation Commission office.

APPROVAL VALID FOR 90 DAYS
PERMIT EXPIRES 8-16-81
UNLESS DRILLING UNDERWAY

OIL CONSERVATION COMMISSION TO BE NOTIFIED WITHIN 24 HOURS OF BEGINNING OPERATIONS

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: If proposal is to deepen or plug back, give data on present productive zone and proposed new productive zone. Give blowout preventer program, if any.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

Signed Wayne E. Christian Title Manager, Environmental Affairs Date May 12, 1981

(This space for State Use)

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 5/18/81

CONDITIONS OF APPROVAL, IF ANY:

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. BOX 2088 SANTA FE 87501

Form G-102
Revised 10/1/74

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SANTA FE

GEOTHERMAL RESOURCES WELL LOCATION AND ACREAGE DEDICATION PLAT

All distances must be from the outer boundaries of the Section.

Operator	Lease	
Sunoco Energy Development Co.	#800323 San Diego Grant	4

it Letter	Section	Township	Range	County
A	18	18N	3E	Sandoval

Actual Footage Location of Well:
250' FNL 860' FEL (NW1/4 NE1/4 NE1/4) all projections onto the Canon de San

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
8012.30	Precambrian	Diego Grant	40 Acres

1. Outline the acreage dedicated to the subject well by colored pencil or hachure marks on the plat below.

2. If more than one lease is dedicated to the well, outline each and identify the ownership thereof (both as to working interest and royalty).

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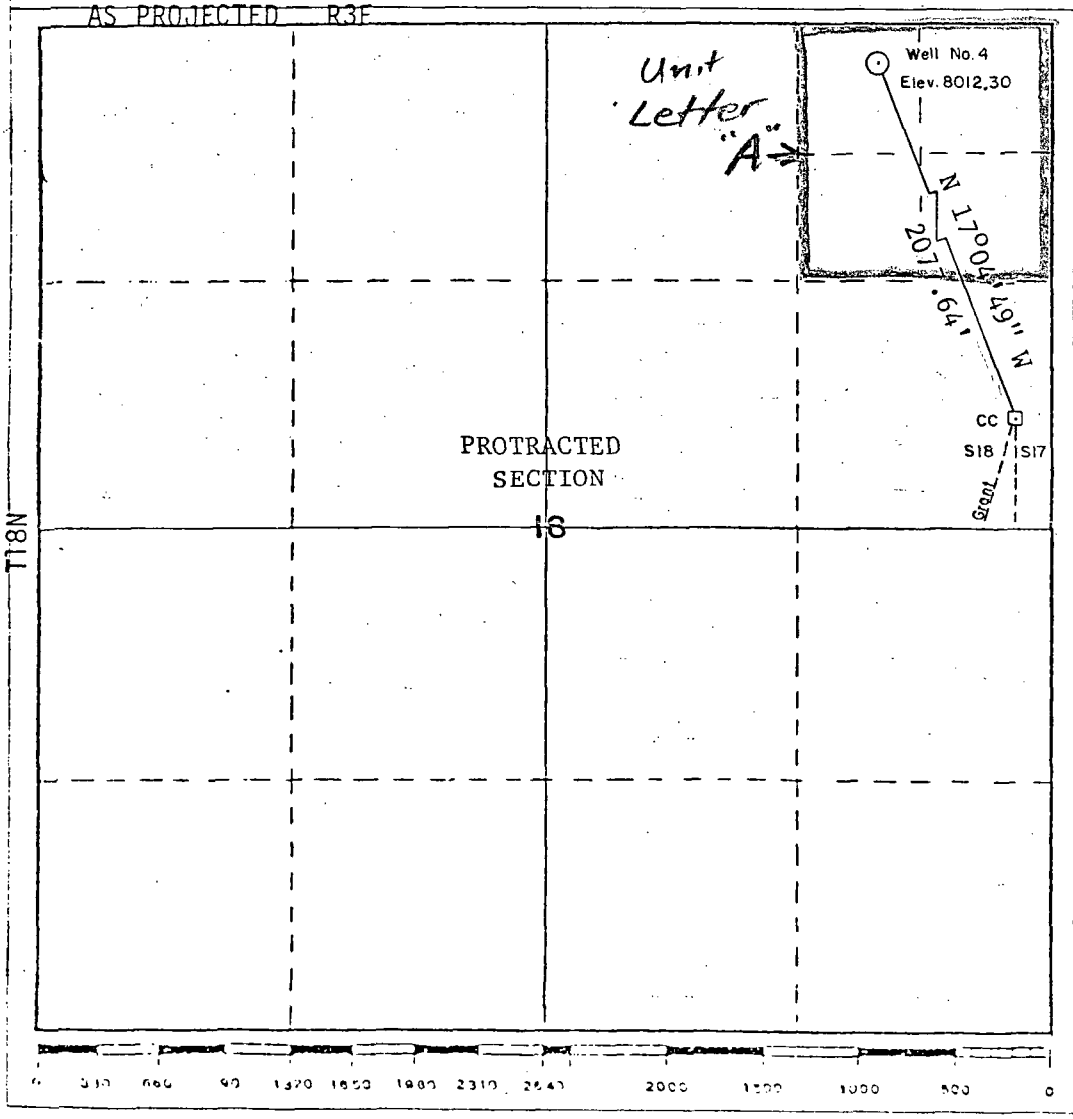

CERTIFICATION

I hereby certify that the information contained herein is true and complete to the best of my knowledge and belief.

Name: Wayne G. Christian

Position: Mgr., Environmental Affairs

Company: Sunoco Energy Development Co.

Date: May 12, 1981

I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

KG FREDERICK SURVEYING
No. 4995
DOUGLAS FREDERICK STERCK
STATE OF NEW MEXICO

Date Surveyed: August 8+9, 1979

Registered Professional Engineer and/or Land Surveyor: Douglas F. Sterck

Certificate No. N.M.L.S. # 4995

Form G-101
Adopted 10/1/7-

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Operator		
Land Office		

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. Box 2088, Santa Fe 87501

APPLICATION FOR PERMIT TO DRILL, ~~DEEPEN~~ OR ~~PLUG BACK~~ --GEOTHERMAL RESOURCES WELL

5. Indicate Type of Lease STATE ☐ FEE ☒
5.a State Lease No.

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b. Type of Well: Geothermal Producer ☒ Low-Temp Thermal ☐ Temp Observation ☐ Injection/Disposal ☐

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Signed Wayne E. Christian Title Manager, Environmental Affairs Date May 12, 1981

(This space for State Use)

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 5/18/81

CONDITIONS OF APPROVAL, IF ANY:

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. BOX 2088 SANTA FE 87501

Form C-102
Adopted 10/1/74

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SANTA FE

GEOTHERMAL RESOURCES WELL LOCATION AND ACREAGE DEDICATION PLAT

All distances must be from the outer boundaries of the Section.

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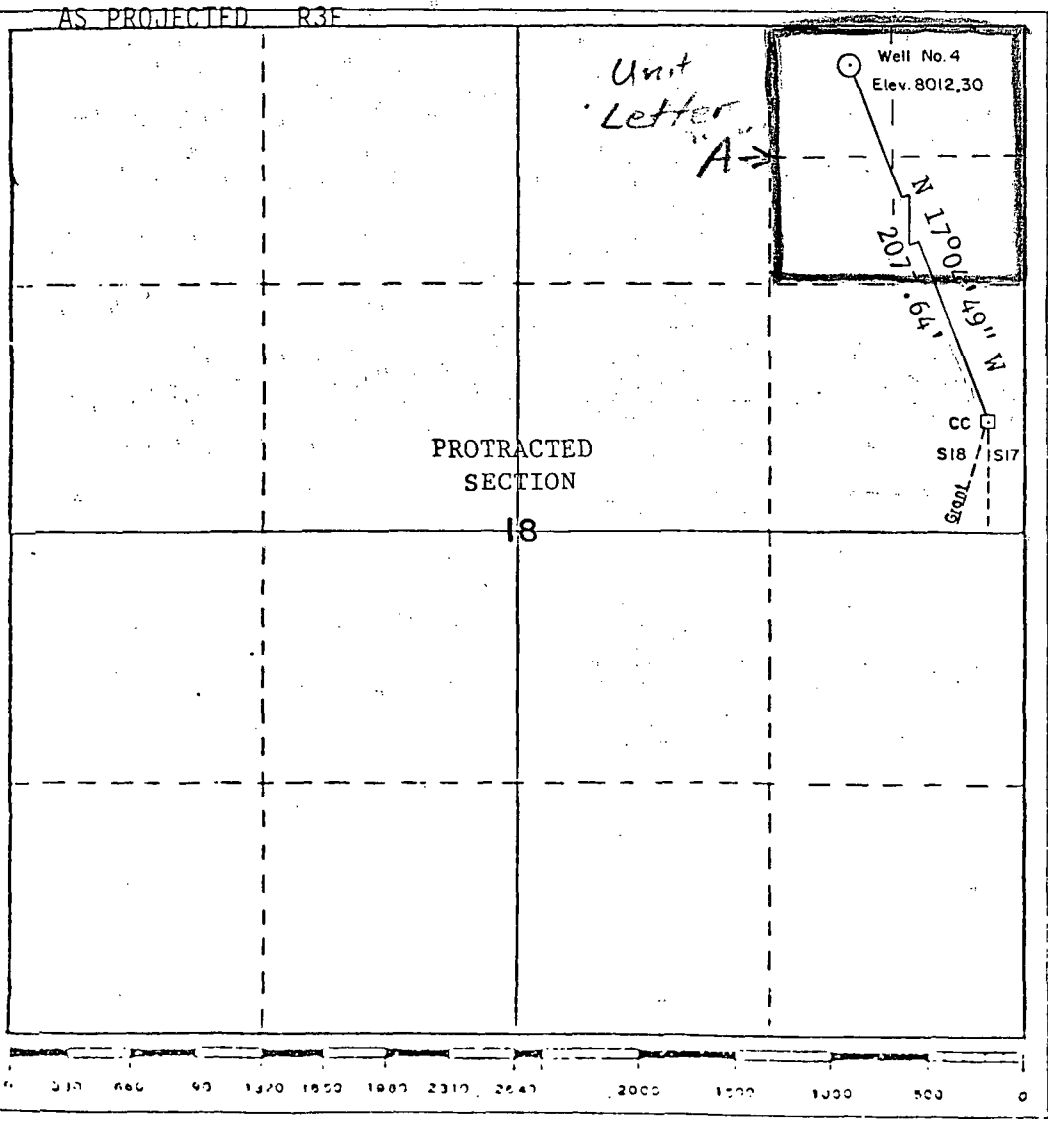

CERTIFICATION

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Name: Wayne R. Christian

Position: Mgr., Environmental Affairs

Company: Sunoco Energy Development Co.

Date: May 12, 1981

I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

REGISTERED LAND SURVEYOR
NO. 4995
DOUGLAS FREDERICK STERCK
STATE OF NEW MEXICO

Date Surveyed: August 8+9, 1979

Registered Professional Engineer and/or Land Surveyor: Douglas F. Sterck

Certificate No. N.M.L.S. # 4995

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT
OIL CONSERVATION DIVISION

BRUCE KING
GOVERNOR

LARRY KEHOE
SECRETARY

June 3, 1981

POST OFFICE BOX 2088
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO 87501
(505) 827-2434

Sunoco Energy Development Co.
12700 Park Central Place
Box 9, Suite 1500
Dallas, Texas 75251

Re: $10,000 Multiple-Well Geothermal Exploratory Bond, Sunoco Energy Development Co., Principal
Federal Insurance Company, Surety, Bond No. 8089-80-83

Gentlemen:

The Oil Conservation Division hereby approves the above-referenced geothermal bond effective June 2, 1981.

Sincerely,

JOE D. RAMEY,
Director

dr/

cc: Carl Ulvog-Oil Conservation Division - Santa Fe

Federal Insurance Company
Marsh & McLennan, Inc.
P. O. Box 26593
Albuquerque, New Mexico 87125

PLAN OF OPERATIONS

San Diego Grant

Geothermal Project

Jemez Springs, New Mexico

Sunoco Energy Development Company

March 9, 1979

385-5005

SUNOCO ENERGY DEVELOPMENT CO. 12700 PARK CENTRAL PL., BOX 9, SUITE 1500, DALLAS, TEX. 75251 (214) ~~263-2600~~

March 13, 1979

Mr. Carl Ulvog
Oil and Gas Commission
State Land Office Building
Santa Fe, New Mexico 87501

Dear Mr. Ulvog:

Sunoco Energy Development Company is proposing to initiate exploratory drilling for geothermal resources in the San Diego Grant Area near Jemez Springs, New Mexico this summer. Sunedco's "Plan of Operations" for that program was submitted to Charles E. McGlothlin, Jemez District Ranger, U.S. Forest Service, on March 9.

For your information, a copy of that plan is attached. If you need additional information, please let me know.

Sincerely,

Wayne G. Christian
Manager
Environmental Affairs

WGC/bjw

Attachment

cc: Charles E. McGlothlin
W. L. Parchman

SUNOCO ENERGY DEVELOPMENT CO. 12700 PARK CENTRAL PL., BOX 9, SUITE 1500, DALLAS, TEX. 75251 (214) 233-2600

March 9, 1979

Mr. Charles E. McGlothlin
Jemez District Ranger
United States Department of Agriculture
Forest Service
Box 98
Jemez Springs, New Mexico 87025

Dear Mr. McGlothlin:

In response to your January 31st letter and subsequent telephone conversations, SUNEDCO wishes to submit the following "Plan of Operations" (in triplicate) for geothermal exploratory drilling in the San Diego Grant area near Jemez Springs. These data are being presented to meet requirements set forth by the U. S. Department of Agriculture, CFR 36, Chapter II, Section 251.15, and the Geothermal Steam Act of 1970. We trust this document will provide the information you need as you prepare the required environmental assessment of the area.

SUNEDCO proposes to utilize existing roads and trails when possible and plans to build only essential access roads to the sites. Those proposed road segments are shown on the accompanying map. For geologic reasons, wells numbered 2 and 4 should be drilled first; but since archaeological clearance has been secured only for sites 1 and 2, that means site 2 may have to be drilled first. (If archaeological clearance is obtained in time, site 4 may still be drilled first.) Approximately 2,700 feet of new road will be needed from the existing trails to both well sites 2 and 4. As soon as the area is free of snow, SUNEDCO personnel will visit the area to discuss the road situation with you and decide upon a course of action. The details of surveying and engineering design of such roads will be done by a registered engineer who will consult with you concerning forest service requirements.

Plans call for water for drilling and other uses to be obtained from the Madera formation in the Jemez River Valley and piped to the drilling sites. (Estimated requirements will be 20 gpm.) A steel tank at the site will provide sufficient reserve for times when the pipeline may not be functioning.

Present plans call for drilling operations on sites 2 or 4 to start in late May or early June, depending upon rig availability; if not then, no later than the last of July or early August.

PLAN OF OPERATIONS

San Diego Grant

Geothermal Project

Jemez Springs, New Mexico

Sunoco Energy Development Company

March 9, 1979

The general dimensions of each single well drill pad will be approximately 250 feet by 250 feet. If in the future a multiple well program is developed from a single site, the pad size will need to be expanded to approximately 350 feet by 350 feet (2.83 acres). For a typical well pad layout, see the attached sketch.

A recommendation for archaeological clearance for proposed well sites 1 and 2 has been received from Dr. Meade F. Kemrer of the San Juan County Archaeological Research Center and Library. His report is in Appendix D. Please note that snow prevented study of other sites in the fall of 1978. Dr. Kemrer is to complete his survey as soon as field conditions permit this spring.

Earlier communications contained information regarding work force and certain socioeconomic factors; therefore, that information is not given here. Our plan of operations covers, basically:

Methods of Handling Wastes
Proposed Methods To Protect Environment
Drilling Operations
Mitigating Measures

Sincerely,

W. G. Christian
Manager
Environmental Affairs

gwc

Enclosure

cc: J. W. Knox
W. L. Parchman
J. C. Swift
E. R. Western

TABLE OF CONTENTS

PLAN OF OPERATIONS

TABLES

FIGURES

METHODS OF DISPOSING OF WASTES

Liquid Drilling Wastes

During well drilling operations when mud is used, a combination of drilling mud, rock cuttings, and various minor additives will be discharged into the waste sump. Potential wastes that may be retained in the sump are listed in Table 1 below. Total volume liquid waste handled at each drill site may be as much as 400,000 gallons, of which about 20 percent can be recycled. Discharge of sump contents by overflow, sump wall seepage, or wall breakdown and discharge from elsewhere on the location will be avoided by proper engineering design. Shallow lost circulation which could channel through to the surface will be prevented by surface casing.

Table 1

Wastes*

Constituent		Volume ($ft.^3$)
Drill Cuttings (Native Rock)		20,000
Drilling Mud		
Wyoming Bentonite	900	
Bicarbonate of Soda	40	
Caustic Soda	40	
Lignite	240	
Quebracho	40	
Water	12,040	
		13,300
Water		28,000
Sulfatex (Biodegradable Drilling Soap)		100
Unistream (Graphite in Polymer)		100
Lost Circulation Material (Cottonseed Hulls)		1,000
Cement		1,000
Oil (Drippings from Engines and Machinery)		15
TOTAL WASTES		63,515
Less Waste Removed by Recycling		19,600
		43,915

* From Report of Waste Discharge - Chas. Binkley No. 1.

The project will be subject to waste discharge requirements outlined by the Forest Service. Drilling personnel will be provided with contingency plans to report, clean up and abate discharge incidents, and monitor steam condensate. All liquid waste produced during any well testing operation, after the sump has been filled, will be containerized and removed to an acceptable

disposal sites if required. To prevent discharge of petroleum products into surface waters, equipment service and fuel and transfer areas, as well as the area occupied by the drill rig, will drain into the waste sump.

Material safety data sheets on various products used in drilling mud, as well as toxicity data on Magcogel, McQuebracho, and Cypan (all drilling mud additives), are presented in Appendix A. None of the products proposed for use contain asbestos, chrome, or lead which are found in certain drilling mud additives.

Condensate

Small quantities of condensate occasionally collect as standing water at wellheads. Constituents which may be found in a geothermal condensate are identified in Table 2 below. Chemical constituents in condensate are quite

Table 2

Constituents of Geothermal Steam Condensates

Constituents	Range Reported	
Arsenic	.003 - 9.3	mg/l
Aluminum	0.09 - 75	mg/l
Boron	8.0 - 450	mg/l
Cadmium	0.0 - .004	mg/l
Calcium	0.09 - 75	mg/l
Copper	0.0 - 1.15	mg/l
Chromium	0.0 - 1.5	mg/l
Iron	0.6 - 80.0	mg/l
Lead	0.0 - 1.5	mg/l
Magnesium	0.09 - 60	mg/l
Manganese	0.0 - 2.0	mg/l
Mercury	.00002- 0.08	mg/l
Nickel	0.0 - 7.5	mg/l
Selenium	0.0 - 0.028	mg/l
Silicon	0.09 - 200	mg/l
Silver	0.0 - .00009	mg/l
Sodium	0.09 - 80	mg/l
Sulfur	.01	mg/l
Titanium	0.0 - 0.9	mg/l
Zinc	0.0 - 0.2	mg/l
Ammonia-Nitrogen	3.7 - 224	mg/l
Chloride	10.0 - 23.0	mg/l
Hydrogen Sulfide	0.36 - 0.96	mg/l
Sulfate	3.0 - 960	mg/l
Physical Properties		
Alkalinity	26 - 400	mg/l
pH	3.62 - 8.05	
Turbidity	1.0 - 83 FTU	

* Compiled from PG&E, 1973; USGS, 1973; Parametrix, 1975.

variable, depending on the source being measured; therefore, it is highly unlikely that any one source would obtain all identified constituents at the high concentration range reported.

PROPOSED MEASURES TO PROTECT ENVIRONMENT

Fires

The potential for fires is increased by greater human activity; however, the nature of geothermal drilling operations requires few special precautions, mostly common sense. Fuel tanks will be located at a safe distance from the drill rig and provided with a fire guard of bare mineral soil at least 15 feet wide. Its position will be elevated so that any spillage will drain directly into the sump. Any contaminated soil will be incorporated into the solid waste within the sump. Burnable refuse will be placed in appropriate receptacles and disposed of according to solid waste control requirements. None will be allowed to accumulate on the pad except in appropriate fire-safe bins or in the sump.

There will be a fire control plan which will be operational on site, a designated person to be responsible for fire control measures, and a prearranged system for contacting Forest Service fire control units. The following considerations will be included in the plan: fireproofing of work sites, fire prevention measures for welding and for working with other fire-causing activities.

There will be routine, regular patrols and inspections for: compliance with fire safety rules, availability of manpower, fire tools and fire equipment, disposal procedures for flammable materials, communications for contact with fire officials, and road accessibility for fire-fighting crews.

Erosion and Sedimentation

Both vegetative and structural practices may be used to control erosion and sedimentation. Vegetative control practices are given in Appendix B, page 31. Vegetative buffers, as described above, detain, absorb, and filter overland runoff, thereby removing sediment from the water. Structural practices include installations and sediment basins if needed. The use of a cyclonic muffler will eliminate the direct effects of steam and abrasion in the path of escaping steam during the air drilling sequence.

Potential soil impacts include direct soil losses due to erosion, physical changes due to compaction and landscaping, and possible chemical biological alternations due to particulate and gaseous emissions. Clearing and grading operations will remove surface vegetation and alter existing terrain contours at construction and installation sites, thereby increasing erosion potential. Great care in road and pad construction can minimize soil loss. To avoid adverse impacts, the following measures will be considered standard procedure:

1. Only that portion of grading and construction involving soil disturbance which can be completed and adequately protected from soil erosion will be permitted during any one construction season. No grading will be done during periods of precipitation sufficient to create muddy conditions, except to repair damage threatening human safety or environmental integrity at the site.

2. There will be minimal removal of vegetation. Cuts and fills will be kept to the smallest surface area possible. Existing roads will be used except where absolutely necessary for access and servicing of drill sites.

3. Road bases will be graded and compacted and adequately surfaced (where necessary) to Forest Service standards.

4. Fill slopes greater than a vertical distance of three feet will be reduced to 1.75 to 1 (horizontal to vertical) where possible. If greater than 30 feet, a bevel will be constructed and the slope will be 2:1. All fills will be compacted to 80 percent of an acceptable engineering laboratory standard. Spoil material from cuts and fills will be disposed of in designated sites where it cannot endanger water quality.

5. Cuts and fills and other areas of exposed soils will be promptly protected against erosion. Hydromulching may prevent temporary erosion. An alternative would be to cover bare soil areas with a coating of punched or otherwise anchored straw (one ton per 2.0 acres) to absorb raindrop impact and act as a mulch for viable seed buried in the soil. Whichever method is used, topsoil will be stockpiled for future reclamation activity.

6. A long-term vegetation and revegetation program will be started at the earliest possible time. Plant species environmentally suited for each site and soil phase will be used after consultation with Forest Service range specialists. Slope aspect, soil type, and microclimate will be considered in plant type selection.

7. Adequate water drainage systems will be constructed using drainage control practices to avoid saturation of road and pad fills and unstable slopes.

8. If roads must cross unstable slopes, they will be built on southern or western exposures.

Hydrologic Alterations

Removal of vegetation and compaction of ground during construction of drill sites and their access roads will increase the amount of short-term volatility of runoff. Precipitation falling on pads will be trapped and retained in reserve pits, thereby decreasing runoff proportionately. Excess runoff from roads will be collected in adequate size culverts of line ditches and transported to the natural stream source. Energy dissipators will be

installed at all outfalls located in soil or highly weathered rock. Underdrains will be installed as necessary. All drainage control devices will be regularly inspected and maintained.

To reduce the possibility of disruption from drainage and ground surface alterations, grading and other construction operations will be avoided in the immediate areas of springs, seeps, and waterways. Postconstruction effects of site preparation on runoff into local creeks are anticipated to be very slight.

The proposed wells will be cased in such a manner as to protect useful groundwaters, if such are found, thereby ensuring that geothermal fluids will not be placed in contact with any usable groundwater resources in the development area.

Water Consumption

The project will require water to control dust, replace lost drilling fluid, and compact engineering fills. Wetting road beds will consume about 10,000 gallons per day for four to six months, depending on rainfall. Controlling dust emissions during air drilling will consume about 5,000 gallons per day or 53,000 to 120,000 gallons per well. Mud drilling consumes about 4,000 gallons per day or 120,000 gallons per well. Lost circulation would increase these figures. The amount of water needed to compact fills depends on the character and water content of the material. Very little water need be added while the ground is still wet from spring and winter rain. Fills constructed during summer may require several thousand gallons of replacement water.

During the rainy season, rainwater collected in sumps adjacent to the well can be used in preparing drilling fluid and wetting dust in the cyclonic separator. It can also be used for dust control and construction if the water has been analyzed and found to be of acceptable quality.

Accidental Spills and Discharges Control Procedures

In the event of discharges of condensate, drilling muds, petroleum products, or construction debris, an example of an overall contingency plan for geothermal operations is as follows:

1. The person responsible for the operation will make an immediate investigation, then call the production foreman and advise him of the spill. The production foreman will in turn call out men and equipment, regulate field production, or do other work as applicable for control and cleanup of spill. If spill is small (i.e., less than 250 gallons) and easily containable without endangering watershed, production foreman will direct and supervise complete cleanup and return to normal operations.

2. If spill is larger than 250 gallons, or is not easily contained, or endangers or has entered the watershed, the production foreman will proceed to take necessary action to curtail, contain, and clean up spill, and notify personnel as follows:

A. Call out company employees, as above, to man heavy equipment, regulate field production, etc.

B. Call production engineer, drilling manager or operations manager, and resident forest ranger and advise of spill.

C. Call contractors for crews and equipment, if necessary.

D. Call for contract vacuum trucks.

E. Specific procedures:

(1) For condensate: Contain spillage with dikes, if possible. Haul to disposal well by vacuum truck.

(2) For drilling muds (contact drilling foreman): Repair sump or contain with dikes. Spread straw or hay to impede flow. Haul liquid to another sump or available tank or county-approved site. Dry and solidify other material, compact, and bury solids where possible.

(3) For petroleum products: Contain spill with available manpower. Use absorbents in stock at field warehouse and dispose of same in county-approved areas.

(4) For construction debris: Pick up or otherwise contain and remove to disposal area.

D. Direct repair of the source of spill at earliest practical time.

E. Continue working contract crews on cleanup until all concerned agencies are satisfied.

For a more detailed plan, see Appendix C.

Habitat Loss

Riparian corridors and water sources are of critical importance. The distribution of such features within the project area is shown on Map 1. Approximately 2 to 2.5 acres will be cleared and graded for each well pad and sump construction. The major impact will be loss of forage and cover for deer. Noise and human activity during construction, drilling, and testing will cause a slight temporary reduction in bird and mammal use of adjoining habitat. Loss of woodland habitat along the access roads will total less than three acres. Careful siting of geothermal facilities and other mitigating measures can greatly reduce adverse impacts on fish and wildlife resources. Recreational opportunities to enjoy fish and wildlife resources will not be significantly reduced by project activity or by habitat loss.

Mitigations

1. The pad will be located on the ridge top's broader portion where possible.

2. The reserve pit will not be sited on steep flanking side slopes.

3. Setbacks from these slopes will be established for both pad and reserve pit.

4. Culverts and/or lined ditches draining the site will be extended downslope to the gullies. Energy dissipators will be installed at outfalls.

5. Care will be taken during access road improvement to avoid disturbance of any natural seeps and springs. Construction in stream courses will be avoided wherever possible.

6. Care will be taken to avoid large conifers and snags which provide perches for raptors.

7. Toxic material control will be achieved through proper sump construction, maintenance, and operation.

8. Dust will be controlled by sprinkling construction work and roads as needed during the dry season and/or by surfacing heavily trafficked roads.

Operations Scheduling

In some cases, scheduling of operations to specified time periods can greatly lessen environmental impacts. For example:

1. Excavation and grading operations will be scheduled for the dry season to minimize erosion problems.

2. To the maximum extent practical, well cleanouts and tests will be conducted during periods when good atmospheric mixing conditions prevail.

Engineering

Once plans for the general project have been approved, engineers will design and supervise construction of installations in a manner that minimizes impact. Best available techniques will be included in final project design. Progress in the development of systems for hydrogen sulfide and particulate emissions control will be carefully followed so that they can be put to use as soon as practical.

Safety and environmental protection will be primary engineering criteria in the development of site plans, as well as in the selection of equipment and

apparatus. Conformance to codes and standards of the Forest Service and the State of New Mexico is the minimal engineering requirement. (See Appendix C for more details regarding safety.)

Maintenance

Regular maintenance and follow-up inspections are as fully importance in overall mitigations as are measures taken initially in planning and engineering. Erosion control devices, road alignments, drill sumps, wellhead apparatus, pollution control devices, etc., will be inspected regularly and maintained in good condition as long as the site is being used, which could be 30 years or more. Revegetation of cut and fill areas is a long-term activity which requires constant attention. Contingency plans for accidents, such as sump failures, well blowout or blowdown, spill of drilling wastes, or wildlife, will be prepared well in advance so that, if corrective action is necessary, the proper course of action can be taken promptly.

Monitoring

Monitoring of critical environmental concerns such as air quality, water quality, soils, subsidence, seismic activities, wildlife, noise, and archaeological resources will be determined after consultation with Forest Service personnel.

Construction Equipment Operation and Traffic

Dozers, graders, trucks, cranes, and other equipment will be employed for road and pad construction and equipment installation. Additionally, daily vehicle trips are needed to support construction activities. In almost all cases, larger vehicles and equipment are diesel-powered. Their operation produces engine exhaust emissions; however, these are relatively minor in nature.

Electric power will be provided by two sets of diesel generators. (See Table 3.)

Drilling Operations

Geothermal wells are drilled with conventional drill rigs. Mud pumps and air compressors are typically equipped with diesel engines. A total of about 1,200 gallons of fuel is consumed per day in drilling an average geothermal well. The drilling operation is short-term, and exhaust emissions are not a significant source of air pollutants. For a more complete list of on-site equipment, see Table 3.

Initial operations consist of drilling a 26-inch hole to approximately 300 feet and cementing to the surface a 20-inch diameter steel casing. A 17 1/2 inch hole is then drilled to approximately 2,000 feet and a 13 3/8 inch casing run and cemented back to the surface. A 12 1/4 inch hole will then be drilled to approximately 6,000 feet. A 9 5/8 inch casing will be cemented

Table 3

Typical On-Site Drilling Equipment

DRAWWORKS:	National 75 CA double drum drawworks.
ROTARY TABLE:	National 27 1/2 MS rotary table.
POWER:	Two sets--GM twin 6-110 diesel engines with Allison torqmatic drive converters (1,200 hp.)
MAST:	127-foot late style Bender, 450,000 pounds gross nominal capacity mast.
SUBSTRUCTURE: (with mats)	26 feet 6 inches high by 23 feet wide by 40 feet long.
TRAVELING EQUIPMENT:	Emsco 250-ton 4-sheave traveling block with Web Wilson Hydra-Hook combination. Oilwell 500-ton swivel. 5 1/4 Hex Kelly.
MAIN PUMP:	Ideco MM600 (7 3/4 x 16) 600 hp. duplex pump powered by one set of 6-100 GM twin diesel engines with Allison torqmatic drive converters (600 hp.)
AUXILIARY PUMP:	National C-250 (7 1/4 x 15) 370 hp. duplex pump powered by one set of 6-110 GM twin diesel engines.
MUD SYSTEM:	1,048-barrel capacity surface equipment with two Medearis shakers.
CENTRIFUGALS:	Two 5 x 6 Thompson centrifugal pumps powered by two 50 hp. explosion-proof electrical motors.
WATER STORAGE:	524-barrel capacity tank plus 750 barrels in Thermogenics tanks.
LITE PLANTS:	One 150 kw GE generator powered by a 6-110 GM diesel engine. One 150 kw GE generator powered by a 6-110 GM diesel engine.
BOE:	12-900 GK Hydril. 12-900 double Shaffer. 12-900 type D spool. 80-gallon Hydril accumulator with nitrogen bottles with remote electric control station. Blowdown manifold (3" = 5,000 psi).
DRILL PIPE:	4 1/2 OD, Grade E, 16.60 lb/ft, R-2 drill pipe.

Source: Big "O" Drilling Company's Rig #2, 1978.

from the bottom of the hole to the bottom of the 13 3/8 inch casing. An 8 3/4 inch hole will then be drilled into the reservoir at approximately 9,000 feet. As an extra precaution, a tie-back string of casing will be run from the top of the 9 5/8 inch casing to the surface. (See Figure 1.)

The drilling process is conducted in three stages:

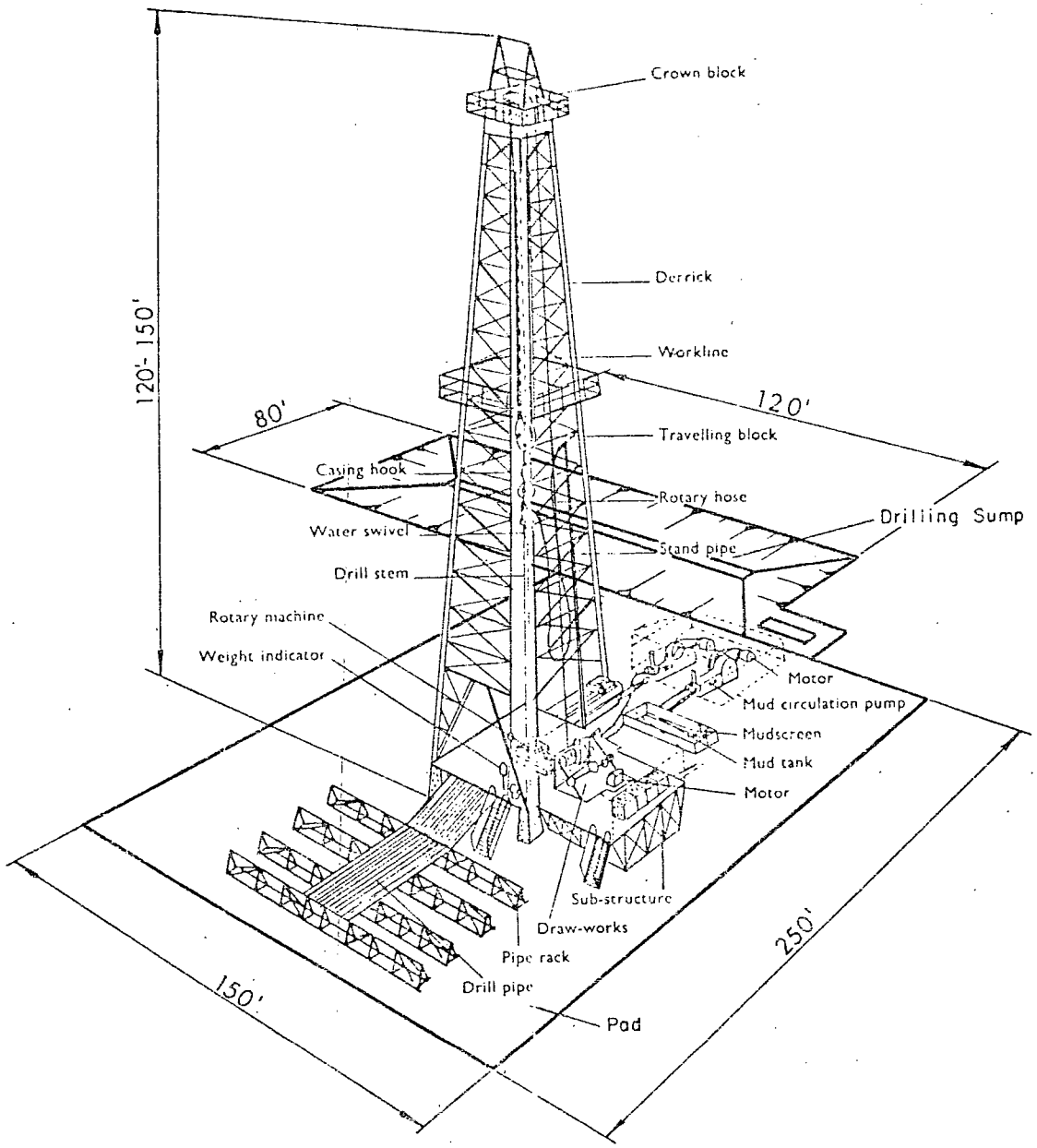
1. Shallower portions of wells are typically drilled using a water-based mud slurry to remove drill cuttings. No pollutants are emitted.

   The upper portion of the well will be drilled with a nontoxic drilling mud circulated through a closed system (Figure 2). The lower portion will be air or air-mud drilled. As the mud comes uphole, it passes across a shaker which will separate the mud from the drill cuttings. Drilling mud is generally a mixture of clay and water with the following basic composition: water, bentonite, clay, sodium bicarbonate, quebracho, mica, lignite, cottonseed hulls, graphite, and caustic soda. Except for the caustic soda (lye), none of the materials used in drilling will be hazardous. About one-half pound of caustic soda per day for each ton of drilling mud will result in a dilution which is not hazardous and cannot cause skin burns.

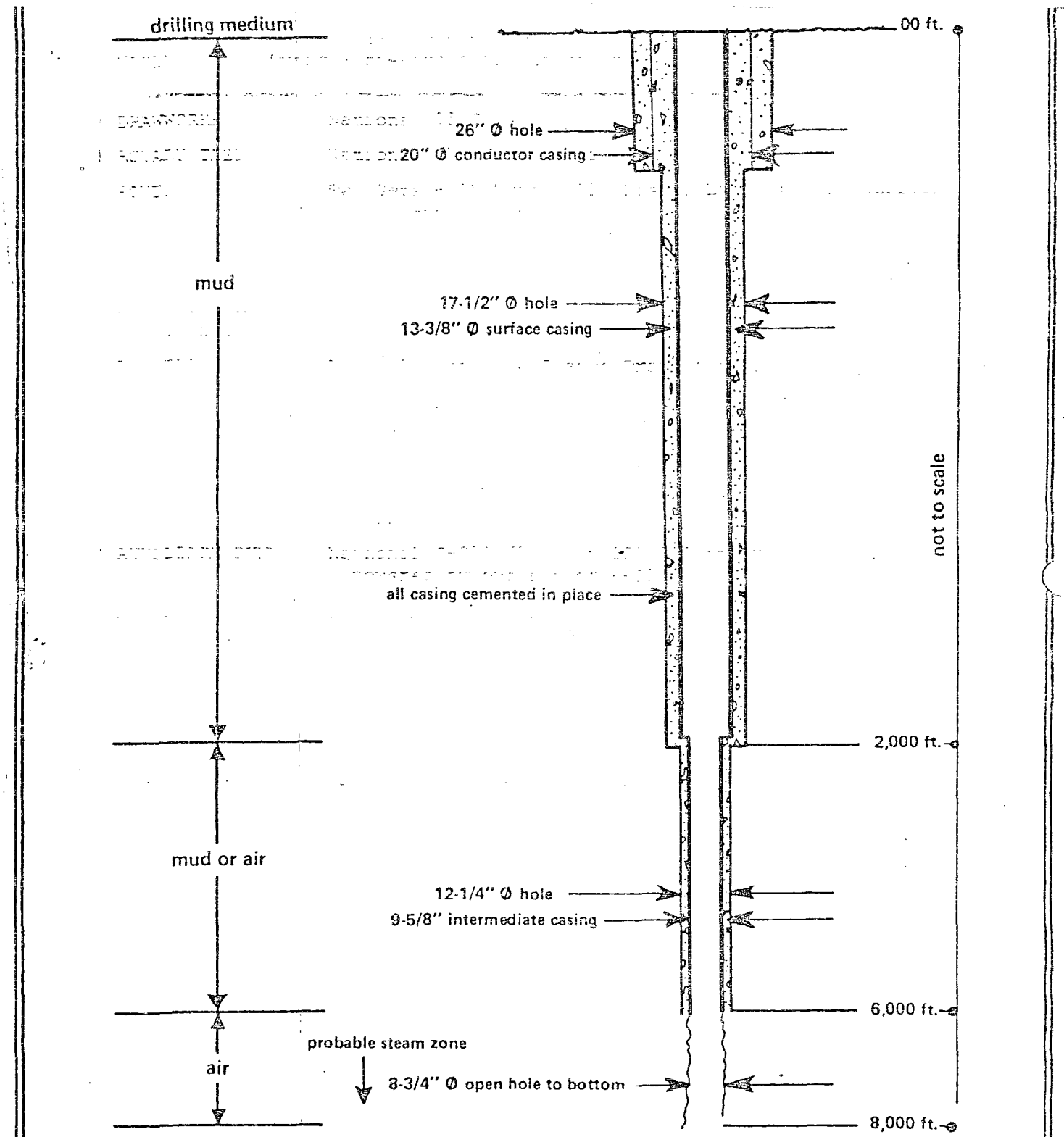
2. Intermediate well sections may be drilled using mud or air. When compressed air is used, steam (if encountered) and rock cuttings brought to the surface are collected in a flow-diverting device (banjo box) and directed through a horizontal pipe (blooie line) into a cyclone dust arrestor and muffler before discharge to the atmosphere (Figure 3). Water is injected into the blooie line between the banjo box and cyclonic muffler. This creates a venturi scrubbing effect where rock particles are agglomerated through high turbulence and water contact. Heavier particles and condensate are removed by centrifugal action and fall to the muffler's bottom. Lighter particulates and steam pass through the cyclone stack and escape to the atmosphere.

3. The steam-producing section of the well is typically drilled with air because the high temperatures destroy the colloidal properties of the drilling mud. Air is used to cool the bit and to convey rock fragments to the surface. Up to 992 pounds/hour of rock may be drilled in this manner, most of which ends up as drill chips in the sump. However, some is ground into dust and escapes with steam to the air. Particulates also arise from erosion within the well bore and from within the steam fracture.

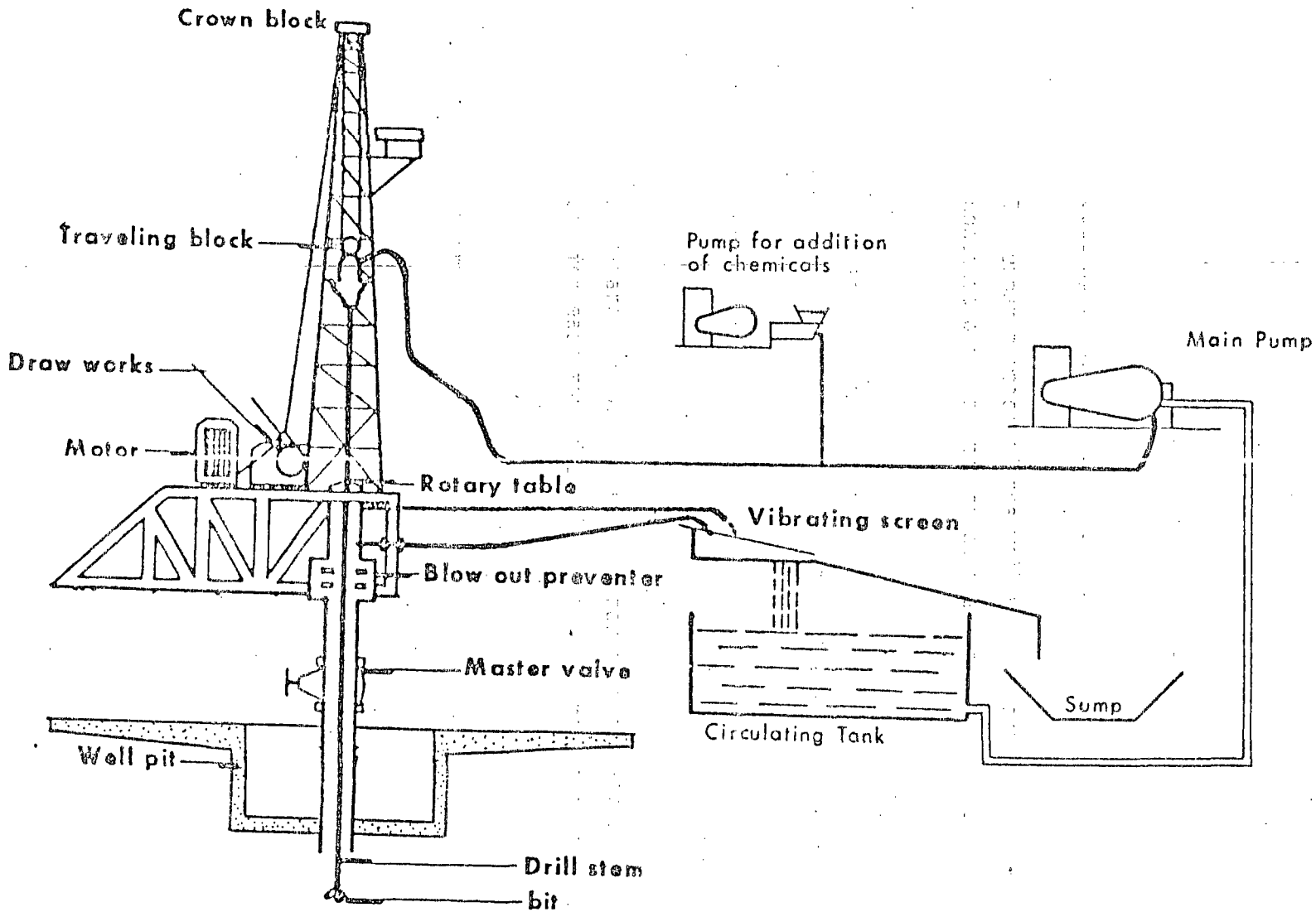
4. The danger of blowouts is mitigated by blowout prevention equipment (Figure 4). The total drilling operation normally takes 45 to 60 days for each well, including 15 to 20 days for air drilling. Steam and accompanying noncondensable gasses are produced at increasing rates from zero at the start of drilling to essentially full flow at the time of well testing. Air drilling itself restricts full flow. Full flow emissions vary considerably from well to well;



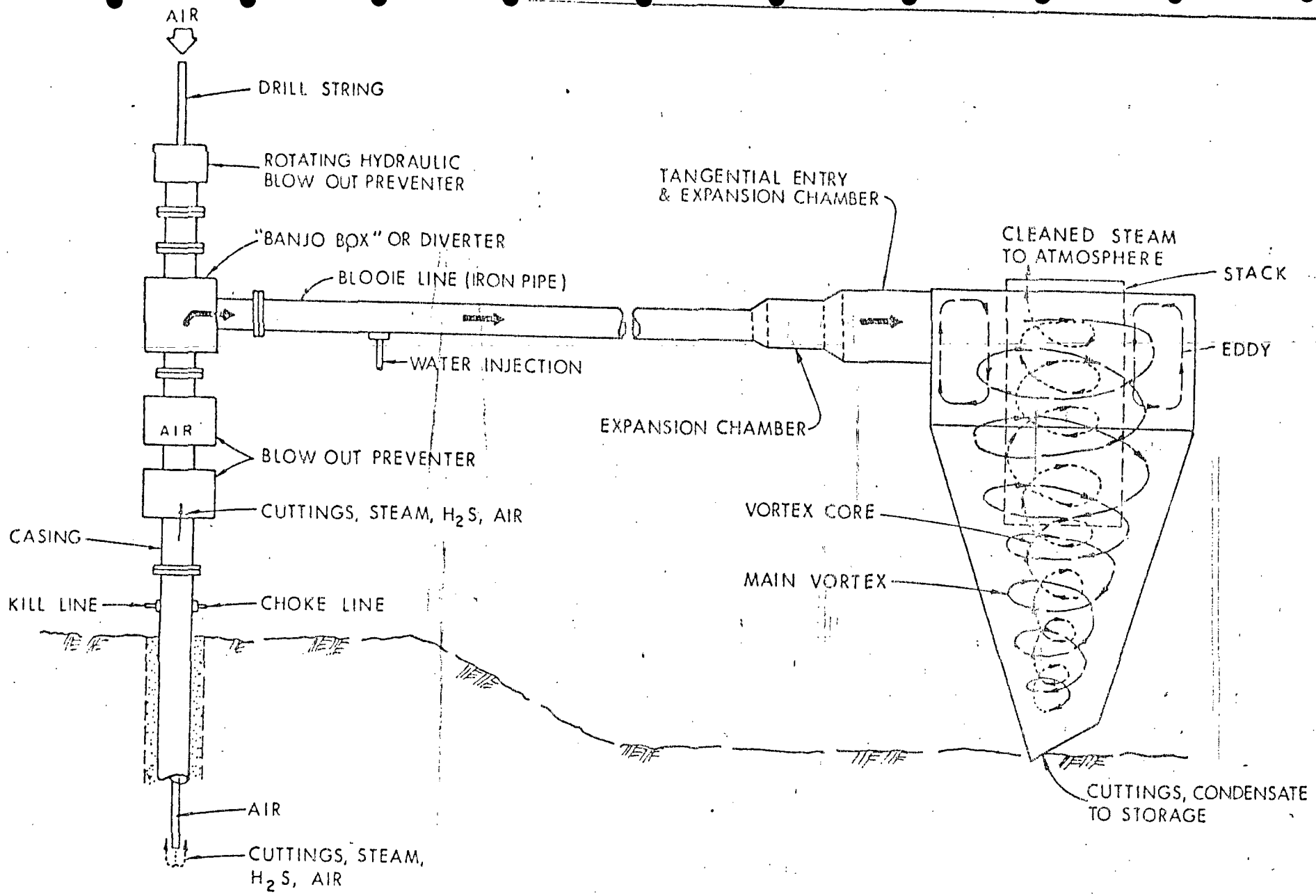
TYPICAL GEOTHERMAL WELL PAD LAYOUT



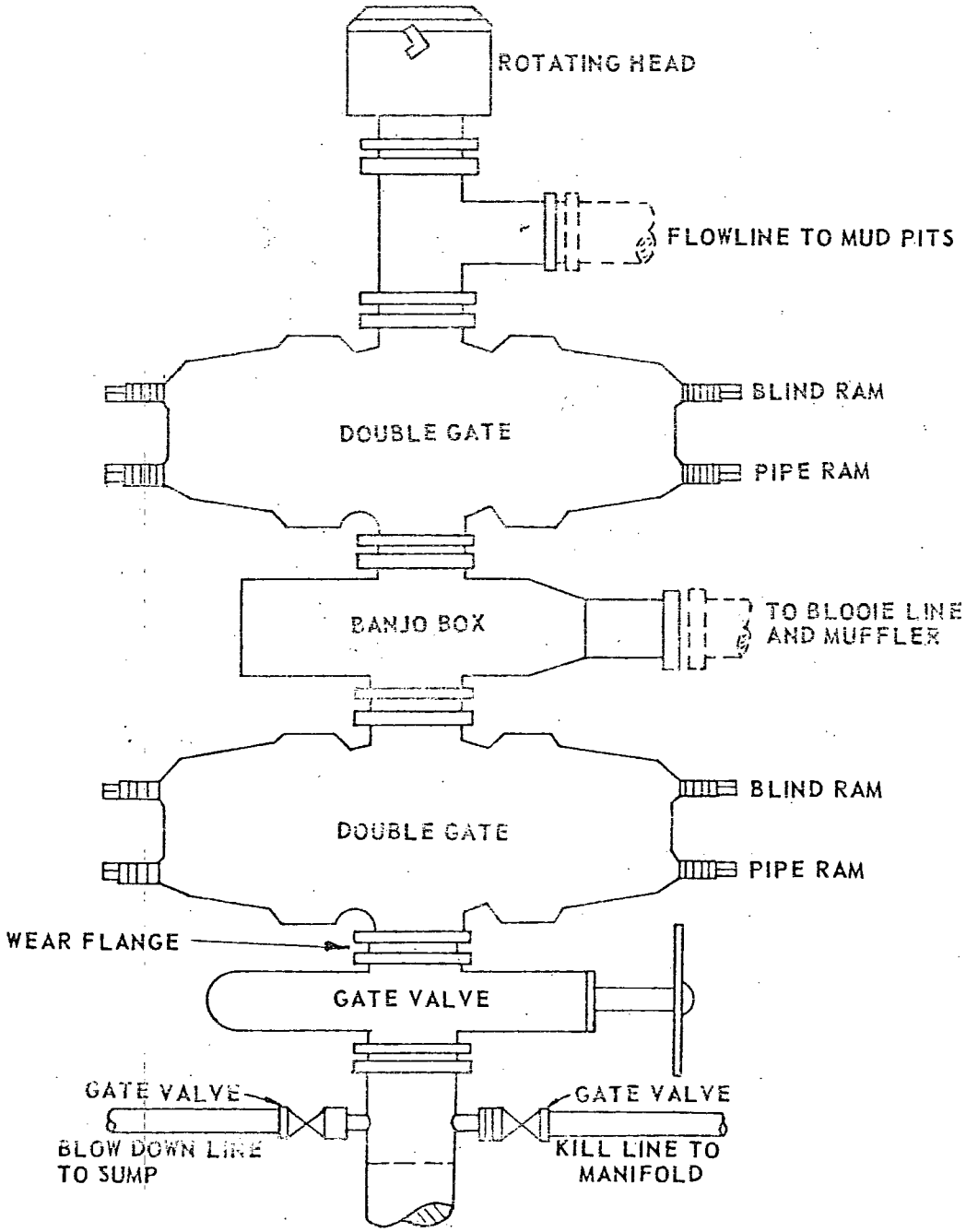
Cross section of proposed geothermal well



TYPICAL DRILLING MUD CYCLE



BLOOIE LINE MUFFLER SYSTEM



BLOW OUT PREVENTER STACK

FIGURE 4

however, the average for the Geysers steam field in California is about 120,000 to 150,000 pounds/hour steam. Well drilling contributes a small percentage (about 4%) of the total prepower plant steam vented at the Geysers (Tolmansoff, 1976).

Well Testing and Cleanout

When a productive geothermal zone is encountered, wells are tested to determine steam flow rates and physical properties. A flow test may be completed in as little as four hours or may take as much as four days. A typical well testing setup is shown in Figure 5.

Shut-In Wells

When brought back into production, wells are vented at full flow so that large rock particles and water are not directed into the steam pipeline. This operation usually requires only a few hours, but can take up to several days. About 14 million pounds of steam is vented per well for each test. Although testing and cleanout operations are short-term, they generate the highest emission rate of steam and noncondensable gases encountered in normal well operations.

Well Bleeds

When a well is shut in, well temperature is maintained by constant bleeding of steam through a vent. A single well bleed allows 300 to 1,200 pounds of steam to vent per hour. While emission rate is relatively low during bleeds, a well may be on standby status for several months or even a few years.

Air Pollutants

Air pollutants associated with each mission source are identified in Table 4.

Table 4

Air Pollutants
Associated with Exploratory Geothermal Well Drilling

Source Category	Air Pollutants					
	Particulates	H_2S	CO	HC	NOx	SOx
Construction Equipment Operation and Traffic	X		X	X	X	X
Well Drilling						
Drilling Drives	X		X	X	X	X
Well	X	X				
Well Testing and Cleanout	X	X				
Uncontrolled Wells	X	X				
Well Bleeds	X	X				

Source: ECOVIEW, 1977.

FIGURE 5

WELL TESTING SET UP

Meter run with micrometered orifice plate and tubes
157" tube upstream of orifice
157" tube downstream of orifice

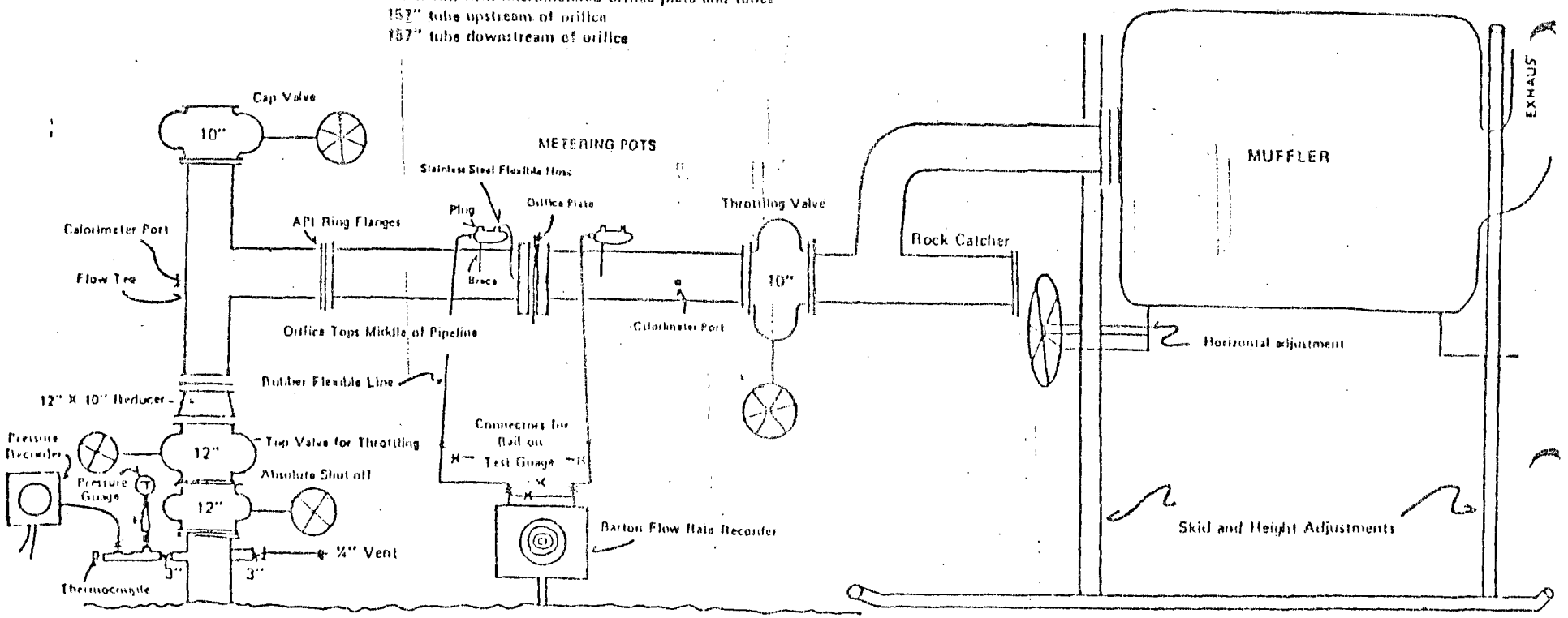


Table 5 provides a specific analysis of typical geothermal well hydrogen sulfide emissions.

Table 5

Geothermal Well Hydrogen Sulfide Emissions

Operation	Emission Rate	Duration
Drilling		
Mud Drilling	0 lbs. H_2S/Hr.	30 Days
Air Drilling	0 lbs. H_2S/Hr. 0-70 lbs. H_2S/Hr.	2-5 Days 8-15 Days
Flow Test	5-70 lbs. H_2S/Hr.	4-6 Hours
Standby Well		
Normal (1/2" Diameter Bleedline)	0.05-0.2 lbs. H_2S/Hr.	Indefinite
Abnormal		
(a) New Well	0.2-0.8 lbs. H_2S/Hr.	7-15 Days
(b) Very Wet Well (1/2"-2" Diameter Bleedline)	0.2-6 lbs. H_2S/Hr.	Indefinite

Adapted from Tolmasoff, 1977.

The data indicate that particulate emission rates are quite variable. For the selected wells shown in Table 6, particulate emission rates varied from 3 to 140 pounds per hour. Emission rate is primarily a function of material drilled through, blooie line water injection rate, and quality of water injected. Most particulates emitted from tested cyclonic mufflers were generally less than 10 microns in diameter. In all cases where a ten-foot diameter was used, 90 percent plus of particulates emitted to the air were 2 microns or less in diameter.

Table 6
Particulate Emission Rates and Size Distribution

Well	Steam Rate 1,000 lb/hr	Emission Rate lb/hr	Particle Size by Percent 2u	2-4u	4-8u	8u
A-9	85	3	93	7	9	0.0
DX-29	99	18	94.5	4.1	1.1	.3
A-10	145	23	98.3	1.1	0.0	.6
SB-23	117	66	95.6	3	1.4	0.0
SB-20	193	72	93	5	2	0.0
Filley 2	41	81	94	6	6	0.0
SB-21	124	140	91.8	6.3	1.4	.5
C-4	162	74	52.5	19	19	9.5

Source: Tolmasoff, 1976.

Table 7 gives a rough approximation of distances particulates can be transported from an emitting source. Five to ten micron diameter particles may travel up to ten miles from the source. Smaller particles, in the range predominantly emitted during drilling operations, can be suspended "indefinitely" in the upper atmosphere.

Table 7

Distances a Particle Could Travel from an Emitting Source

Diameter of Particles	Distance	
Microns	Feet	Meters
5	66,000	20,146
10	16,600	4,998
20	5,100	1,249
40	1,021	311
80	256	78
100	164	50

Assumptions: (1) Six knots average wind velocity, (2) no turbulence, (3) flat topography. Calculations of particle settling rate according to Perry's Chemical Engineering Handbook, third edition.

Source: Northern Sonoma County Air Pollution Contro District.

Particulate and Gaseous Emissions

Since the advent of muffler-separators, improved casing standards, controlled well testing, and muffled bleed lines, there have been no significant adverse impacts on nearby vegetation in active geothermal developments. The effects of H_2S at concentrations usually encountered in drilling and standby are low enough and dispersed enough to be of no detriment to local vegetation.

Other Contaminants

Parameters frequently monitored include ozone, carbon monoxide, oxides of nitrogen, methane, nonmethane hydrocarbons, and coefficient of haze.

To assess potential air quality impacts from the project, several factors must be taken into account:

1. Existing ambient air quality.
2. Specific pollutants emitted during the project's life.
3. Probable pollutant emission rates and duration.
4. Possible environmental and health hazards associated with air pollutants (see Appendix C).

5. Probable transport and dispersion of significant pollutants, given meteorological and terrain characteristics of the locale, as well as physical characteristics of emitting sources.

In terms of potential air quality impact, most effluents emitted are expected to be carried off by higher speed flows aloft most of the time. On a few occasions (probably less than 1 percent of the time), nocturnal emissions could be incorporated in downslope drainage flow. Drainage flows are expected during pre-dawn hours in any season. These flows will follow the natural hydrologic drainage.

Mitigations

The following methods can be used for abating hydrogen sulfide emissions from geothermal wells.

Abatement of Hydrogen Sulfide Emissions During Well Drilling

Air injected into the drill string as the circulating medium and water injected into the blooie line for particulate emission control were shown to reduce H_2S emissions appreciably below open flow conditions. Measurements illustrating the effect on emissions of just air and water injection used during normal drilling operation are given in Table 8.

Most reduction in H_2S is believed to be due to exposing downhole H_2S to air under high temperatures and pressures. The reaction which takes place is probably as follows:

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

Neither rate nor pH of water injected into the blooie line had any measurable effect on H_2S levels.

Two other processes that abate hydrogen sulfide emissions by use of chemicals were investigated:

- Injection of ammonium hydroxide and air into the drill string.
- Injection of hydrogen peroxide and sodium hydroxide into the blooie line.

Ammonium hydroxide has been used by geothermal operators to abate hydrogen sulfide emissions. The procedure consists of pumping various concentrations down the drill string with air. In the test case, ammonium hydroxide reduced hydrogen sulfide emissions 7 to 16 percent (Table 9).

The abatement process consists of exposing downhole hydrogen sulfide to ammonium hydroxide. Hydrogen sulfide reacts with ammonium hydroxide as follows:

$$2\ NH_2OH + H_2S \rightarrow (NH_4)_2S + 2\ H_2O$$

Table 8

Effect of Drilling Practices on Hydrogen Sulfide Emissions

	Air Injection Rate (CFM)	Water Injection Rate (GPM)	H_2S Concentration (ppm)	Flow Rate (1,000 lbs/hr)	H_2S to Atmosphere (lbs/hr)	% Reduction
Well A	None	None	82	93.6	7.7	24
	2,570	None	63	93.6	5.9	
	None	50	73	114.0	8.3	
	2,570	50	60.5	114.0	6.9	17
	None	50	93	117.5	10.9	
	2,620	50	67	117.5	7.9	28
	None	50	100	127.2	12.7	
	2,412	50	79	127.2	10.0	
Well C	None	None	163	48.9	8.0	
	2,400	None	92	48.9	4.5	44

Source: Union Oil Company, 1977.

Table 9

Effect of Ammonium Hydroxide on Hydrogen Sulfide Emissions During Well Drilling

NH^4OH Injection (16-mole/hr)	H_2S Concentration (ppm)	Flow Rate (1,000 lbs/hr)	H_2S to Atmosphere (lbs/hr)	% Abatement
Well A				
None	74	127.2	9.4	-
0.008	69	127.2	8.7	7
0.041	62	127.2	7.9	16
0.073	63	127.2	8.0	15

Source: Union Oil Company, 1977.

The principal disadvantage of this abatement scheme is that the use of ammonium hydroxide may create a waste water sulfide problem. The product, ammonium sulfide, will regenerate hydrogen sulfide if the pH of the disposal pond is allowed to drop below 9.3.

Use of an aqueous solution of sodium hydroxide and hydrogen peroxide to abate hydrogen sulfide emissions during well drilling was demonstrated during a pilot test in August 1974. It has since been tested on a full-scale basis. Abatement up to 95 percent attributable to sodium hydroxide and hydrogen peroxide injected into the blooie line was measured (Table 10). Sodium hydroxide (NaOH) has a high affinity for hydrogen sulfide, and hydrogen peroxide (H_2O_2) reacts readily with alkaline sulfide (NaHS) as follows:

$$H_2S + NaOH \text{ --- } NaHS + H_2O$$
$$NaHS + 4H_2O_2 \text{ --- } NaHSO_4 + 4H_2O$$
$$H_2O + NaOH \text{ --- } Na_2S + 2H_2O$$
$$Na_2S + 4H_2O_2 \text{ --- } Na_2SO_4 + 4H_2O$$

Products of these reactions, Na_2SO_4 and $NaHSO_4$, will not physically revert to hydrogen sulfide. The H_2O_2 can react with H_2S or the sodium sulfides (Na_2S) to form trace amounts of S, SO_2, SO_3, and possibly trisulfate. The H_2O_2 will further oxidize the SO_2 to SO_4.

The advantage of this method is that the process can be effective any time steam is vented, since sodium hydroxide and hydrogen peroxide can be injected into the blooie line on a continuous basis, independent of other drilling activities. Also, the abatement system can easily be fitted as a portable system so that it can be moved from location to location as necessary.

Projected ranges of hydrogen sulfide emission reduction during the air drilling of a typical well at the Geysers are shown in Figures 6 and 7. The bottom set of lines of Figure 6 represents range of abatement that can be achieved by injecting ammonium hydroxide with air into the drill string. Test data for wells drilled using ammonium hydroxide show a reduction in hydrogen sulfide emissions in the 49 to 73 percent range when the effects of drill pipe restriction, air injection down the drill pipe, and water injection into the blooie line on H_2S emissions are taken into account. At this abatement level, total H_2S emissions for a typical well would range between 9 and 17 pounds/hour. Onion Oil Company estimates cost of chemicals required to abate hydrogen sulfide to this level would be less than $100 for a typical well.

The bottom set of lines of Figure 7 represents the range of abatement that can be achieved by injecting an aqueous mixture of hydrogen peroxide and sodium hydroxide into the blooie line. For a typical well, the values measured show that emissions have been reduced from 34 to 0.7 pounds/hour.

Noise and Disturbance

Noise and disturbance from construction and drilling operations during the course of this project may have some direct adverse impact on fauna by discouraging use of adjacent habitat. During the approximately 60-day period required for drilling, maximum noise levels expected at pad edge are 75-90 dBA. At 660-825 feet from the drilling rig, noise levels should be well below

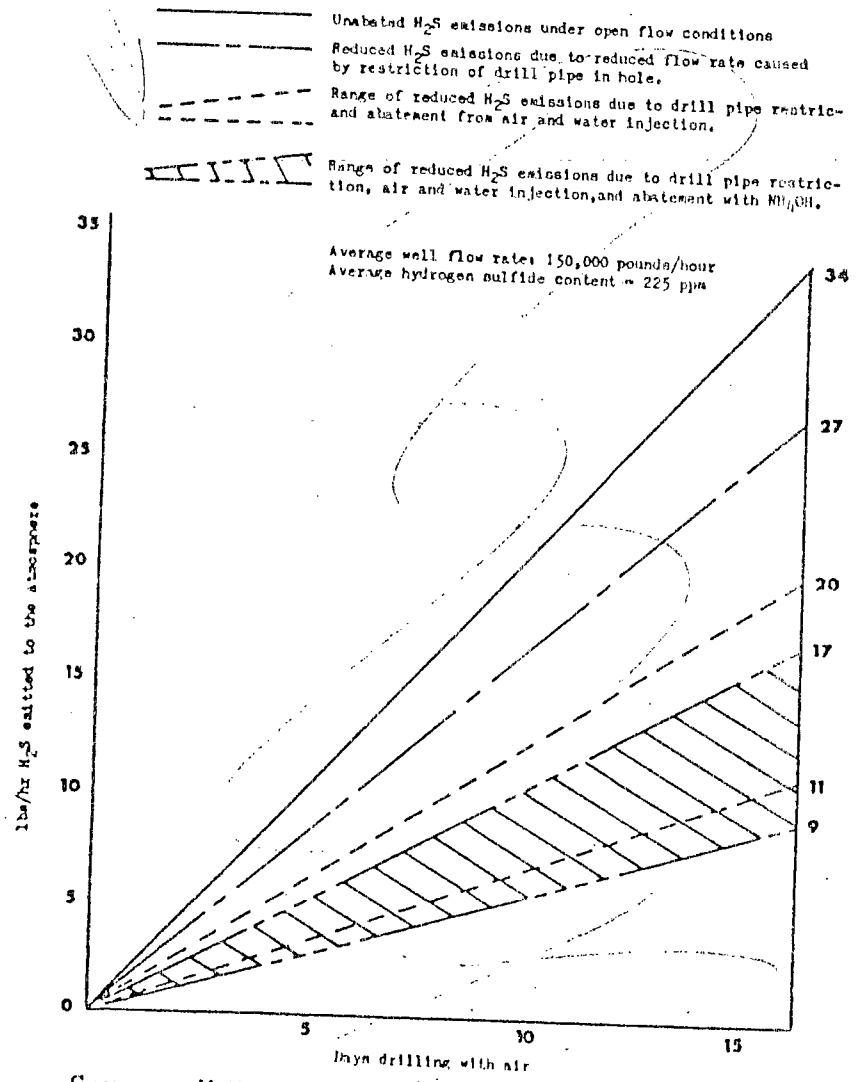
Table 10

Effect of Sodium Hydroxide and Hydrogen Peroxide Injection on Hydrogen Sulfide Emissions During Well Drilling

	Air Injection Rate (CFM)	Water Injection Rate (GPM)	H_2O_2 Injection (lb-more/hr)	NaOH Injection (lb-more/hr)	H_2S to Atmosphere (lbs/hr)	% Abatement
Well C	2,400	None	None	None	3.9	72
	2,400	None	0.463	0.504	1.1	
	2,400	None	None	None	4.5	78
	2,400	None	0.695	0.820	1.0	
	None	None	None	None	9.4	94
	None	None	0.811	0.933	0.56	
	2,477	10	None	None	4.2	85
	2,477	10	0.371	0.404	0.63	
	2,489	None	None	None	9.4	95
	2,489	None	0.811	0.933	0.44	

FIGURE 6

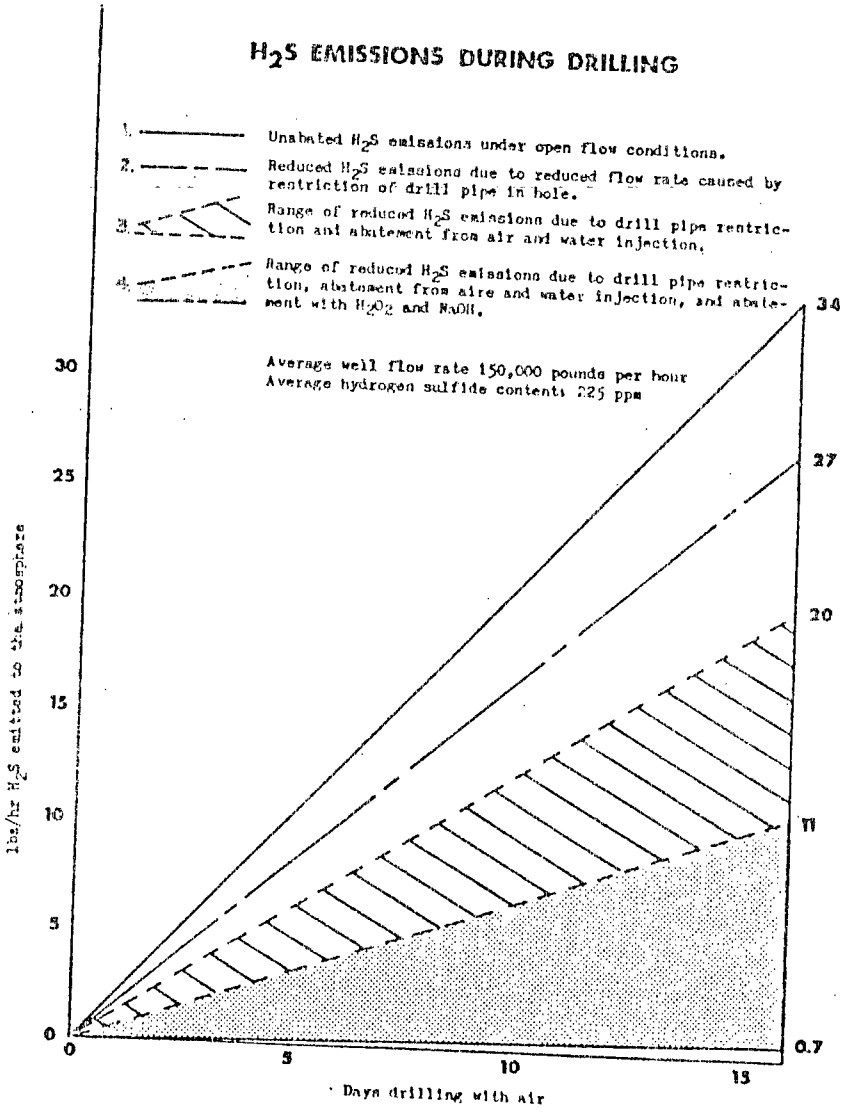
H_2S EMISSIONS DURING DRILLING



Source: Union Oil Co., 1977.

FIGURE 7

H_2S EMISSIONS DURING DRILLING



65 dBA. Between the latter distance and pad edge, some reduction in bird nesting and feeding activities may occur, but other animals will probably be unaffected. If commercial quantities of steam are encountered, cleanout and production testing may require up to five days; this will generate noise levels from 95 dBA at pad edge, depending on noise control technology employed. Behavioral responses of wildlife to noise of this intensity are not well understood; but since it would be of brief duration, no serious impacts would be expected.

Visual Impacts

Vistas are dominated by the series of mountain ridges and valleys comprising the range which display a variety of cover ranging from coniferous and deciduous species to underbrush and small patches of meadow grasslands.

Due to terrain relief, visual impact will generally be confined to the immediate lease area. The major exception will be steam plumes which are visible to the naked eye at distances as great as ten miles under the right meteorological conditions. However, very few public distance vantage points occur from which to view the proposed well sites. Nearly all vantage points are limited to the sparsely inhabited canyon above Jemez Springs. The well sites will not be visible from public recreation areas, towns, or major thoroughfares.

Since access roads will generally follow existing trails, little new surface disturbance will be required for these improvements. Well sites will not assume high visual presence contrasting in color, form, and texture with the natural vegetative backdrop

- Drill rigs, even when on ridge tops silhouetted against the skyline, will not be visible from the highway. Trees surround most of the sites and the rig will not be easily seen unless one is in the near vicinity. Outdoor lighting, required for round-the-clock operations, accentuates nighttime visibility of the rig.

- Steam emissions will be visible at times throughout the life of the project. Relatively large-volume emissions, such as occur during well tests and cleanouts, will be infrequent and restricted to a relatively limited time period. Emissions associated with standby venting are continuous, but of relatively small volume. Visibility of steam plumes will depend primarily upon climatic conditions and will be most likely during calm, cool weather conditions.

- Dust from traffic and construction activities will slightly increase atmospheric haze, reducing the clarity of air, and will be unsightly where deposited on roadside vegetation. These impacts are transient and short-term.

On-Site

The project will affect land use in two ways: It will convert a small percentage of land to industrial use and thereby infringe upon, or possibly

exclude, other existing or potential uses in the immediate vicinity of each well. Conversion of land to industrial use may be only temporary (60-100 days per well) in the event exploration is unsuccessful. A successful project must indicate adequate steam reserves to sustain a power-generating unit for at least 30 years.

CYPAN®

Drilling mud additive

APPENDIX A

TOXICITY STATEMENT

We have the following toxicity statements regarding CYPAN® drilling mud conditioner from our Toxicology Group:

"The single oral dose LD_{50} of CYPAN drilling mud conditioner for young male albino rats and the LD_{50} by 24 hour contact with clipped skin of rabbits are greater than 10.0 gm./kg. Therefore, the product is considered to be practically nontoxic by ingestion in single doses and by single skin applications.

This product is not appreciably irritating to rabbit skin or eyes.

The LC_{50} (median lethal concentration) of CYPAN drilling mud conditioner for bluegill is approximately 681 mg./1 and the LC_{50} for rainbow trout is approximately 768 mg./1. Therefore, the product is considered to have a low order of toxicity to fish."

TOXICITY DATA ON MAGCOGEL

A BIOASSAY - MAGCOGEL - A DRILLING FLUID ADDITIVE

INTRODUCTION:

Magcogel is a naturally occuring ore consisting of a sodium montmorillonite, colloidal clay commonly known as bentonite. It is water insoluble; however, it is a hydrophilic clay. It is used as an additive to develop controlled viscosity, gel strengths, and filtration rates of water base drilling fuids. It may be dehydrated in fresh water for use as a viscosifying and fluid loss control agent in certain brine systems.

It is considered to be non-toxic to man as it can be used as a bulk laxative and a base for preparations which may be used on the skin. The toxic effects of bentonite on aquatic life (both marine and fresh water species) are of great importance and the following tests were conducted to determine the acute fish toxicity of Magcogel.

PROCEDURE:

Fish kill studies applying the Acute Fish Toxicity Test of the American Public Health Association were conducted using a current production sample of Magcogel. All tests were conducted by an independent testing laboratory.

TEST RESULTS AND CONCLUSIONS:

Test results are listed as TL_m (Median Tolerance Limit) which represents the concentrations of the material tested that caused fatalities in 50% of the test organisms (Mollienisias Latipinna-Sailfin Molly) for a specified period of time.

Magcogel is normally used in concentrations of 5-35 pounds/barrel which corresponds approximately to 5,770 - 40,384 ppm. This product is a fine particle-sized, high yield clay that wets fairly readily and disperses well in a seawater media. It forms an extremely viscous gel at high concentrations which increases with time in a freshwater media, and it virtually restricts any mobility of the test organisms.

A. FRESHWATER*

24-96 hour TL_m = 14,500 ppm

B. SEAWATER

24-96 hour TL_m = >100,000 ppm

Any higher concentrations would exceed the practical limits of the test mothod.

* Due to the formation of an extremely viscous gel in freshwater, a loss of viability in the test organisms occured, and thus obscures the standard consideration of "toxicity". This loss of viability can be attributed to mechanical blockage of gill function.

TOXICITY DATA ON MC QUEBRACHO

A BIOASSAY - MC QUEBRACHO - A DRILLING FLUID ADDITIVE

INTRODUCTION:

MC Quebracho is a moderately water soluble tannin used as a drilling fluid additive. It is a powerful organic dispersing agent composed of 100 % active materials for controling viscosity, gel strength, and improving wall cake properties. It functions equally well in low pH, high pH, and lime treated mud systems. As a protective colloid it aids in overcoming the effects of cement in low pH systems.

The toxic effects of tannin on aquatic life (both marine and fresh water species) are of great importance; hence, the following tests were conducted in order to determine the acute fish toxicity of MC Quebracho.

PROCEDURE:

Fish kill studies applying the Acute Fish Toxicity Test of the American Public Health Association were conducted using a current field sample of MC Quebracho. All tests were conducted by an independent testing laboratory.

TEST RESULTS AND CONCLUSIONS:

The test results are listed as TL_m (Median Tolerance Limit) which represents a concentration which caused fatalities in 50% of the test organisms (Mollienisias latipinna-Sailfin Molly) for a specified period of time.

MC Quebracho is normally used in concentrations ranging from 2-5 pounds/barrel. This corresponds approximately to 6,000 - 15,000 ppm depending on viscosity.

A FRESHWATER

24 - 72 hour TL_m = 140 ppm

96 hour TL_m = 135 ppm

B. SEAWATER

24 hour TL_m = 170 ppm

48 - 96 hour TL_m = 158 ppm

DRESSER

ADVISORY BULLETIN
FOR
BENTONITE CLAY IN CASES WHERE FREE SILICA MAY BE PRESENT

General- Bentonite clay is not considered a toxic or hazardous material although it may contain a small percentage of free silica in the crystalline forms of alpha quartz and/or cristobalite. To determine if such an exposure to silica exists, airborne dust samples must be taken in the work area for qualitative determination of silica content and total quantitative dust per given unit of air—either in M.P.P.C.F. (million particles per cubic foot) or in mg/M^3 (milligrams per cubic meter).

Airborne Dust Silica Analysis- Qualitative silica determination of airborne dust samples is the only acceptable means of silica exposure evaluation. Evaluation must not be based on qualitative analysis of the raw bentonite mineral or settled dust in the work area inasmuch as this is not representative of the actual silica dust content in the breathing zone of the employee.

Analysis for silica content of airborne dust should be conducted with x-ray diffraction for most accurate results. Wet chemistry analysis is not recommended.

Silicosis- Frequently referred to as pneumoconiosis or a "dusty lung condition" may occur to employees who are exposed to high concentrations of very fine silica particles (0-5 microns) over long periods of time. Employees exposed on a daily basis may begin exhibiting indications on chest x-rays within three (3) to five (5) years, although an advanced stage may not be reached for twenty (20) years or longer. Such indications are dependent upon the susceptibility of the individual. Many individuals might have exposures of twenty years or longer with no medical indication of Silicosis.

T.L.V.-Threshold Limit Value- The T.L.V. established by the A.C.G.I.H. (American Conference of Governmental Industrial Hygienists) and adopted by O.S.H.A. is as follows:

1. Cristobalite-Use one-half the value calculated from the count or mass formulae for quartz.

2. Quartz- TLV in mppcf: $\dfrac{300}{\%\ \text{quartz} + 10}$

TLV for respirable dust in mg/M^3:

$$\frac{10\ \text{mg/m}^3}{\%\ \text{Respirable quartz} + 2}$$

TLV for "total dust", respirable and non-respirable:

$$\frac{30\ \text{mg/m}^3}{\%\ \text{quartz} + 3}$$

Time Weighted Exposure- Industries with employees exposed to silica dust on a daily basis for many years are more likely to identify possible silicosis cases. On the other hand, industries that use a material containing silica for short periods of time on an infrequent schedule are not likely to experience silicosis cases. One example of very minimal exposure to silica dust due to the time-weighted exposure is in the oil drilling industry where employees infrequently introduce small quantities of materials into the drilling mud system. However, for maximum comfort of that employee, U.S. Bureau of Mines approved respirators are required during even the short duration of time that he is handling such material.

Prevention of Possible Silicosis- The following is recommended for the protection of employees in industries where silica may be present in airborne dust over extended periods of time.

1. **Health and Employment History Examination** - An employee health history must be examined prior to placing him in any dusty work condition—particularly when silica may be present. This should include working in dusty trades or welding. It also should include a review of respiratory problems such as tuberculosis, histoplasmosis, emphysema, etc.

2. **Physical Examination** - The pre-employment examination should include a vital capacity test of the respiratory system, and both lateral and posteroanterior x-rays of the chest. A competent radiologist should be chosen to interpret x-rays, both at the time of employee placement in a dusty atmosphere and following future routine x-rays for consistency in comparison and interpretation.

3. **Follow-up Examination** - Vital capacity tests, and PA and Lateral x-rays of the chest should be conducted annually or as the radiologist requires during the employee's tenure in a dusty trade containing airborne particles of silica.

4. **Respiratory Protective Equipment** - The employee must be required to wear U.S. Bureau of Mines approved respiratory protective equipment suitable for this work and consistent with his need for protection.

5. **Monitor Airborne Dust for Silica** - Frequent monitoring should be conducted to assure maintenance of airborne dust levels below the T.L.V.

6. **Dust Controls and Preventative Maintenance** - Plant dust control equipment must be installed and maintenance constantly performed to maintain airborne dust to zero or well below the T.L.V.

7. **Removing Employees from Dusty Atmosphere** - Should an employee be diagnosed as having an indication of Silicosis, he should be immediately transferred to a non-dusty work place.

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APPENDIX B

Summary of methods and costs of common erosion-control practice.

Treatment	Comments	Pregeneration Erosion Effectiveness*	Effectiveness on Plant Establishment*	Approx. Cost per Acre $**
1. Seed and fertilizer broadcast on the surface, no soil coverage or mulch.	Inexpensive and fast. Most effective on rough seedbeds with minimum slope and erodability where seed will cover naturally with soil. Suitable for remote or critical areas where machinery cannot be taken.	1	1-4	250
2. Hydroseeding or hydromulching (seed + fertilizer) with 500 lb. wood fiber, 1,500 gal water/ 1 acres.	Similar effectiveness to broadcasting seed and fertilizer. Not enough fiber to hold seed in place or produce a mulch effect. Seed distribution would be improved by increased volume of water.	1	1-4	250
3. Seed and fertilizer broadcast and covered with soil (raking or dragging a chain, etc.).	Does not require special equipment. Generally a very effective treatment. Labor cost is high on areas not accessible by equipment.	1	1-4	320
4. Hydromulching with 1,500 lb/acre wood fiber (plus seed and fertilizer).	Most common hydromulch mix in California. Advantages include holding see and fertilizer in place on steep and smooth slopes where there may not be an alternative method. Only a minimal mulch effect. Cost is much higher than 2.	2	3-5	425-520
5. Hydromulching with 1,500 lb. woodfiber plus an organic glue: Ecology Control, Terratack III etc. plus seed and fertilizer.	The addition of an organic glue will sometimes improve fiber holding and germination. Does not increase labor or machinery cost.	2 +	3-6	550-650
6. Hydromulching with 2,000-3,000 lb/acre wood fiber plus seed and fertilizer.	Produce a true mulch effect and some erosion protection. Commonly better results than 1,000 lb fiber or fiber plus glue.	2-3	4-7	530-750
7. Seed and fertilizer broadcast and covered with soil as in 3 above, but followed with hydromulch of wood fiber at 2,000-3,000 lb/acre.	Very effective, combines advantages of seed coverage and mulching.	2-3	6-8	680-865
All of the above treatments offer only minimal protection from the impact of raindrops and water flowing over the surface, but are all weed free.				
8. Straw or hay broadcast with straw blower on the surface at 3,000 lb/acre and tacked down (asphalt emulsion, Terratack II, etc.). Seed and fertilizer broadcast with hyroseeder by hand.	Common elsewhere in U.S. Very effective as energy absorber, mulch; and straw forms small dams to hold some soil. May be weedy depending on straw source. Not for cut slopes steeper than 2:1. Cost would increase significantly if slopes over 50 feet from access, or application is uphill.	5-7	8-10	650
9. Straw broadcast 4,000 lb/ acre rolled to incorporate (punched) another 4,000 lb straw broadcast and rolled, seeded and fertilized. Seed and fertilizer broadcast with hydroseeder or by hand.	Common on difficult fill slopes in California. Very effective. Not possible on most cut slopes. Very weedy. Cost would increase significantly if slopes over 50 feet from access.	6-8	8-10	877-1070
10. Roll-out mats (jute, excelsior, etc.). Held in place with wire staples. Seed & fertilizer as in 1 or 2.	Some are a good mulch, weed free, adapted to small areas. Can be installed any season, cuts or fills. Unsightly. Difficult to install on rocky soils.	5-7	5-10	2400-2700
11. Polyethylene sheets. (4 mil) Seed & fertilize as in 1 or 2, use clear plastic, black if no seed is used.	Useful for temporary control. Can be installed any season. Unsightly, wind is a problem in installation and maintenance. May be difficult to establish plants.	10	?	2400-2700
12. Seed and fertilizer broadcast, or hydromulched with fiber (treatment 2 or 4), followed by erosion control chemical such as polyvinyl acetate at 6:1 dilution (6 parts water) at 1,000 lb solid/acre (approx. 200 gal. PVA).	Very expensive, but will hold soil and seed in some very difficult conditions. May restrict penetration of water into soil. Will not cure below 55° F. Not effective on soils which crack. Will not support animal or vehicle traffic.	10 +	?	1070-1370

* 1 - minimal, 10 - excellent.

** Assume seed plus fertilizer $150.00, fiber $150/ton, Ecology Control $1.25/lb., PVA $3.00/gal., 1,500 gal hydroseeder with 2 man crew $55.00/hr., labor $13/hr., straw $50/T, straw mulcher with 4 man crew $64/hr (applies 2 T/hr) and markup of 30% for overhead (including equipment depreciation), and profit. Cost figures were derived from conversations with contractors, and by review of recent Caltrans contracts.

† Adapted from: Kay, Burgess L. 1976. Soil binders--a progress report on the use of "plastic" emulsions. International Erosion Control Association Conference VII, Portland, OR. Department of Agronomy and Range Science, UCD, mimeograph. 9 p. February.

APPENDIX C

REACTION - TYPE CONTINGENCY PLAN

Slightly modified from
a plan suggested by:

Kenneth W. Bull
Salt Lake City, Utah

CONTINGENCY PLAN

EMERGENCY ACCIDENTAL SPILLS AND DISCHARGES CONTROL PROCEDURES

I INTRODUCTION

- A. PRE-PLANNING THE DRILLING OPERATION

II POTENTIAL LOCATIONS WHERE DISCHARGE INCIDENTS MIGHT OCCUR

- A. POTENTIAL LOCATION FOR ACCIDENTAL SPILLS
- B. DRILLING FLUIDS (MUD)
- C. LUBRICATING OR FUEL OILS AND PETROLEUM PRODUCTS
- D. CONSTRUCTION/MAINTENANCE DEBRIS

III POSSIBLE WATER QUALITY EFFECTS

- A. CONDENSATE OR DRILLING MUDS
- B. PETROLEUM PRODUCTS

IV PLAN FOR CLEAN-UP AND ABATEMENT

- A. SPILL LESS THAN 250 GALLON
- B. SPILL LARGER THAN 250 GALLON

V CONFIRMATION OF TELEPHONE NOTIFICATION TO AGENCIES AND REGULATORY BODIES

VI HYDROGEN SULPHIDE AND OTHER TOXIC GASES CONTINGENCY PLAN

- A. INTRODUCTION
- B. GENERAL INFORMATION
- C. APPENDIX 'A'
- D. TRAINING
- E. DRILL PROCEDURES
- F. PROCEDURES FOR OPERATING CONDITIONS

VII CONTINGENCY PLAN FOR UNCONTROLLED BLOWOUT

- A. INTRODUCTION

VIII INJURIES

IX RESCUE

X EMERGENCY PERSONNEL AND SERVICES

I. INTRODUCTION

This plan is intended to give specific and general information regarding the development of an overall contingency plan for the control and abatement of spills and specific procedures when poisonous gases and/or uncontrolled blowout occur during the drilling of Geothermal Resource wells.

Not all portions are applicable in all cases but the possibility of encountering gases of poisonous portions are a real threat each time a well is drilled. Therefore, the Company requesting permission to drill must be prepared to protect all persons involved, in case of a spill, an uncontrolled blowout or encounter with poisonous gases.

The plan should follow the suggested outline but the introduction portion (giving the location and proposed drilling plan), the list of personnel to be notified and other specific requirements for a specific site can be submitted as an addendum to the plan for which approval is being requested from the Area Geothermal Supervisor.

A. PRE-PLANNING THE DRILLING OPERATION

This section is written with wildcat drilling in mind where the location should be planned to obtain maximum safety consistent with rig configuration, well depth, terrain, prevailing winds, etc. Modification of requirements may be indicated in the areas of well workover and development drilling.

1. Using a contour map, check out the area within a one-mile radius of the location. Except in a dead calm and a tremendous release of high concentration gases, the probability of lethal dosages beyond a mile is extremely unlikely. Note on the map the direction of prevailing

winds for summer and winter. It may be necessary to move the well site from a low area to a higher one to take advantage of wind movement.

2. Note on a map the location of houses, schools, barns, pens, roads, and anything else that might cause people to be present and who might need to be warned or evacuated in a crisis. Recording this information is important and in an emergency could prevent a catastrophe. Names should be listed and contact should be made, after drilling begins, explaining the hazard and that evacuation might be necessary should an emergency develop.
3. Wind socks or streamers should be utilized to give wind directions at several elevations (i.e., tree top or monkey board level, derrick floor level, and 6 to 8 feet above ground level). Personnel should develop the practice of routine observation of wind direction.
4. Mud tanks should be located away from the derrick substructure to facilitate circulation of fresh air around the cellar area.
5. Reliable 24-hour radio and/or telephone communication should be available at the rig. Emergency telephone numbers for: Sheriff's Department; ambulance; hospitals; doctors; and contractor's and operator's supervisory personnel should be prominently posted.
6. Physical examinations should be given to all personnel to assure that no individual with any of the following conditions is allowed to work in the area:
   a. Perforated ear drums
   b. Psychological diseases or other medical conditions apt to produce loss of consciousness.
   c. Any inflammatory conditions of the eyes.

d. Any serious respiratory disease

e. Alcoholism

7. Designate smoking areas and prohibit smoking elsewhere.

8. Assign a safety coordinator to each tour and provide a check-list for his use. During an emergency, supervisors have so many other responsibilities they may neglect this important duty.

9. Do not permit sleeping in cars on location. If practical, maintain a parking area remote from the location.

10. Safety meetings and training sessions should be held at frequent intervals. All persons required to work on the location should be throughly familiar with the use, care, and servicing of: Personal protective equipment; resuscitation equipment; and gas detection equipment. New employees and those who are present on a sporadic basis (i.e., geologists, engineers, service personnel, etc.) should be indoctrinated in the location and use of personal protective equipment before commencing work.

11. All electric lighting, wiring, and devices within 100 feet of the well should be put in vapor-proof condition to minimize the possibility of explosion.

II. POTENTIAL LOCATIONS WHERE DISCHARGE INCIDENTS MIGHT OCCUR

A. Potential locations for accidental spills are:

1. Drilling Rigs
2. Water ponds, or mud pits.
3. Pipelines at well or drillsites.

B. Drilling Fluids (Muds):

These are a mixture of water, chemicals, and solid particles used in drilling operations. Mud is pumped down the drill pipe, through the bit and carries drilled cuttings to the surface. The cuttings are screened out and the mud recirculated. A small amount of mud is spilled into the sump, along with water used to wash down the rig floor, etc. The sump is designed to be large enough to contain all cuttings, mud and water that will accumulate during the drilling of the well. The sump is an earthen pit whose bottom is lined with Bentonite to prevent any perculation. The sump is positioned in such a manner as to prevent flooding from runoff water from a heavy rainstorm.

Although the danger is slight, a spill could occur by the sump overflowing, the wall breaking or through fluid seepage. Some mud is spilled onto the area immediately round the well bore during normal drilling operations, but these volumes are small. A spill could occur if circulation were lost at a very shallow depth and mud channeled back to the surface.

C. Lubricating or fuel oils and petroleum products - A discharge of this type would probably be very small and from equipment used in the field. Potential locations for accidental spills are:

1. Drilling equipment and machinery at and around drilling locations.

2. Other miscellaneous equipment and machinery at well sites and on roads.

D. Construction/maintenance debris - Minor consideration, usually able to be cleaned up on the job. Potential locations are the same as for lubricating or fuel oils, (C), above.

III. POSSIBLE WATER QUALITY AFFECTS

A. Condensate or drilling muds.

1. Contaminate water possibly making it unsuitable for human or wildlife consumption.
2. Possible detrimental affect to flora of area.
3. Increase turbidity of water by particulates in fluid or by soil erosion.

B. Petroleum products

1. Contaminate water
2. Cover wildlife and plant life

IV. PLAN FOR CLEAN-UP AND ABATEMENT

In the event of discharges of condensate, drilling muds, petroleum products or construction debris, the overall contingency plan is as follows:

A. The person responsible for the operation will make an immediate investigation, then call the Field Drilling Foreman and advise him of spill. The Field Drilling Foreman will in turn call out heavy equipment, regulate field operations, or do other work as applicable for control and clean-up of spill. If spill is small (i.e., less than 250 gallons) and easily containable without endangering watershed, Field Drilling Foreman will direct and

supervise complete clean-up and return to normal operations.

B. If spill is larger than 250 gallons, or is not easily contained, or endangers or has entered watershed, Field Drilling Foreman will proceed to take necessary action to curtail, contain and clean-up spill, and notify personnel as follows:

1. Call out heavy equipment, regulate field production, etc.
2. Call for contract vacuum trucks or water pump trucks.
3. Brief his immediate supervisor on the situation and course of action under way.
4. Specific Procedures:

   A. For drill water:

   Contain spillage with dikes if possible haul to disposal sump or well by vacuum or water trucks.

   B. For drilling mud:

   Repair sump or contain with dikes.

   Haul liquid to another sump or available tank or approved disposal site.

   Dry and solidify other material, compact and bury solids where possible.

   C. For petroleum products:

   Contain spill with available manpower.

   Use absorbents and dispose of same in County approved area.

   D. For construction debris:

   Pick up or otherwise contain and remove to disposal area.

5. Have source of spill repaired at earliest practical time.
6. Continue working crews, equipment and vacuum trucks on clean-up until all concerned agencies are satisfied.

7. Notify the following agencies or regulatory bodies as soon as practical and work closely with them in all phases of operations.

   A. United States Forest Service - District Ranger (if on forest lands or if forest lands included)

   B. U. S. Fish & Wildlife Service

   C. Any livestock owners or landowners, if spills affect stock or property.

V. CONFIRM TELEPHONE NOTIFICATION TO AGENCIES AND REGULATORY BODIES

Telephone notification shall be confirmed by the District Drilling Superintendent in writing within two (2) weeks of telephone notification, containing:

1. Reason for discharge or spillage.
2. Duration and volume of discharge.
3. Steps taken to correct problem.
4. Steps taken to prevent recurrence of problem.

VI. HYDROGEN SULFIDE AND OTHER TOXIC GASES CONTINGENCY PLAN

A. Introduction

It is recognized that hydrogen sulfide gas (sour gas) or other toxic gases could be encountered during the drilling of geothermal wells. The well stream will be monitored at all times and if a dangerous increase in H_2S is noted controls will be applied immediately to keep the emission rate at an acceptable level.

The Lessee or operator will be prepared to protect all personnel in the event dangerous amounts of hydrogen sulfide are discharged into the atmosphere. The wells will be drilled using accepted drilling practices.

The plan will provide safety programs for personnel, safety equipment, safety drills, and up-to-date instructions in rescue techniques. The overall plan will be directed by consultants who have specialized in these emergency procedures. Each person participating in the drilling of the wells will know the location of all safety equipment and will be responsible for its maintenance.

Before drilling has begun, all personnel will be advised of an escape route other than the main access road and will be instructed as to evacuation procedures. If danger to life becomes extreme, all nonessential personnel will be evacuated.

B. General Information

All personnel involved with the mechanics of drilling, evaluation and testing the wells will be throughly trained in the recognition of warning signals, the operation of breathing equipment and their responsibilities in case of emergency rescue techniques and first aid.

1. PRECAUTIONS TO BE TAKEN WHEN HYDROGEN SLUFIDE GAS IS KNOWN OR SUSPECTED

a. Every person involved in the operation should be informed of the characteristics of Hydrogen Sulfide gas, its danger, safe procedures to be used when it is encountered, and recommended first aid procedures. This should be done through frequent safety talks and training sessions.

b. Instructions in the use of available resuscitators and personal protective equipment should be given to all personnel.

c. Any time Hydrogen Sulfide gas is suspected, a test should be made to determine its presence and concentration. Do not try to determine the presence of Hydrogen Sulfide by its odor because the sense of smell is rapidly paralyzed by the gas.

d. Personnel should watch out for each other, using the "buddy" system whenever possible.

e. Warning signs should be posted to alert the uninformed.

f. Adequate ventilation should be maintained in all work areas.

g. Never allow personnel to enter an enclosed area where Hydrogen Sulfide may have accumulated without wearing proper respiratory protective equipment. If the worker is over an arm's length away, a safety belt should be worn secured to a life line held by a

responsible person who is in the clear.

h. Protective equipment should be readily accessible to all personnel.

i. It should be recognized that Hydrogen Sulfide, being heavier than air, will collect in low spots around the rig, particularly in the well cellar.

2. PHYSICAL AND CHEMICAL PROPERTIES OF HYDROGEN SULFIDE GAS (H_2S)

a. Extremely toxic (as toxic as Hydrogen Cyanide and 5 to 6 times as toxic as Carbon Monoxide).

b. Colorless.

c. Offensive odor, often described as that of rotten eggs. Unreliable indicator because high concentrations dull sense of smell.

d. Heavier than air - Specific gravity 1.189 (Air = 1.000 @ 60°F).

e. Forms an explosive mixture with air in concentrations between 4.3 & 46 percent by volume with auto-ignition occuring at 500°F.

f. Burns with a blue flame and produces Sulfur Dioxide (SO_2). which is highly toxic and very irritating to eyes and lungs and can cause serious injury.

g. Soluble in both water and liquid hydrocarbons.

h. Produces irritation to eyes, throat, and respiratory system.

i. Threshold Limit Value (TLV) - Maximum of eight hours exposure without protective respiratory equipment - 10 ppm.

j. Corrosive to all electrochemical series metals.

k. Boiling Point (-) 79°F.

l. Melting Point (-) 117°F.

3. SEE TABLE

a. Toxicity of Hydrogen Sulphide to men

b. Toxic of Various Gases

TABLE 'A

Table

Toxicity of hydrogen sulfide to men

H_2S %	0-2 Min	2-15 Min	15-30 Min	30 Min-1 Hr	1-4 Hr	4-8 Hr	8-48 Hr
0.005 0.010 50-100 ppm				Mild conjunctivitis; respiratory tract irritation.			
0.010 0.015 100-150 ppm		Coughing; irritation of eyes; loss of sense of smell.	Disturbed respiration; pain in eyes; sleepiness.	Throat irritation.	Salivation and mucous discharge; sharp pain in eyes; coughing.	Increased symptoms.*	Hemorrhage and death.*
0.015 0.020 150-200 ppm		Loss of sense of smell.	Throat and eye irritation.	Throat and eye irritation.	Difficult breathing; blurred vision; light shy.	Serious irritating effect.*	Hemorrhage and death.*
0.025 0.035 250-350 ppm		Irritation of eyes; loss of sense of smell.	Irritation of eyes.	Painful secretion of tears; weariness.	Light shy; nasal catarrh; pain in eyes; difficult breathing; conjunctivitis.	Hemorrhage and death.*	
0.035 0.045 350-450 ppm		Irritation of eyes; loss of sense of smell.	Difficult respiration; coughing; irritation of eyes.	Increased irritation of eyes and nasal tract; dull pain in head; weariness; light shy.	Dizziness; weakness; increased irritation; death.	Death.*	
0.050 0.060 500-600 ppm	Coughing; collapse and unconsciousness.*	Respiratory disturbances; irritation of eyes; collapse.*	Serious eye irritation; light shy; palpitation of heart; a few cases of death.	Severe pain in eyes and head; dizziness; trembling of extremities; great weakness and death.*			
0.060 0.070 0.080 0.10 0.15 600-1,500 ppm	Collapse;* unconsciousness;* death.	Collapse,* unconsciousness;* death.*					

*Data secured from experiments on dogs which have a susceptibility similar to men.

Source: National Safety Council data sheet D-chem. 16

TOXICITY OF VARIOUS GASES

Table "B"

Common Name	Chemical Formula	Specific Gravity (SG) SG Air = 1	Threshold[1] Limit	Hazardous[2] Limit	Lethal[3] Concentration
Hydrogen Cynaide	HCN	0.94	10 ppm	150 ppm/hr	300 ppm
Hydrogen Sulfide	H_2S	1.18	10 ppm[4] 20 ppm[5]	250 ppm/hr	600 ppm
Sulfur Dioxide	SO_2	2.21	5 ppm	-	1,000 ppm
Chlorine	Cl_2	2.45	1 ppm	4 ppm/hr	1,000 ppm
Carbon Monoxide	CO	0.97	50 ppm	400 ppm/hr	1,000 ppm
Carbon Dioxide	CO_2	1.52	5,000 ppm	5%	10%
Methane	CH_4	0.55	90,000 ppm (9%)	Combustible - above 5% in Air	

[1]Threshold Limit - concentration at which it is believed that all workers may be repeatedly exposed day after day without adverse effects.

[2]Hazardous Limit - concentration that may cause death.

[3]Lethal Concentration - concentration that will cause death with short-term exposure.

[4]Threshold Limit = 10 ppm - 1972 ACGIH (American Conference of Governmental Industrial Hygienists).

[5]Threshold Limit = 20 ppm - 1966 ANSI acceptable ceiling concentration for eight-hour exposure (based on 40-hour week) is 20 ppm. OSHA Rules and Regulations (Federal Register, Volume 37, No. 202, Part II, dated October 18, 1972).

3. PHYSICAL EFFECTS OF HYDROGEN SULFIDE POISONING

The principal hazard is poisoning by inhalation. When the concentration of gas absorbed into the blood stream is high enough, systemic poisoning results, with specific action on the nervous system. Respiratory irritation occurs at low concentrations and respiratory paralysis may follow immediately at higher concentrations. This condition may be reached almost without warning as the originally detected odor of Hydrogen Sulfide may have disappeared due to olfactory paralysis. Death then occurs from asphyxiation unless the exposed person is removed immediately to fresh air and breathing stimulated by artificial respiration. Other levels of exposure may cause the following symptoms individually or in combinations:

a. Headache.

b. Dizziness.

c. Excitement.

d. Nausea or gastrointestinal disturbances.

e. Dryness and sensation of pain in eyes, nose, throat and chest.

f. Coughing.

4. TREATMENT FOR HYDROGEN SULFIDE POISONING

a. Inhalation - Hydrogen Sulfide in the blood is det oxified rapidly, and symptoms of acute poisoning may pass off when inhalation of the gas ceases. It is important, therefore, to get the victim of poisoning to fresh air as quickly as possible. He should be kept at rest and chilling should be prevented. If respiration is slow, labored or impaired, artificial respiration, either mouth-to-mouth resuscitation or use of a resuscitator, may be necessary. Artificial respiration should be performed with great caution, but with presistence and skill. Most persons overcome by Hydrogen Sulfide gas may be revived if artificial respiration is applied before the heart action ceases. Victims of poisoning should be under the care of a physician as soon as possible. Irritation due to subacute poisoning may lead to serious complications such as pneumonia. Under these conditions, treatment by a physician is mandatory. The patient should be kept in fresh air and hygienic conditions should be watched carefully until proper medical care is obtained.

b. Contact with Eyes - Prolonged eye contact with liquids or gases containing Hydrogen Sulfide in low concentrations or short eye contact at high concentrations will cause painful irritation (conjunctivitis). In the case of short contact, flush the eyes with pure water (do not use a hose or other pressured device). apply cool compresses to the eyes, and send for a physician. Eye irritation caused by exposure to Hydrogen Sulfide requires treatment by a physician, preferably an eye specialist. Recovery in these cases is usually good.

c. Contact with Skin - Skin absorption is very low. Skin discoloration is possible after contact with liquids containing Hydrogen Sulfide. If such skin contact is suspected, the area should be throughly washed.

5. DRILLING AND TESTING HYDROGEN SULFIDE WELLS

1. RIG LOCATION

The drilling rig should be situated on location such that prevailing winds blow across the rig toward the reserve pit or at right angles to a line from the rig to the reserve pit.

2. SAFETY AREAS

At least two safety areas should be established at least 200 feet from the wellhead and in such location that at least one area will be upwind of the well at all times. Personnel gas protective equipment should be stored in these areas. It may be necessary to move equipment with changes in wind direction. In the event of an emergency, personnel should assemble at the most upwind safety area for instructions from their supervisor. (See Appendix for list of safety equipment.)

3. GAS TRAP AND DEGASSERS

A gas trap and degasser (see Appendix A) should be installed on the mud tanks with their gas discharge lines connected with two flare lines laid in opposite directions perpendicular to prevailing winds, at least 150 feet in length, securely staked, and terminating in a 30 to 50-foot riser equipped with a butane line and pilot lights which can be remotely ignited.

4. KILL LINE

A kill line of ample strength and securely staked should be laid to the wellhead from a safe location to permit pumping into the well in an emergency.

5. H_2S SCAVENGER

Well planning should provide for the use of a suitable hydrogen sulfide scavenger in the drilling mud. Due to its corrosive side effects, copper carbonate is not suitable. The mud should be maintained in an overbalanced condition to preclude the entry of formation fluids into the well bore and thereby restrict the hydrogen sulfide to be treated to that contained in the formation drilled.

6. WARNING SIGNS

Warning signs should be posted on all access roads to the location and at the foot of all stairways to the derick floor.

7. GAS MASKS

Filter-type gas masks are not considered suitable for use on drilling rigs. Bureau of Mines-approved, self-contained breathing apparatuses (air-pack type masks) provide protection in any hydrogen sulfide concentration. The self-contained breathing apparatuses that have alarms that signal when air supply is getting low should be used. Their operation is simple; they are easily and quickly serviced with replacement bottles; they are not physically exhausting to use; and they are rugged, dependable, and require little maintenance.

8. GAS MASK STORAGE

Masks should be stored on racks and protected from the weather in the safety areas mentioned in item h. There should be sufficient masks on location for every person working in the area. For hygienic reasons, regular crews should have masks assigned to each individual for his exclusive use and maintenance. The derrickman should have a mask, mask storage, and connection through a quick-disconnect on his mask to a 300-cubic foot capacity bottle of breathing air so that if he must evacuate the derrick, he will have a full air bottle with his mask. The line to the 300-cubic foot capacity bottle should be attached to the ladder in such a manner that the derrickman can bring the line with him leaving the derrick if he should so choose.

9. EXTRA SUPPLIES

Provide a minimum of: one spare air-pack bottle for each pack, plus several extra bottles; three or four 300-cubic foot capacity air cylinders and a bottle

filling manifold at each safety area; at least one resuscitator, preferably one at each safety area. The rig air system is not a satisfactory source of compressed air for breathing purposes because of oil and other contaminants which are invariably found in such systems.

10. DETECTORS

Provide hand-operated hydrogen sulfide detectors in addition to the equipment used by the drilling technology unit.

11. ALARMS

Install an alarm system that can be heard during operations and which can be activated from several points if gas is detected.

12. BOP

Blowout preventers, particularly the ram carrier rods, should be dressed for hydrogen sulfide service.

13. BOP TESTS

Installation, operation, testing of blowout preventers, choke manifolds, etc., dressed for hydrogen sulfide service, should be conducted in accordance with standard company practice. Inclusion of a rotating blowout preventer should be considered.

C. APPENDIX 'A'
SAFETY EQUIPMENT

Gas Dectors - The following are examples of the types of Hydrogen Sulfide detectors available for use by rig personnel:

1. Del Mar Products "Spot Check" Hydrogen Sulfide Detector is a light-weight, inexpensive unit, which can be carried in a shirt pocket. The sensitized tape will detect minute amounts of Hydrogen Sulfide depending on time of exposure, but will instantly show high concentrations. Over 1,000 tests can be made before tape is exhausted. Replacement tapes are easily installed. It is not intended to be a scientific measurement device, but will indicate concentration by various shadings of brown spot coloring. Very light, visible spots will indicate as low as 2 to 3 ppm and very dark brown spots will indicate 20 ppm or higher.

2. M.S.A. Hydrogen Sulfide Gas Detector

   a. Range - 0.0025% or 25 ppm to 0.04% or 400 ppm.

   b. Principle of Operation - The detector consists of a bulb, detector tube, and a movable scale reading in % and ppm. Squeezing and releasing the bulb draws the tested air through the detector tube to react with lead acetate-silica gel granules. Presence of Hydrogen Sulfide in the air sample is shown by the development of a dark brown stain on the granules.

   c. Test Procedure - Break both ends of detector tube, insert colored end through guide to rest in cushion at the bulb end, adjust the upper end of the instrument over the top of the detector tube and hold the tube in place with the retaining head. Adjust the sliding scale on the detector until the zero line is opposite the beginning of the lead acetate-silica gel granules. Squeeze the bulb 8 to 10

times allowing the bulb to expand completely after each squeeze The reading opposite the end of the dark stain gives a direct reading of the concentration of Hydrogen Sulfide in the air sampled.

3. Bacharach Hydrogen Sulfide Indicator Code 19-5027 - Very similar in principle of operation and test procedure to the M.S.A. detector described above. By varying the number of strokes and scale selection, the detection range has been expanded from zero to 650 ppm.
4. Houston Atlas, Inc. Model 722 AEX Hydrogen Sulfide Gas Analyser - Furnishes continuous monitoring and a chart recording with 20 ppm full scale reading on the standard unit. A photoelectric cell measures color change on a tape impregnated with lead acetate. The unit can be used for stripped stream or atmospheric sampling. It is equipped with an explosion-proof alarm.

Degasser

1. Principle of Operation - The degasser is a cylindrical vacuum vessel mounted over or near the first mud settling pit. It normally has a flow capacity several times the normal mud flow rate and is equipped to: Treat all the gas-cut mud as it comes from the flowline or gas box; separate and vent all the entrained gas; and return the mud, free of gas, to the mud system ahead of the suction pit.
2. Procedure - When Hydrogen Sulfide gas cutting of the mud is detected, close the annular blowout preventer, if a rotating blowout preventer is not in use, and maintain normal circulation through open coke lines to the gas box, put the degasser into operation, and light the flare. Continue circulating while observing well pressures and changes in gas volume, if any. All personnel in the pit area should wear gas protection equipment during this period. Should the gas volume continue at a steady rate or

increase in volume, an increase in mud weight is probably necessary. Should the gas volume decrease, it may be possible to open the blowout preventer and resume drilling while running the degasser. Adjustments in the pH of the mud system and the addition of suitable Hydrogen Sulfide scavengers should also be considered. Make frequent checks for Hydrogen Sulfide accumulation, use protective equipment above 10 ppm, and use ventilating fans to prevent gas accumulation. Trip gas or connection gas is handled in the same manner as gas cut mud. All personnel should wear protective equipment if any significant volume of gas in anticipated on "bottoms up"

Pneolator or Resuscitator

1. Principle of Operation - The Pneolator is an instrument which automatically performs artificial respiration with a gentle predetermined pressure on inhalation and without suction on exhalation. This most nearly represents normal respiration and has been selected by medical authorities as the preferred method in restoring breathing. In addition, when the patient is breathing, the Pneolator becomes an effective oxygen inhalator by a simple adjustment. If the air passage is obstructed by mucous or foreign material, a warning is immediately given by a chattering of the cycling valve and the Pneolator provides an aspirator for removing the obstruction. The Pneolator can be taken to the hospital with the patient if necessary.
2. Procedure - When asphyxia occurs, remove patient to fresh air and immediately apply artificial respiration. Do not wait for the Pneolator. As soon as the Pneolator is available, apply it to the patient as it will perform artificial respiration more efficiently than manual techniques. The patient should be placed on his back with a rolled blanket, jacket, pillow, etc., under his shoulders, his head pulled far backward

with chin pointing up and with front of neck taut. This permits best ventilation of the lungs.

The 21-cubic foot capacity bottle of oxygen in the Pneolator should be checked in advance at regular intervals to assure its readiness when needed. It is recommended that an extra supply of oxygen (i.e.,a commercial tank) be kept on hand.

Personal Gas Protection Equipment (Gas Masks)

1. M.S.A. Tank Gauger's Mask - Filter-type gas masks are not considered suitable for use on drilling rigs because of the high concentrations of Hydrogen Sulfide which may be encountered.
2. Scott Presur-Pak II - The Scott Presur-Pack II is a self-contained air breathing apparatus which operates on the demand principle. Pure breathing air flows from a 45-cubic foot capacity cylinder through a regulator to the face mask. The regulator provides a static, positive pressure inside the mask which will exclude the external atmosphere should a leak develop. The unit has a built-in alarm which rings and vibrates to warn of diminishing air supply.
3. Scott Ska-Pak - The Scott Ska-Pak provides instant emergency respiratory protection to anyone suddenly exposed to an unbreathable atmosphere. This unit consists of a face mask, an air cylinder with 5 to 9 minutes air supply, a regulator, and connection to external air cylinders. It is not necessary to close the cylinder valve as an external air supply pressure of 90 to 125 psi will close the regulator and preserve the air in the cylinder until needed for exit, taking over automatically when the external supply hose is disconnected. This unit is provided for the derrickman with a hoseline from the ground to

the derrickman's work area. It is important when putting the air hose along the ladder that it not be wrapped around a girder so that the derrickman can quickly bring the hose down the ladder with him if he desires.

D. TRAINING

A training and information session will be conducted covering the following:

1. Location of H_2S Safety Equipment, portable fire extinguishers and H_2S detectors.
2. Proper use of H_2S detectors.
3. General information on breathing equipment including length of time it can be worn, testing for leaks around face and hose connections, warning signals when pressure is depleting, maintenance and storage procedures.
4. Proper use of oxygen resuscitators.
5. Importance of wind direction when dealing with H_2S.
6. Procedure for rescuing a person overcome by H_2S.
7. Responsibilities and duties during an emergency.
8. Condition I, II and III alerts.

E. DRILL PROCEDURE

A drill, with breathing equipment, will be conducted with each crew, including the mud loggers and mud engineer. The purpose of the drill is to instruct the crew in the use of breathing equipment and H_2S emergency procedures.

1. The drill will include the following personnel.
   a. Rig crew.
   b. Mud Engineer
   c. Mud Logger
   d. Service Company Personnel assigned to essential duty during an emergency
   e. Drilling Contractor's Supervisor

2. The following procedure will be used for drills:

   a. All personnel will be informed that a drill is to be staged

   b. The mud logger will initiate the drill by manually activating the alarm system

   c. The rig crew, mud logger, mud engineer and drilling supervisors will put on their breathing equipment.
   All other personnel will report to the proper briefing station.

   d. Once breathing equipment is on, the driller will pull off bottom, shut down pumps and check for flow.

   e. The driller shall proceed as if the well is flowing and simulate well shut in procedures.

   f. Mud Logger will continue to monitor his equipment.

   g. The Mud Engineer will perform a mud check for weight, funnel viscosity and run a "Hatch Test" to determine the Sulfide concentration.

   h. Drilling Supervisors will observe to make sure all personnel know their duties. Make corrections where needed.

F. PROCEDURES FOR OPERATING CONDITIONS

When H_2S has been detected in the drilling fluid, operations will be performed under one of the three conditions as listed

1. CONDITION I = POTENTIAL DANGER

   a. Alarms Less than 10 ppm - None

   b. OPERATIONS

   Drilling operations in zones that may contain Hydrogen Sulfide This condition will be in effect continuously from the commencement of drilling unless it is necessary to go to Condition II.

c. GENERAL ACTION

a. Be alert for condition changes.

b. Run a "Hatch Test" on drill fluid routinely.

c. Check all safety equipment and monitors for proper functioning. Keep equipment available and working.

d. Conduct drills and familiarization programs.

2. CONDITION II = MODERATE DANGER

a. ALARM = Horn or Siren actuates at 10 ppm

b. GENERAL ACTIONS

(1.) The following personnel will immediately put on their breathing equipment.

(a) All personnel on rig floor

(b) All personnel in area of mud pits.

(2.) Notify Drilling Supervisors.,

(3.) Follow instructions of Drilling Supervisors.

(4.) Immediately begin to ascertain the source of the H_2S and take the required steps to suppress the H_2S. Drilling will not proceed until the source is determined, the well is circulated and the gas is controlled.

(5.) The Supervisors will make sure all non-essential personnel are out of the potential danger area.

(6.) Check all gas monitoring devices and increase gas monitoring activities with the portable hand operated H_2S detector units.

(7.) The Supervisor will assess the situation, outline a control program and assign duties to each person or group as required to bring the situation under control.

(8.) Signs to be posted on access road to location indicating: "DANGER - HYDROGEN SULFIDE - H_2S".

(9.) Access to drill site to be limited to authorized personnel only.

3. CONDITION III - EXTREME DANGER TO LIFE

(a) ALARM = Horn or Siren
Blinking Lights

(b) CHARACTERIZED BY:

Critical well operations, well control problems, poisonous gas above threshold levels (as defined under toxicity of various gases); and in the extreme, loss of well control.

(c) GENERAL ACTIONS

(1) All personnel will put on their protective breathing equipment.

(2) All personnel not required for well control proceed to upwind briefing area for evacuation instructions.

(3) Follow instructions of Drilling Supervisors.

(4) The Drilling Supervisor will assess the situation, outline a control program, and assign duties to each person or group as required to bring the situation under control.

(5) The Drilling Supervisor will contact the following office:

United States Forest Service

District Ranger (if on forest service lands)

4. EXTREME EMERGENCY

a. If there is no hope of containing well under prevailing conditions and there is a definite threat to human life and property.

(1) Inititate Emergency Evacuation Plan

(2) Refer to Contingency Plan for Uncontrolled Blowout.

(3) Time and circumstances permitting, the District office should be notified of the situation.

(4) As a last resort the well is to be ignited (Poison Gas)

b. INSTRUCTIONS FOR IGNITING THE WELL:

(1) Two people are required for the actual igniting operation. Both men will wear self-contained breathing units and will have 200 foot retrieval ropes tied around their waists. One man is responsible for checking the atmosphere for explosive gases with Explosimeter. The other is responsible for lighting the well. Keep personnel not assigned special duties within the "Safe Briefing Area". Those in the "Safe Briefing Area" will be alert to the needs of the two men assigned to ignite the well. Should either of these men be overcome by fumes, they will immediately pull him to safety by the retrieval ropes.

(2) The primary method for igniting the well is a 25mm meteortype flare gun. It has a range of approximately 500 feet. If this method fails or well conditions are such that a safer or better method is apparent, then the alternate should be used.

(3) If the well is ignited, the burning Hydrogen Sulfide will be converted to Sulfur Dioxide which is also poisonous. Therefore

DO NOT ASSUME THAT THE AREA IS SAFE AFTER THE GAS IS IGNITED. CONTINUE TO OBSERVE EMERGENCY PROCEDURE AND FOLLOW THE INSTRUCTIONS OF SUPERVISORS.

C. Initiate program to kill, plug and abandon well.

VII. CONTINGENCY PLAN FOR UNCONTROLLED BLOWOUT

A. When the means to shut in or control the flow from a well is lost, the Drilling Supervisor is to:

1. Initiate appropriate control procedures, (Procedures will vary greatly depending on the magnitude of the problem).
   (a) If any injuries have occurred, dispatch all injured personnel to the nearest medical facility by the fastest transportation available.
   (b) If there is a threat to any local residents the sheriff should be notified as soon as possible.
2. Secure and maintain control of access roads to area to eliminate entry of unauthorized personnel.
3. Initiate any further or supplemental steps which may be necessary or advisable based on consultation with the District Geothermal Supervisor
4. Put into motion plans for containment or confinement of the flow.
5. Notify "Wild Well Control" specialists and apprise them of the problem:

   Red Adair Company, Inc.
   Houston, Texas

   (713) 526-4717
   (713) 562-1602

6. Construct sumps or dikes to contain fluid flow if necessary
7. Attempt to control well with rig personnel.
8. Attempt to remove any damaged wellhead facility or blowout prevention equipment and install operable equipment.

9. If contractor's personnel are unable to contain flow, notify "Wild Well Control" specialists.

10. Maintain an inspection of the drill site for any erosion that could undermine the rig structure.

11. After the flow has been contained, prepare to return the area as nearly as possible to its original contour and reseed with approved vegetation.

VIII. INJURIES

In the event of injuries that may occur, connected with the SUNEDCO geothermal operation, procedures will be followed with specific and immediate attention given to proper air and/or transportation to a medical facility as required. Refer to Emergency Phone Numbers, Emergency Personnel and Services. Copies of accident reports will be submitted to the U. S. Forest Service, District Ranger.

IX. RESCUE

While drilling operations have made extensive preparations for personnel safety, all personnel should be aware of first aid procedures in the event someone becomes careless. First aid for H_2S victims is based primarily on:

(A) Move the victim to fresh air immediately.

1. Warning--Do not jeopardize your own safety. Always wear a self-contained breathing apparatus while attempting rescue.

(B) If victim is unconscious and not breathing, move the victim at once to the safe breathing area and apply mouth-to-mouth artificial respiration until a resuscitator is available. Use the resuscitator until normal breathing is restored. Symptoms may

pass rapidly; however, keep the victim warm and take him to a hospital and place under the care of a physician.

X. EMERGENCY PERSONNEL AND SERVICES

(The following list of personnel and services shall be submitted as an addendum to the Plan of Operations.)

SERVICE OR INDIVIDUAL	LOCATION	PHONE NUMBERS
Doctors (local)		
Hospitals (local)		
Ambulance Service (ground)		
Ambulance Service (air)		
U. S. Forest Service District Ranger		
Sheriff Department		
Highway Patrol		
Any others needed to be notified.		

APPENDIX D

Project No. 117-78-MK Permit No. USFS December 31, 1978

An Archaeological Clearance Survey in the Jemez Subregion of the Santa Fe National Forest

for

Sunoco Energy Development Company

Locations

Sunedco #1
Sunedco #2

Prepared by:

Meade F. Kemrer

Submitted by:

Meade F. Kemrer, Ph.D.
Principal Investigator

DIVISION OF CONSERVATION ARCHAEOLOGY

Contributions to Anthropology Series, No. 117
San Juan County Archaeological Research Center and Library

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Abstract

The Division of Conservation Archaeology of the San Juan County Archaeological Research Center and Library has completed an archaeological clearance survey of two proposed geothermal drill sites and associated access roads in the Jemez subregion of the Santa Fe National Forest for Sunoco Energy Development Company. The survey was conducted by Meade Kemrer of the Division of Conservation Archaeology on November 15, 1978. The project was administered by Dr. W. G. Christian of Sunoco and Dr. Kemrer of DCA.

Several isolated artifacts were found scattered along the proposed route of the access road to the drill pad of Sunedco #2. No other materials or features of historic/prehistoric significance were found in the areas of proposed impact. Archaeological clearance is recommended for both drill sites and associated access roads.

Introduction

The Division of Conservation Archaeology of the San Juan County Archaeological Research Center and Library has completed an archaeological survey of two geothermal drill sites and associated access roads for the Sunoco Energy Development Company of Dallas, Texas in the Jemez subregion of the Santa Fe National Forest. The survey was requested by Mr. John Knox of Sunoco on November 8, 1978. The survey was conducted by Meade Kemrer, Principal Investigator of the DCA on November 15, 1978 under the provisions of a USFS antiquities permit issued to the DCA on August 8, 1978. The project was administered by Dr. W. G. Christian of Sunoco and Dr. Kemrer of the DCA.

Legislation enacted by the Congress of the United States requires compliance with laws designed to protect archaeological resources. Laws such as the National Environmental Policy Act of 1969 (PL 91-852) and Executive Order No. 11593 entitled "Protection and Enhancement of the Cultural Environment" prevent enterprises which might result in the destruction or alteration of cultural resources. Federal and State governments and the professional scientific community have come to realize that the material remains of a prior culture are a limited, non-renewable part of the environment. As such, the State of New Mexico has enacted legislation regulating archaeological resources. The Cultural Properties Act is analogous in content to the National Historic Preservation Act of 1966 (PL 89-665), which provides for preservation of significant archaeological sites.

Those present in the field at the time of the November 15 survey included Mr. Robert Macy of Sunoco; Mr. Doug Sterck of Rocky Mountain Surveyors, Albuquerque; Mr. Landon Smith, archaeologist for the Santa Fe National Forest; Ms. Louise Obergaard of the Recreation and Land Use staff, Santa Fe National Forest; Mr. Chuck McClothlin, Ranger, Jemez Springs subregion, Santa Fe National Forest; Mr. Doug Neely, Forest Engineer, Santa Fe National Forest; and Dr. Kemrer of the DCA.

All areas inspected were staked and flagged.

Survey Methods

All areas of proposed impact were examined on foot. The access roads and drill pads were visually examined while walking the areas in a series of overlapping transects. In addition to the search for materials/features of prehistoric or historic significance, data pertinent to the description of the environmental settings were also collected.

Survey Locations

Sunedco #1

Legal Description: Unsurveyed lands; metes and bounds had not been determined at the time of the survey. UTM Coordinates: Zone 13, 395560 (N); 348220 (E) Sandoval County, New Mexico.

Map Source: USGS 7.5' Ponderosa Quadrangle (1970).

Areas Surveyed: 200' x 200' (drill pad); approximately 1500' x 20' (access road).

Description: The proposed drill pad is located on a 20-25° southwest facing slope of a small drainage basin on the top of Cat Mesa. The soils in the area are composed of sandy colluvium. The proposed access road will leave an existing road and will head in a S35°E bearing to the proposed drill site. The dominant vegetation is composed of pinyon (Pinus edulis) and juniper (Juniperus sp.). Other plant species noted in the area include blue grama (Bouteloua gracilis) and other unidentified grass species. Cattle and deer graze the area.

Cultural Resources: No materials or features of prehistoric or historic significance were observed in the areas of proposed construction.

Recommendations: Archaeological clearance is recommended.

Sunedco #2

Legal Description: Unsurveyed lands; metes and bounds had not been determined at the time of the survey. UTM Coordinates: Zone 13, 3956940 (N); 348920 (E), Sandoval County, New Mexico.

Map Source: USGS 7.5' Ponderosa Quadrangle (1970).

Areas Surveyed: 200' x 200' (drill pad); approximately 2450' x 20' (access road)

Description: The proposed drill pad is located on a relatively flat surface adjacent to the edge of Cat Mesa. The proposed access road will leave an existing road and will head in a south-southeasterly direction to the drill site. The bedrock outcrops appear to be composed of light yellow-brown welded tuffs, and the soils are sandy colluvium. The predominant vegetation in the area are tree species, including ponderosa pine (Pinus ponderosa), pinyon, and juniper. Other vegetation noted in the area includes prickly pear cacti (Opuntia sp.), and various herbs and grasses. Deer graze the area.

Cultural Resources: No materials or features were noted on the proposed drill pad area. Several artifacts, including an obsidian flake, a basalt flake, a redware rimsherd and a mano fragment were found widely scattered along the proposed route of the access road. Searches were made in the vicinity of each artifact which revealed no additional materials or features. The artifacts therefore appear to be isolated and thus of minimal interpretive significance, other than specifying use-areas.

Recommendations: Since the materials appear to be isolated and of low interpretive potential, archaeological clearance is recommended.

USDA - FOREST SERVICE
FSM 2361.73

INVENTORY STANDARDS AND ACCOUNTING
(Instructions: Archeological Coding Guide)

CARD #1: 1 (1)

Archeological Report Number:

YEAR	FOREST	NUMBER
1978 (2-5)	10 (6-7)	(8-10)

Report Date:

Month	Day	Year
01 (11-12)	18 (13-14)	1979 (15-18)

Inventory Type: A (19)

Percent of Statistical Sample: (20-21)

Average Number of Individuals Used: 001 (22-24)

Total Project Acreage: 000003.6 (25-31)

Average Spacing Between Individuals (feet): 010 (32-34)

Acreage Completely Inventoried: 000003.6 (35-41)

Acreage Sample Drawn From: 3-6 (42-47)

Number of Sites Located: 0 (48-51)

Project Function: Geothermal Drilling (52-53): 28

Institution Conduction Inventory: Division of Conservation Archeology (54-55): 00

Man Hours Expended:

FIELD	LAB	ADMIN.
08 (56-60)	16 (61-64)	08 (65-68)

Project Mileage: 200 (69-74)

Determination of Effect: (By Professional Cultural Resource Specialist only.) 2 (75)

District Number: 03 (76-77)

CARD #2: 2 (1)

PROJECT LOCATION

	ZONE	NORTHING			EASTING		
UTM	13 (2-3)	39 (4-5)	55 (6-7)	560 (8-10)	3 (11)	48 (12-13)	220 (14-16)
	13 (17-18)	39 (19-20)	56 (21-22)	940 (23-25)	3 (26)	48 (27-28)	920 (29-31)
	(32-33)	(34-35)	(36-37)	(38-40)	(41)	(42-43)	(44-46)
	(47-48)	(49-50)	(51-52)	(53-55)	(56)	(57-58)	(59-61)
	(62-63)	(64-65)	(66-67)	(68-70)	(71)	(72-73)	(74-76)

R3 2300-4
(Rev. 5/78)

USDA - Forest Service

ARCHEOLOGICAL REPORT
CARD #3

3
1

November 15, 1978
Date of Examination

Author / Archeologist:

MEADE KEMRER														
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

January 18, 1979
Date of Report

Report Title (abreivate if necessary):

AN ARCH. CLEAR. SURVEY IN																						
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55

JEMEZ DIST. SANTA FE N.F.																						
56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

Brief of Recommendations:

Sunedco #1: Archeological clearance for drill pad and access road recommended without stipulations.

Sunedco #2: Archeological clearance for drill pad and access road recommended without stipulations.

Report accepted / not accepted: (cross out one)

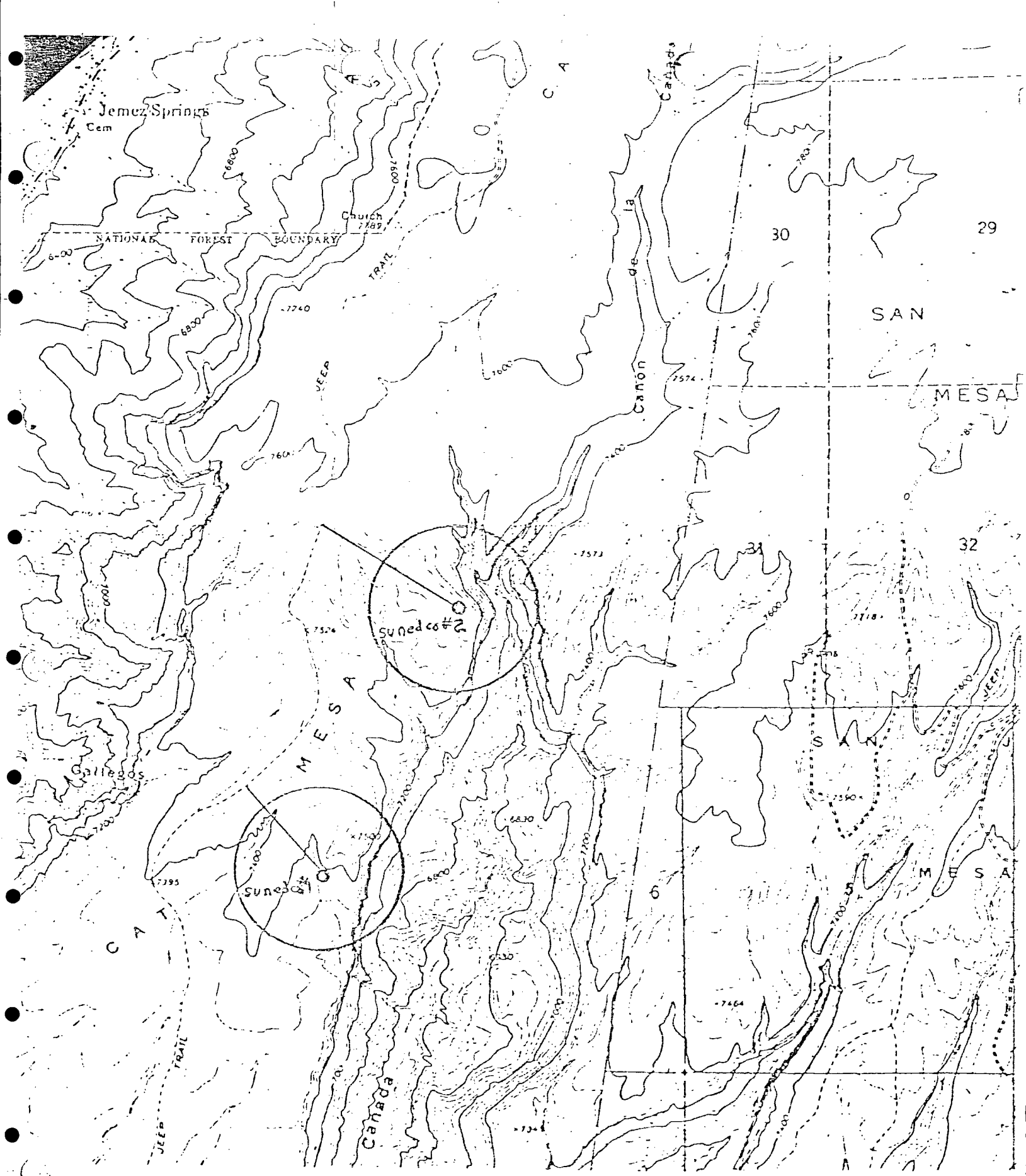
_____ Date: _____
(Regional Archeologist)

Clearance recommended / not recommended: (cross out one)

_____ Date: _____
(Regional Archeologist)

Clearance approved / not approved: (cross out one)

_____ Date: _____



USGS Ponderosa Quadrangle

Form G-103
Adopted 10/1

NO. OF COPIES RECEIVED		
DISTRIBUTION		
File	1	✓
N. M. B. M.		
U. S. G. S		
Operator	1	
Land Office		

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. Box 2088, Santa Fe 87501

SUNDRY NOTICES AND REPORTS ON GEOTHERMAL RESOURCES WELLS

5. Indicate Type of Lease State ☐ Fee ☒
5.a State Lease No.

Do Not Use This Form for Proposals to Drill or to Deepen or Plug Back to a Different Reservoir. Use "Application For Permit —" (Form G-101) for Such Proposals.)

1. Type of well: Geothermal Producer ☐ Temp. Observation ☒ Low-Temp Thermal ☐ Injection/Disposal ☐

7. Unit Agreement Name: None

2. Name of Operator: Sunoco Energy Development Corporation

8. Farm or Lease Name: San Diego Grant

3. Address of Operator: 12700 Park Central Pl., Suite 1500, Dallas, TX 75251

9. Well No.: 3-77-3

4. Location of Well: Unit Letter L, 550 Feet From The W Line and 2000 Feet From The S Line, Section 30 Township 18N Range 3E NMPM.

10. Field and Pool, or Wildcat: None

15. Elevation (Show whether DF, RT, GR, etc.): 7680' G.L.

12. County: Sandoval

16. Check Appropriate Box To Indicate Nature of Notice, Report or Other Data

NOTICE OF INTENTION TO:		SUBSEQUENT REPORT OF:	
PERFORM REMEDIAL WORK ☐	PLUG AND ABANDON ☐	REMEDIAL WORK ☐	ALTERING CASING
TEMPORARILY ABANDON ☐		COMMENCE DRILLING OPNS. ☒	PLUG & ABANDONMENT
PULL OR ALTER CASING ☐	CHANGE PLANS ☐	CASING TEST AND CEMENT JOB ☐	
OTHER ☐		OTHER	

17. Describe Proposed or completed Operations *(Clearly state all pertinent details, and give pertinenet dates, including estimated date of starting any proposed work)* SEE RULE 203.

On 9/21/77 Hole No. 3-77-3 was spudded at 10:30 (AM) PM

The hole was T.D.'d on 9/25/77 @ 250 ' BGL

OK-CH

18. I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNED [signature] TITLE Chief Geologist Geothermal Services, Inc. DATE 10/1/77

APPROVED BY Carl Mrog TITLE SENIOR PETROLEUM GEOLOGIST DATE 10/4/77

CONDITIONS OF APPROVAL, IF ANY:

Form G-101
Adopted 10/1

NO. OF COPIES RECEIVED	4	
DISTRIBUTION		
File	1	✓
N.M.B.M.	1	
U.S.G.S.	1	
Operator	1	
Land Office		
BLM	1	

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. Box 2088, Santa Fe 87501

RECEIVED
MAY -3 1977
OIL CONSERVATION COMM.
Santa Fe

APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK---GEOTHERMAL RESOURCES WELL

5. Indicate Type of Lease STATE ☐ FEE X
5.a State Lease No.

1a. Type of Work: Drill X ☐ Deepen ☐ Plug Back ☐

b. Type of Well: Geothermal Producer ☐ Low-Temp Thermal ☐ Temp Observation X ☐ Injection/Disposal ☐

7. Unit Agreement Name: None

8. Farm or Lease Name: San Diego Grant

2. Name of Operator: SUNOCO ENERGY DEVELOPMENT CORPORATION

9. Well No.: 3-77-3

3. Address of Operator: 12700 Park Central Pl., Suite 1500, Dallas, TX 75251

10. Field and Pool, or Wildcat: None

4. Location of Well ** UNIT LETTER L LOCATED 550 FEET FROM THE West LINE AND 2000 FEET FROM THE S LINE OF SEC. 30 TWP. 18N RGE. 3E NMPM

projected

12. County: Sandoval

19. Proposed Depth	19A. Formation	20. Rotary or C.T.
500 ft.	unknown	rotary

21. Elevations (Show whether DF, RT, etc.)	21A. Kind & Status Plug. Bond	21B. Drilling Contractor	22. Approx. Date Work will start
7680' (GL)	see note "A"	Geothermal Services	June 15, 1977

PROPOSED CASING AND CEMENT PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	SACKS OF CEMENT	EST. TOP
5-1/8"	3/4"	1.14 lbs.	500'	1.5	6" BGL

Program- See attached "Standard Shallow Temperature Gradient Hole Drilling Program"

**- All section lines projected

Note A- Type of bond will be $10,000 multiple-well low-temperature well or geothermal observation well bond. The bond is in the process of being filed, and a bond number will be furnished as soon as available before operations commence.

APPROVAL VALID
FOR 90 DAYS UNLESS
DRILLING COMMENCED
EXPIRES 8/11/77

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: If proposal is to deepen or plug back, give data on present productive zone and proposed new producti zone. Give blowout preventer program, if any.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

Signed [signature] Title Chief Geologist, Geothermal Services, Inc. Date April 26, 1977

(This space for State Use)

APPROVED BY Carl Ulvog TITLE SENIOR PETROLEUM GEOLOGIST DATE 5/13/77

CONDITIONS OF APPROVAL, IF ANY:

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. BOX 2088 SANTA FE 87501

Form G-102
Adopted 10/1/74

GEOTHERMAL RESOURCES WELL LOCATION AND ACREAGE DEDICATION PLAT

All distances must be from the outer boundaries of the Section.

Operator	Lease	Well No.
Sunoco Energy Development Corp.	San Diego Grant	3-77-3

Unit Letter	Section	Township	Range	County
L	30	18N	3E	Sandoval

Actual Footage Location of Well:
550 feet from the projected W line and 2000 feet from the S line (projected)

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
7680'	None	None	None Acres

1. Outline the acreage dedicated to the subject well by colored pencil or hachure marks on the plat below.

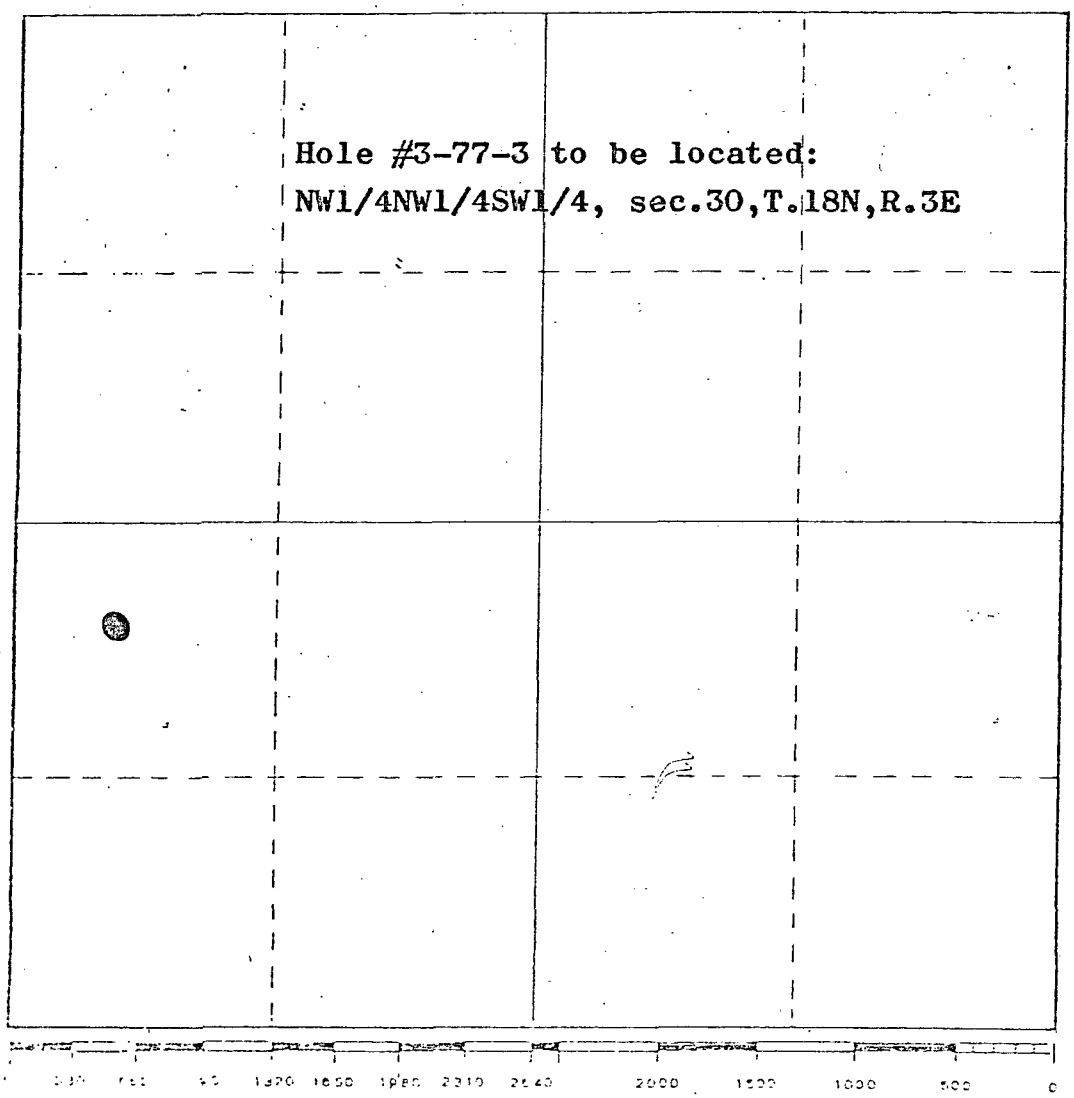
2. If more than one lease is dedicated to the well, outline each and identify the ownership thereof (both as to working interest and royalty).

3. If more than one lease of different ownersip is dedicated to the well, have the interests of all owners been consolidated by communitization, unitization, force-pooling, etc?

☐ Yes ☐ No If answer is "yes," type of consolidation _____

If answer is "no," list the owners and tract descriptions which have actually been consolidated. (Use reverse side of this form if necessary.) _____

No allowable will be assigned to the well until all interests have been consolidated (by communitization, unitization, forced-pooling, or otherwise) or until a non-standard unit, eliminating such interests, has been approved by the Commission.



CERTIFICATION

I hereby certify that the information contained herein is true and complete to the best of my knowledge and belief.

Name: Steve Quiett

Position: Chief Geologist

Company: Geothermal Services, Inc.

Date: April 26, 1977

I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

Date Surveyed

Registered Professional Engineer and/or Land Surveyor

Certificate No.

GEOTHERMAL SERVICES, INC.
7860 CONVOY COURT, SAN DIEGO, CALIFORNIA 92111 • (714) 565-4712

STANDARD SHALLOW TEMPERATURE GRADIENT HOLE DRILLING PROGRAM
(500'/150m; Rubber Tired Equipment; Rotary/Mud)

1. Coordinate "Special Stipulations" or other unusual requirements with the Project Geologist prior to set-up and spud.

2. Choose location and orientation of drilling rig so as to minimize surface disturbance.

3. Drill 4" to 6" hole to maximum depth of 500'/150m. Take cuttings samples, cores, etc. at direction of Project Geologist.

4. If drilling with mud, use regular Bentonite drilling mud. No toxic additives are to be used in drilling fluids without permission of Project Geologist. Have supply of lost circulation material available. Use portable mud pits unless specifically directed otherwise.

5. Have a supply of Barite available in case of artesian flow. If artesian flow is encountered, comply with United States Geological Survey's Stipulations.

6. Mud return temperature shall be measured and recorded on "Drilling History" every 10'/3m.

    a. If temperature reaches 120°F/50°C, STOP DRILLING and circulate for 30 minutes, monitoring mud temperature and pit volume for possible hot artesian flow. If no flow, run pipe at this depth after logging is completed.

    b. If there is a sudden increase in temperature of the drilling mud (several degrees in only a few feet) STOP DRILLING and circulate for 30 minutes, monitoring mud temperature and pit volume for possible hot artesian flow. If no flow, continue drilling CAUTIOUSLY, keeping a careful watch on return temperature of drilling fluid. In no case shall drilling continue after mud return temperature reaches 120°F/50°C.

7. Run pipe immediately after running electric logs or reaching T.D. (if hole is not logged).

   a. Install cap on bottom of first length of pipe. (If using steel pipe, seal each joint with teflon tape to ensure watertight).

   b. Steel pipe must be used when air temperature is 40°F or below, as PVC cement will not adhere.

   c. Steel pipe must be used if drilling fluid temperature exceeds 100°F/40°C.

   d. When pipe is landed, top must be 6" to 12"/ 15cm to 30cm below ground level. (Cut and thread as necessary).

   e. Fill pipe with CLEAN WATER (water that is oily or contains solvents such as gasoline MUST NOT be used) and install cap. Do not seal.

   f. Set paper, rag or dirt bridge down open annulus at least 10'/3m below ground level. Fill annulus with cement up to base of cap on pipe.

8. Clean up location THOROUGHLY.

9. Any excavated pits or sumps must be backfilled to conform to the original topography.

10. When temperature surveys are completed, fill pipe with cement from 10'/3m to top of pipe, fill excavation to original ground topography and restore location as nearly as possible to original condition.

GEOTHERMAL SERVICES, INC.
San Diego, California
December, 1975

7. Run pipe immediately after running electric logs or reaching T.D. (if hole is not logged).

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GEOTHERMAL SERVICES, INC.
San Diego, California
December, 1975