GTLT - ______2______

NMSU No. 4
UL:D 21-23S-02E
Dona Ana County

NEW MEXICO OIL CONSERVATION COMMISSION

P. O. Box 2088, Santa Fe 87501

Form G-112
Adopted 10-1-74

APPLICATION TO PLACE WELL ON INJECTION-GEOTHERMAL RESOURCES AREA

Operator: New Mexico State University

Address: Box 3-PSL, New Mexico State University 88003

Lease Name: N/A

Well No.: N/A

Field: New Mexico State University

County: Dona Ana

Location: N/A
Unit Letter ____ ; Well is Located ____ Feet From The ____ Line And ____ Feet From The ____ Line, Section ____ Township ____ Range ____ NMPM.

CASING AND TUBING DATA

NAME OF STRING	SIZE	SETTING DEPTH	SACKS CEMENT	TOP OF CEMENT	TOP DETERMINED BY
Conductor Pipe N/A					
Surface Casing N/A					
Long String N/A					
Tubing N/A			Name, Model and Depth of Tubing Packer N/A		

Name of Proposed Injection Formation: Surface

Top of Formation: N/A

Bottom of Formation: N/A

Is Injection Through Tubing, Casing, or Annulus? N/A

Perforations or Open Hole? N/A

Proposed Interval(s) of Injection: See attached sketch

Is This a New Well Drilled For Injection? N/A

If Answer is No, For What Purpose was Well Originally Drilled? N/A

Has Well Ever Been Perforated in Any Zone Other Than the Proposed Injection Zone? No N/A

List All Such Perforated Intervals and Sacks of Cement used to Seal Off or Squeeze Each: N/A

Depth of Bottom of Deepest Fresh Water Zone in This Area: None

Is This Injection for Purpose of Pressure Maintenance or Water Disposal? (See Rules 501 and 502): Water Disposal

Anticipated Daily Injection Volume: Minimum ____ Maximum 2.2 acre feet

Open or Closed Type System: N/A

Is Injection to be by Gravity or Pressure? Gravity

Approx. Pressure (psi): N/A

Answer Yes or No Whether the Following Waters are Mineralized to such a Degree as to be Unfit for Domestic, Stock, Irrigation, or Other General Use—Yes, domestic; No all others

Water to be Injected: ____

Natural Water in Injection Zone: same salinity

Are Water Analyses Attached? Yes

Name and Address of Surface Owner (or Lessee, if State or Federal Land): New Mexico State University

List Names and Addresses of all Operators Within One-Half (½) Mile of This Injection Well:
New Mexico State University, Physical Plant Department (PG-2)

Have Copies of this Application Been Sent to Each Operator Within One-Half Mile of this Well? Yes [X] No [ ]

Are the Following Items Attached to this Application (see Rule 503):
Plat of Area: Yes [X] No [ ]
Electrical Log: Yes [X] No [ ]
Diagrammatic Sketch of Well: Yes [X] No [ ]

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

Roy A. Cunniff (Signature) — Roy A. Cunniff

Principal Investigator, NMSU Campus Geothermal Project (Title)

5 December, 1980 (Date)

NOTE: Should waivers from all operators within one-half mile of the proposed injection well not accompany this application, the New Mexico Oil Conservation Commission will hold the application for a period of 20 days from the date of receipt by the Commission's Santa Fe office. If at the end of the 20-day waiting period no protest has been received by the Santa Fe office, the application will be processed. If a protest is received, the application will be set for hearing, if the applicant so requests. SEE RULE 503.

Form G-106
Adopted 10/1/74

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

GEOTHERMAL RESOURCES WELL SUMMARY REPORT

Operator New Mexico State University Address Box 3445 NMSU
Lease Name NMSU Land Well No. 4
Unit Letter D Sec. 21 Twp. 23S Rge 2E
Reservoir NMSU Land County Dona Ana

Commenced drilling December 1961
Completed drilling January 1962
Total depth 606 Plugged depth 505-606?
Junk UNK

GEOLOGICAL MARKERS	DEPTH
Alluvial Fill (Santa Fe)	606

Commenced producing January 1962 (Disposal Well (15 Feb. 82) (Date) Geologic age at total depth: Recent Quaternary

Date	Static test Shut-in well head		Disposal ~~Production~~ Test Data								
			Total Mass Flow Data					Separator Data			
	Temp. °F	Pres. Psig.	Lbs/Hr	Temp. °F	Pres. Psig.	Enthalpy	Orifice	Water cuft/Hr	Steam Lbs/Hr	Pres. Psig.	Temp. °F
15 Dec		Opsig	150,000	110							
~~Thru~~ 15 Feb		Opsig	165,000	110							

CASING RECORD (Present Hole)

Size of Hole	Size of Casing	Weight of Csg/ft.	Grade of Casing	New or Used	Seamless or Lapweld	Depth of Shoe	Top of Casing	Number of Sacks Cement	Top of Cement	Cement Top Determined By
UNK	10"ID	UNK	UNK	UNK	UNK		2' above GL	UNK	2' above GL to 340'	Records

PERFORATED CASING

(Size, top, bottom, perforated intervals, size and spacing of perforation and method.)

-354 to -376, #30 Screen; -395 to #30 Screen; -4444 to -457, #50 Screen; -473 to -478;
#60 Screen; -494 to -507, #50 Screen. All blank and screen sections are 8" ID

Was analysis of effluent made? Yes Electrical log depths 606 Temperature log depths 495

CERTIFICATION

I hereby certify that the information given above and the data and material attached hereto are true and complete to the best of my knowledge and belief.

Signed Roy A. Cunniff Position Project Director Date 15 Feb. 1982
Roy A. Cunniff

Form G-107
Adopted 10/1/74

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

GEOTHERMAL RESOURCES WELL HISTORY

Operator New Mexico State University Address Box 3445 NMSU
Lease Name New Mexico State University Land Well No. 4
Unit Letter D Sec. 21 Twp. 23 S Rge 2E
Reservoir NMSU Land County Dona Ana

It is of the greatest importance to have a complete history of the well. Use this form to report a full account of all important operations during the drilling and testing of the well or during re-drilling, altering of casing, plugging, or abandonment with the dates thereof. Be sure to include such items as hole size, formation test details, amounts of cement used, top and bottom of plugs, perforation details, sidetracked junk, bailing tests, shooting, and initial production data and zone temperature. (Attach additional sheets if necessary.)

Date	
Jan. 1962	Well commenced producing at a reported rate of 600 gpm to irrigate NMSU Golf Course
Late 1971	Well was place in an inactive status
Feb. 1981	Testing begun to determine if the well could be converted to a geothermal disposal well. Flow test indicated well could accept up to 550 gpm in a reinjection mode.
July 13	Disposal order approved. (Administrative Order GIW-2)
Aug. 1981	Pumping test to gather parameters for dissolved minerals, dissolved gases, and
Sept 1981	temperatures.
Sept 1981	5-day disposal test
Dec. 1981	Remedial repairs, casing liner installed; 6-inch ID
Jan-Feb 1982	Follow-on testing
15 Feb. 1982	Well placed on injection in a stop-start test mode; with testing to continue for at least 60 days.

CERTIFICATION

I hereby certify that the information given above and the data and material attached hereto are true and complete to the best of my knowledge and belief.

Signed Roy A. Cunniff Position Project Director Date 15 Feb. 1982

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

Form G-104
Adopted 10/1/74

CERTIFICATE OF COMPLIANCE AND AUTHORIZATION TO PRODUCE GEOTHERMAL RESOURCES

OWNER OR OPERATOR

Name New Mexico State University

Address Box 3445 Las Cruces, NM 88003

TYPE OF WELL

Geothermal Producer [ ]   Low-Temperature Thermal [ ]   Injection/Disposal [X]

REASON FOR FILING

New Well [ ]   Recompletion [ ]

Change in Ownership [ ]   Designation of Purchaser [ ]

Other (Please Explain) [X] Water well converted to disposal well

DESCRIPTION OF WELL

Lease Name NMSU   Well No. 4   Name of Reservoir NMSU

Kind of Lease (Fee, Fed. or State) NMSU Land   Lease Number N/A

LOCATION

Unit Letter D ; 300 feet from the West line and

600 feet from the North line of

Section 21 Township 23S Range 2E

County Dona Ana

TYPE OF PRODUCT

Dry Steam ______   Steam and Water ______   Low Temp. Thermal Water X

DESIGNATION OF PURCHASER OF PRODUCT

Name of Purchaser ______

Address of Purchaser ______

Product Will Be Used For ______

CERTIFICATE OF COMPLIANCE

I hereby certify that all rules and regulations concerning geothermal resources wells in the State of New Mexico, as promulgated by the Oil Conservation Commission of New Mexico, have been complied with, with respect to the subject well, and that the information given above is true and complete to the best of my knowledge and belief.

Signed Roy A. Cunniff   Position Projector Director   Date 15 Feb. 1982

Roy A. Cunniff

Approved Carl Ulvog   Position SENIOR PETROLEUM GEOLOGIST   Date Feb 26, 1982

Form G-105
Adopted 10/1/74

NEW MEXICO OIL CONSERVATION COMMISSION

P. O. Box 2088, Santa Fe 87501

GEOTHERMAL RESOURCES WELL LOG

Operator New Mexico State University

Address Box 3445 New Mexico State University

Reservoir New Mexico State University Land

Lease Name N/A Well No. 4 Unit Letter D

Location: 300 feet from the West line and 600 feet from the North line Section 21

Township 23S Range 2E County Dona Ana

FORMATIONS PENETRATED BY WELL

DEPTH TO		Thickness	Drilled or Cored	Recovery	DESCRIPTION
Top of Formation	Bottom of Formation				
				Drilled	Completed to 505 feet TD; Johnson Closure Valve installed at 505 feet to seal off lowest uncompleted hole. From the 20-year old well log, which apparently was annotated by someone at that time, the following information is available. Ground static water level was 173 feet, just above a 40-feet thick clay layer. From 350 - 500 feet, the hole consisted of alluvial deposits, interspersed with 3-5 feet thick clay lenses at 435 feet, 458 feet, and 479 feet of depth. A 10-feet thick clay lens was intercepted at 507-517 feet and a 20-feet thick layer was intercepted at 535-555 feet. From 560-606 feet, the log was

Attach Additional Sheets if Necessary

See Enclosed Technical Completion Report

This form must be accompanied by copies of electric logs, directional surveys, physical or chemical logs, water analyses, tests, and temperature surveys (See Rule 205).

CERTIFICATION

I hereby certify that the information given above and the data and material attached hereto are true and complete to the best of my knowledge and belief.

Signed Roy A. Cunniff Position Project Director Date 15 Feb. 1982

Roy A. Cunniff

Form G-105
Adopted 10/1/74

NEW MEXICO OIL CONSERVATION COMMISSION

P. O. Box 2088, Santa Fe 87501

GEOTHERMAL RESOURCES WELL LOG

Operator New Mexico State University

Address Box 3445 New Mexico State University

Reservoir New Mexico State University Land

Lease Name N/A Well No. 4 Unit Letter D

Location: 300 feet from the West line and 600 feet from the North line Section 21

Township 23S Range 2E County Dona Ana

FORMATIONS PENETRATED BY WELL

DEPTH TO		Thickness	Drilled or Cored	Recovery	DESCRIPTION
Top of Formation	Bottom of Formation				
					annotated at "questionable". The log indicates possible water bearing tones at 518-534 feet, and 556-560 feet, with a possible water bearing zone at 580 to 600 feet of depth.

Attach Additional Sheets if Necessary

See Enclosed Technical Completion Report

This form must be accompanied by copies of electric logs, directional surveys, physical or chemical logs, water analyses, tests, and temperature surveys (See Rule 205).

CERTIFICATION

I hereby certify that the information given above and the data and material attached hereto are true and complete to the best of my knowledge and belief.

Signed Roy A. Cunniff Position Project Director Date 15 Feb. 1982

Roy A. Cunniff

Form G-106
Adopted 10/1/74

NEW MEXICO OIL CONSERVATION COMMISSION

P. O. Box 2088, Santa Fe 87501

GEOTHERMAL RESOURCES WELL SUMMARY REPORT

Operator New Mexico State University   Address Box 3445 NMSU

Lease Name NMSU Land   Well No. 4

Unit Letter D   Sec. 21   Twp. 23S   Rge 2E

Reservoir NMSU Land   County Dona Ana

Commenced drilling December 1961

Completed drilling January 1962

Total depth 606   Plugged depth 505-606?

Junk UNK

GEOLOGICAL MARKERS	DEPTH
Alluvial Fill (Santa Fe)	606

Commenced producing January 1962 (Disposal Well (15 Feb. 82) (Date)   Geologic age at total depth: Recent Quaternary

Date	Static test Shut-in well head		Disposal ~~Production~~ Test Data Total Mass Flow Data					Separator Data			
	Temp. °F	Pres. Psig.	Lbs/Hr	Temp. °F	Pres. Psig.	Enthalpy	Orifice	Water cuft/Hr	Steam Lbs/Hr	Pres. Psig.	Temp. °F
15 Dec Thru		Opsig	150,000	110							
15 Feb		Opsig	165,000	110							

CASING RECORD (Present Hole)

Size of Hole	Size of Casing	Weight of Csg/ft.	Grade of Casing	New or Used	Seamless or Lapweld	Depth of Shoe	Top of Casing	Number of Sacks Cement	Top of Cement	Cement Top Determined By
UNK	10"ID	UNK	UNK	UNK	UNK		2' above GL	UNK	2' above GL to 340'	Records

PERFORATED CASING

(Size, top, bottom, perforated intervals, size and spacing of perforation and method.)

-354 to -376, #30 Screen; -395 to #30 Screen; -4444 to -457, #50 Screen; -473 to -478; #60 Screen; -494 to -507, #50 Screen. All blank and screen sections are 8" ID

Was analysis of effluent made? Yes   Electrical log depths 606   Temperature log depths 495

CERTIFICATION

I hereby certify that the information given above and the data and material attached hereto are true and complete to the best of my knowledge and belief.

Signed Roy A. Cunniff   Position Project Director   Date 15 Feb. 1982

Form G-107
Adopted 10/1/74

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

GEOTHERMAL RESOURCES WELL HISTORY

Operator New Mexico State University Address Box 3445 NMSU
Lease Name New Mexico State University Land Well No. 4
Unit Letter D Sec. 21 Twp. 23 S Rge 2E
Reservoir NMSU Land County Dona Ana

It is of the greatest importance to have a complete history of the well. Use this form to report a full account of all important operations during the drilling and testing of the well or during re-drilling, altering of casing, plugging, or abandonment with the dates thereof. Be sure to include such items as hole size, formation test details, amounts of cement used, top and bottom of plugs, perforation details, sidetracked junk, bailing tests, shooting, and initial production data and zone temperature. (Attach additional sheets if necessary.)

Date	
Jan. 1962	Well commenced producing at a reported rate of 600 gpm to irrigate NMSU Golf Course
Late 1971	Well was place in an inactive status
Feb. 1981	Testing begun to determine if the well could be converted to a geothermal disposal well. Flow test indicated well could accept up to 550 gpm in a reinjection mode.
July 13	Disposal order approved. (Administrative Order GIW-2)
Aug. 1981 Sept 1981	Pumping test to gather parameters for dissolved minerals, dissolved gases, and temperatures.
Sept 1981	5-day disposal test
Dec. 1981	Remedial repairs, casing liner installed; 6-inch ID
Jan-Feb 1982	Follow-on testing
15 Feb. 1982	Well placed on injection in a stop-start test mode; with testing to continue for at least 60 days.

CERTIFICATION

I hereby certify that the information given above and the data and material attached hereto are true and complete to the best of my knowledge and belief.

Signed Roy A. Cunniff Position Project Director Date 15 Feb. 1982

Form G-105
Adopted 10/1/74

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

GEOTHERMAL RESOURCES WELL LOG

Operator New Mexico State University
Address Box 3445 New Mexico State University
Reservoir New Mexico State University Land
Lease Name N/A Well No. 4 Unit Letter D
Location: 300 feet from the West line and 600 feet from the North line Section 21
Township 23S Range 2E County Dona Ana

FORMATIONS PENETRATED BY WELL

DEPTH TO		Thickness	Drilled or Cored	Recovery	DESCRIPTION
Top of Formation	Bottom of Formation				
					annotated at "questionable". The log indicates possible water bearing tones at 518-534 feet, and 556-560 feet, with a possible water bearing zone at 580 to 600 feet of depth.

Attach Additional Sheets if Necessary

See Enclosed Technical Completion Report

This form must be accompanied by copies of electric logs, directional surveys, physical or chemical logs, water analyses, tests, and temperature surveys (See Rule 205).

CERTIFICATION

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Signed Roy A. Cunniff Position Project Director Date 15 Feb. 1982
Roy A. Cunniff

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

Form G-104
Adopted 10/1/74

CERTIFICATE OF COMPLIANCE AND AUTHORIZATION TO PRODUCE GEOTHERMAL RESOURCES

OWNER OR OPERATOR

Name New Mexico State University

Address Box 3445 Las Cruces, NM 88003

TYPE OF WELL

Geothermal Producer [ ]   Low-Temperature Thermal [ ]   Injection/Disposal [X]

REASON FOR FILING

New Well [ ]   Recompletion [ ]

Change in Ownership [ ]   Designation of Purchaser [ ]

Other (Please Explain) [X] Water well converted to disposal well

DESCRIPTION OF WELL

Lease Name NMSU   Well No. 4   Name of Reservoir NMSU

Kind of Lease (Fee, Fed. or State) NMSU Land   Lease Number N/A

LOCATION

Unit Letter D ; 300 feet from the West line and 600 feet from the North line of

Section 21   Township 23S   Range 2E

County Dona Ana

TYPE OF PRODUCT

Dry Steam ____   Steam and Water ____   Low Temp. Thermal Water X

DESIGNATION OF PURCHASER OF PRODUCT

Name of Purchaser ____

Address of Purchaser ____

Product Will Be Used For ____

CERTIFICATE OF COMPLIANCE

I hereby certify that all rules and regulations concerning geothermal resources wells in the State of New Mexico, as promulgated by the Oil Conservation Commission of New Mexico, have been complied with, with respect to the subject well, and that the information given above is true and complete to the best of my knowledge and belief.

Signed Roy A. Cunniff   Position Projector Director   Date 15 Feb. 1982

Roy A. Cunniff

Approved Carl Ulvog   Position SENIOR PETROLEUM GEOLOGIST   Date Feb 26, 1982

Form G-105
Adopted 10/1/74

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

GEOTHERMAL RESOURCES WELL LOG

Operator New Mexico State University

Address Box 3445 New Mexico State University

Reservoir New Mexico State University Land

Lease Name N/A Well No. 4 Unit Letter D

Location: 300 feet from the West line and 600 feet from the North line Section 21

Township 23S Range 2E County Dona Ana

FORMATIONS PENETRATED BY WELL

DEPTH TO		Thickness	Drilled or Cored	Recovery	DESCRIPTION
Top of Formation	Bottom of Formation				
				Drilled	Completed to 505 feet TD; Johnson Closure Valve installed at 505 feet to seal off lowest uncompleted hole. From the 20-year old well log, which apparently was annotated by someone at that time, the following information is available. Ground static water level was 173 feet, just above a 40-feet thick clay layer. From 350 - 500 feet, the hole consisted of alluvial deposits, interspersed with 3-5 feet thick clay lenses at 435 feet, 458 feet, and 479 feet of depth. A 10-feet thick clay lens was intercepted at 507-517 feet and a 20-feet thick layer was intercepted at 535-555 feet. From 560-606 feet, the log was

Attach Additional Sheets if Necessary

See Enclosed Technical Completion Report

This form must be accompanied by copies of electric logs, directional surveys, physical or chemical logs, water analyses, tests, and temperature surveys (See Rule 205).

CERTIFICATION

I hereby certify that the information given above and the data and material attached hereto are true and complete to the best of my knowledge and belief.

Signed Roy A Cunniff Position Project Director Date 15 Feb. 1982
Roy A. Cunniff

NMSU Golf Course Well

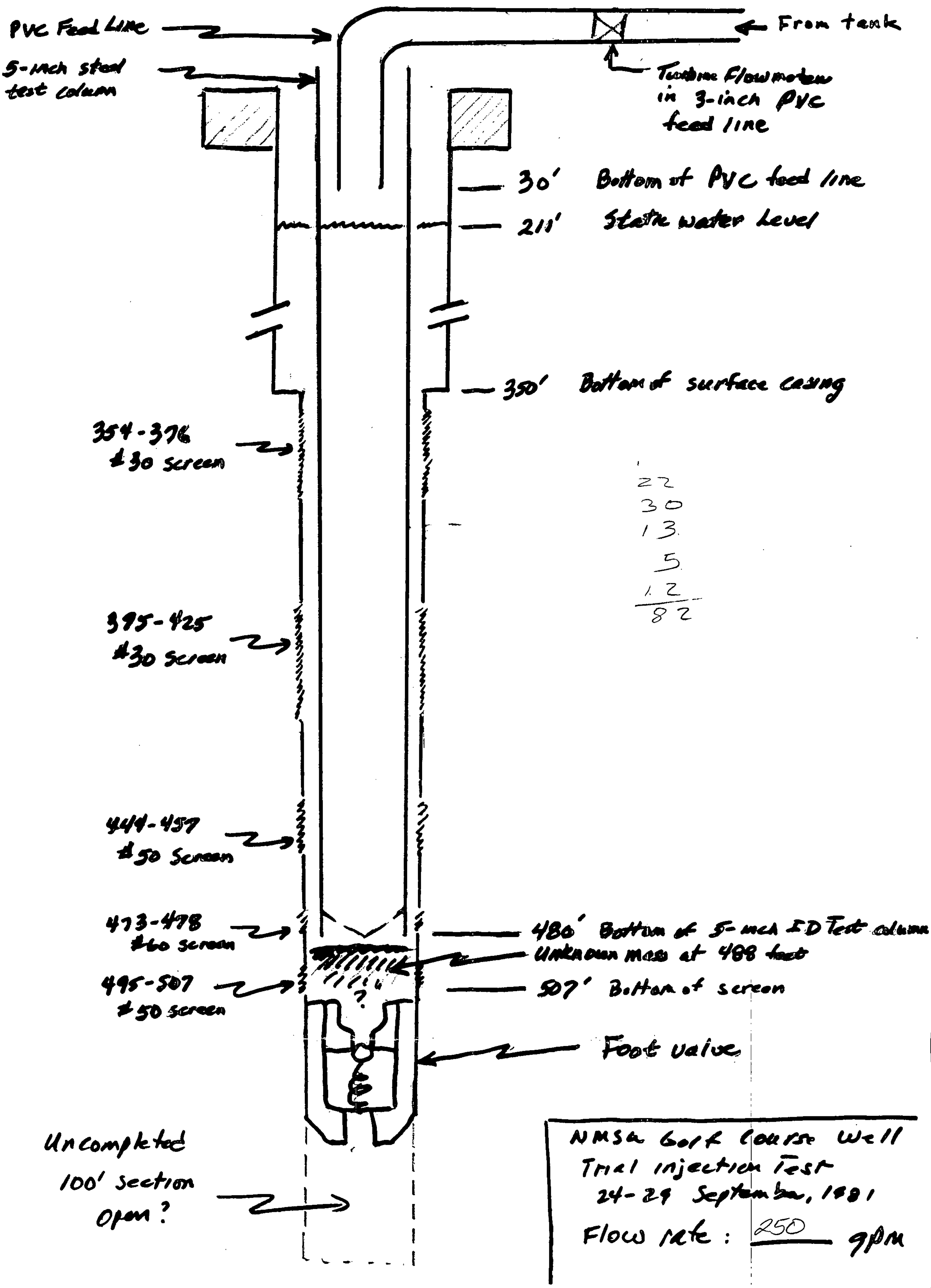
General Data

1. Elevation: 4057' above MSL
2. Depth
   a. Completed well: 507'
   b. Original open hole: 508-605'
3. Completed in 1961
   a. Used for 10 years, at 650 gpm, 75°F
   b. Inactive 1971-1981

4. Current status:
   a. Approved for use as disposal well
   b. Testing underway
   c. Significant data
      (1) Open only to 488'; might allow upward migration from deeper zones.
      (2) Temperature: 95°F; could have higher BHT
      (3) Water quality: At least 1650 ppm
          Partial results: pH 6.8
          Iron 4 ppm

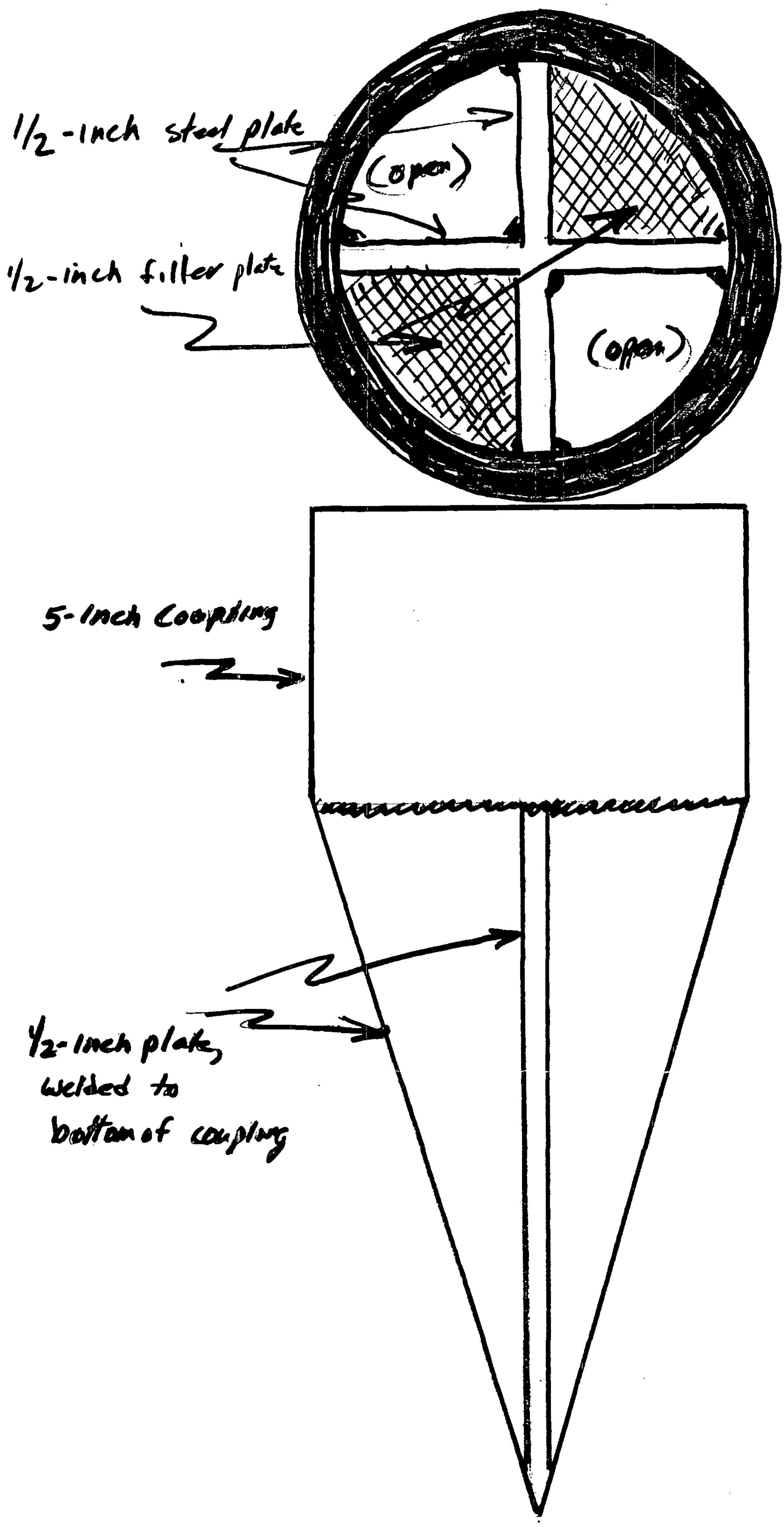
      (4) Dissolved gases in water
          CO_2 68 cc/liter
          H_2S 0.3 cc/liter

9-24-81
Inspected all sites @ NMSU - very clean and organized - only one problem noticed - none of the sites & dry holes are marked - still apparent confusion on well #'s - Roy C. had no enlighting facts on our well file dilema.



@ 250 gpm static water level stabelized @ 71' and holding (6 hrs) - will run test for 5 day & Roy will notify us if any change in water level occurs

Test fixture, screwed onto bottom of
5-inch steel column, NMSA Golf Course Well



STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT
OIL CONSERVATION DIVISION

TONEY ANAYA
GOVERNOR

POST OFFICE BOX 2088
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO 87501
(505) 827-5800

July 13, 1983

New Mexico State University
Physical Plant Dept.
P.O. Box 3545
Las Cruces, NM 88003

Attention: C. D. Black

Dear Mr. Black:

Monthly reports of production (G-108) and injection (G-110) of geothermal fluid submitted by your office continue to confuse and/or complicate our required record keeping and data processing.

For example, the June 20, 1983, reports show two different locations and conditions of Well No. 521, whereas the well number is a unique identification for a single individual location. The parenthesized number (520) immediately below the lowermost 521, suggest that you are attempting to eliminate the well which was initially permitted and drilled as PG-3, later changed to Well No. 520. (See attached.) This would pose an insolvable problem for our data processing department.

The injection report (Form G-110) for June 20, 1983, refers to a Well No. 3648. There is no record in this office of such a well. Presumably the well referred to (P-21-23S-2E) is in reality Well No. 4, sometimes known as the "Old Golf Course Well". However, that location is not in Unit P. (See attached.)

It would be appreciated if some way can be found to eliminate the confusion resulting from the above.

Very truly yours,

Carl Ulvog

CARL ULVOG
Geothermal Supervisor

CU/dp

Attachments.

Form G-103
Adopted 10/1/74

RECEIVED
NOV 05 1981
OIL CONSERVATION DIVISION
SANTA FE

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N. M. B. M.		
U. S. G. S		
Operator		
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

2. Name of Operator: New Mexico State University

8. Farm or Lease Name: NMSU

3. Address of Operator: P.O. Box 3548 New Mexico State University, Las Cruces, New Mexico 88003-3548

9. Well No.: 4

4. Location of Well: Unit Letter D 300 Feet From The West Line and 600 Feet From The North Line, Section 21 Township 23 S Range 2 E NMPM.

10. Field and Pool, or Wildcat: NMSU

15. Elevation (Show whether DF, RT, GR, etc.): 4954 feet above MSL

12. County: Dona Ana

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.

A temporary inner casing was installed to perform a 5-day injection test. This test was witnessed by OCD representatives and the results clearly indicate the well will accept the planned flow rate. Moreover, the test fixture showed that the well is open only to an effective depth of 488 feet. See attached sketches.

The temporary casing will be removed, and a new liner will be installed. Purpose of this liner is to prevent scale from falling in the well and blocking (bridging) the casing. The liner will consist of 10-inch inside diameter, schedule 40 steel pipe to 10 feet of depth, with 6-inch inside diameter, schedule 40 steel pipe, from 10 feet to 350 feet of depth. Johnson well screen, #40, 6-inch inside diameter will be installed opposite the orginal screen settings of 354 to 376 feet, 395 to 425 feet, and 444 to 457 feet. Intervals between screen sections will be blank 6-inch steel pipe.

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

SIGNED Roy A. Cunniff TITLE Chief, Geothermal Project DATE November 3, 1981

Carl Ulvog SENIOR PETROLEUM GEOLOGIST Nov. 12, 1981

NEW MEXICO STATE UNIVERSITY
Physical Science Laboratory
BOX 3-PSL, LAS CRUCES, NEW MEXICO 88003
AREA (505) 522-9100 TWX 910-983-0541

November 2, 1981

Mr. Carl Ulvog
Oil Conservation Division
P.O. Box 2088
Santa Fe, New Mexico 87501

Dear Mr. Ulvog:

Enclosed herewithin are two copies of a properly completed Form G103 notifying you of our intent to perform remedial work on the NMSU Geothermal Disposal Well (Old Golf Course Well).

Pursuant to the disposal order on the well, forwarded by letter from Mr. Ramey dated July 13, 1981, a trial injection test was conducted in the period 20-25 September 1981. Start of the test was witnessed by representatives from your office. This test showed the well could accept safely 200-275gpm of water, which is the planned disposal rate. The test entailed disposal of 1.5 million gallons of fresh water into the well. Prior to the test, the well had been test-pumped at 22gpm in order to acquire samples for water and disolved gas analysis. A final technical report on these tests is in preparation. Upon completion, the report will be provided to your office. In summary, the tests indicate the well has a bottom-hole temperature (480 feet) of at least 95^{o}F, and contains water of at least 1575/ppm total dissolved solids. Dissolved gases consist of CO_2 at 78cc/liter of fluid, N_2 at 7.7cc/liter, and H_2S at 0.3cc/liter. Traces of other rare gases also were detected notably argon at 2200ppm by volume. The relatively large amount of H_2S was not detected in the other NMSU geothermal wells.

The proposed remedial work is designed to prevent scale and rust from falling from the sides of the 20-year old casing and bridging the hole.

On three separate test, the 8-inch screen section from 350 to 480 feet was blocked (bridged) by scale. The specially fabricated fixture was used on the latest test to remove the blockage. With a new liner, as depicted on the Form G-103, we should be able to prevent a reoccurance of the problem.

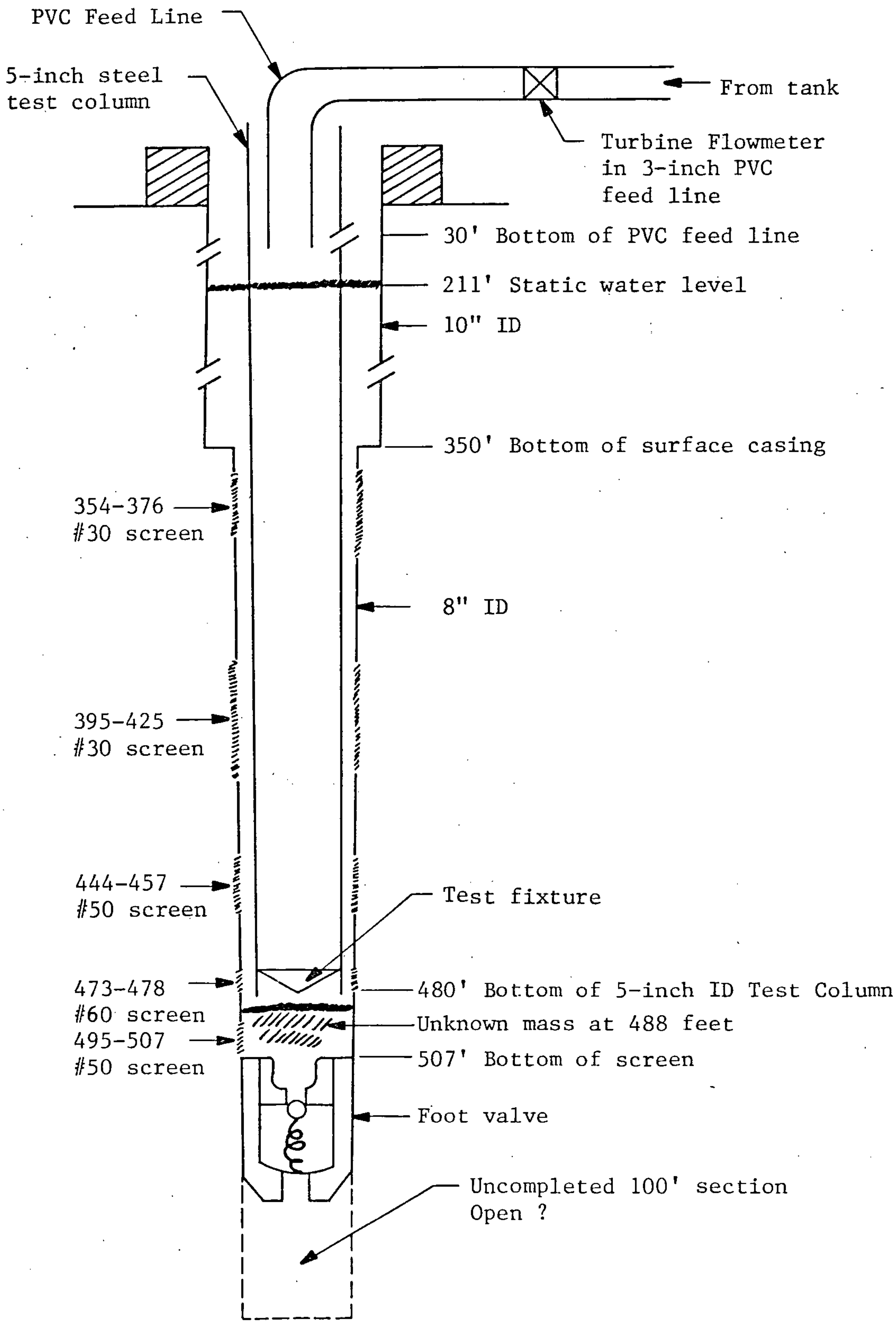
Because of the design of the test fixture used on the trial injunction test, we were able to create a jet of water at the test fixture (479 feet of depth) which was moving at a velocity of at least 60fps and 275 gpm. This jet was unable to dislodge or alter the unknown mass at 488 feet of depth. A conclusion, then, is that the well has an effective depth of only 488 feet, and that the orginal closure device installed at 507 feet of depth is intact enough that there is little risk of washing out the bottom of the well.

Request early approval of this request so that system testing of newly installed heat exchangers and other system components can be completed.

Sincerely,

Roy A. Cunniff

RAC/mm

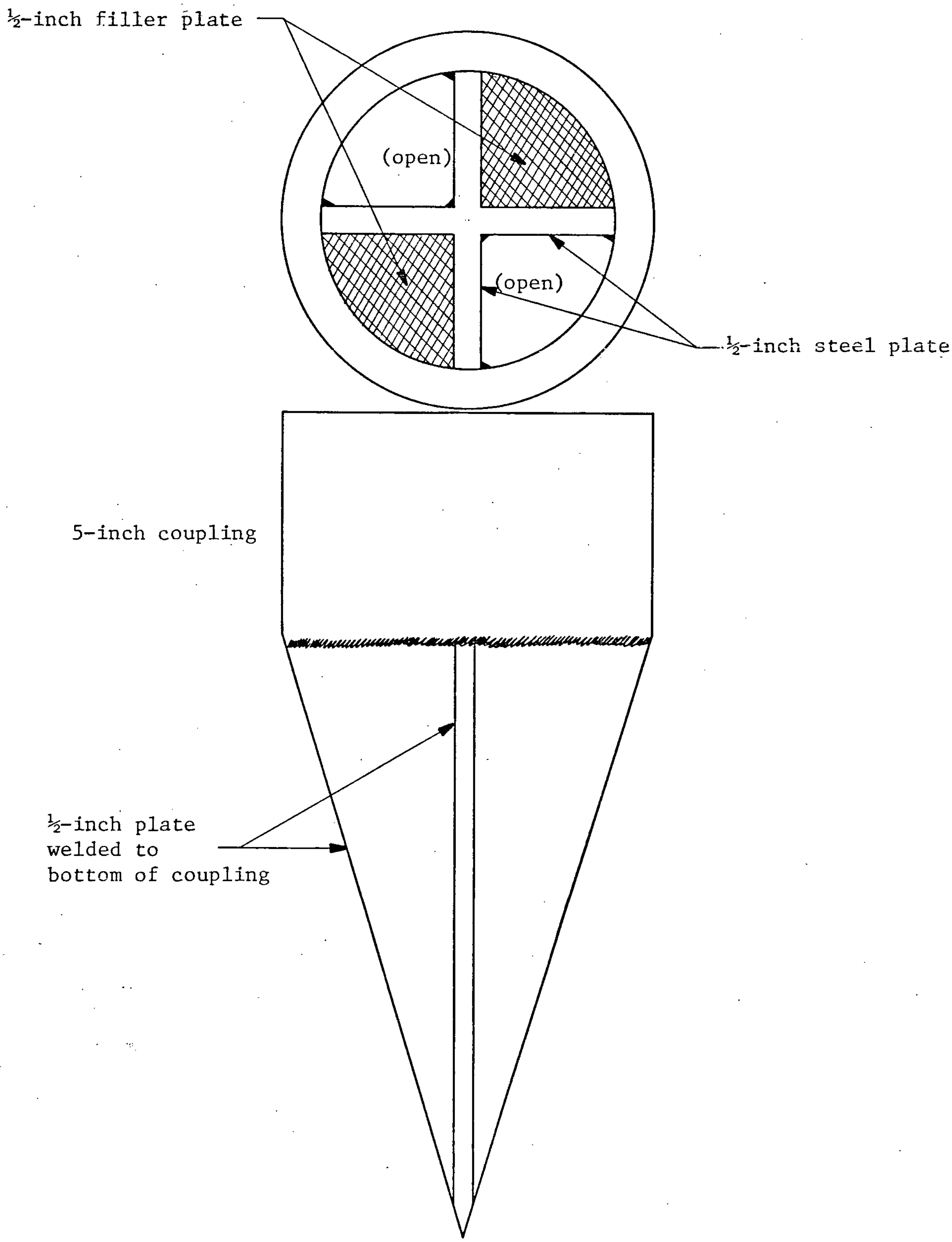


NMSU Golf Course Well

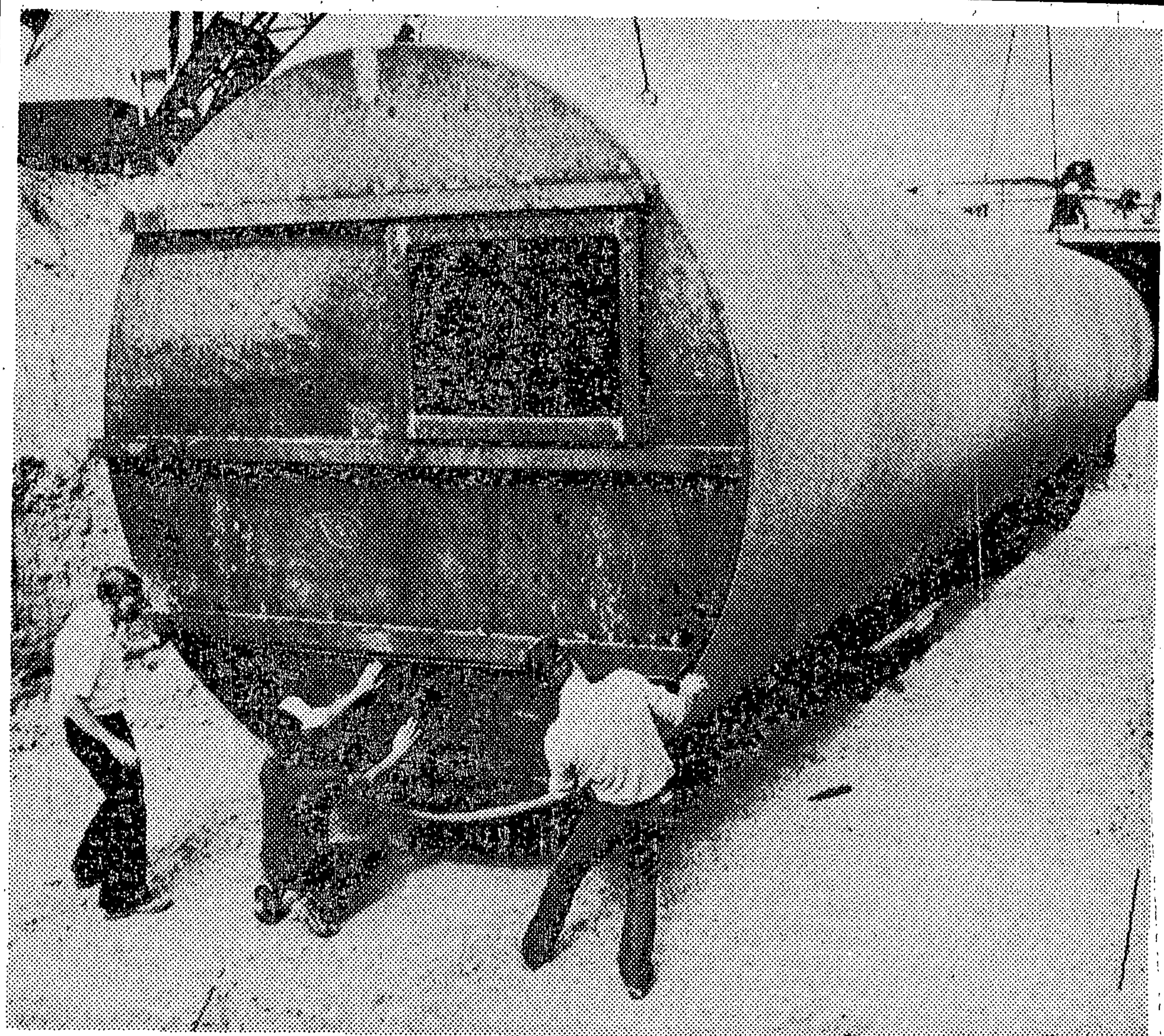
Trial Injection Test

24-29 September, 1981

Flow rate: 200-275 gpm



Test fixture, screwed onto bottom of
5-inch steel column, NMSU Golf Course Well



Journal Photo by Eugene Burton

A 60,000-Gallon Holding Tank Is Positioned for Installment at NMSU
The Unit Will Provide About Four To Six Hours of Heated Water

Geothermal System Gets Backup

By JOE SMITH
Of the Journal's
Las Cruces Bureau

LAS CRUCES — A 60,000-gallon holding tank, part of a geothermal heating system for several New Mexico State University buildings, was lowered into the ground on the campus here Wednesday.

The tank will provide about four to six hours of heated water as a backup should the pumping system from the well on the east side of the campus fail, a university spokesman said.

Geothermal water will be pumped from the well at about 200 gallons per minute and, via a heat exchanger, heat potable water that will go into the holding tank, then out to the buildings around the campus.

The geothermal water, which naturally is heated to about 145 degrees farenheit, then is piped to the NMSU golf course and finds its way back into the aquifer for reuse.

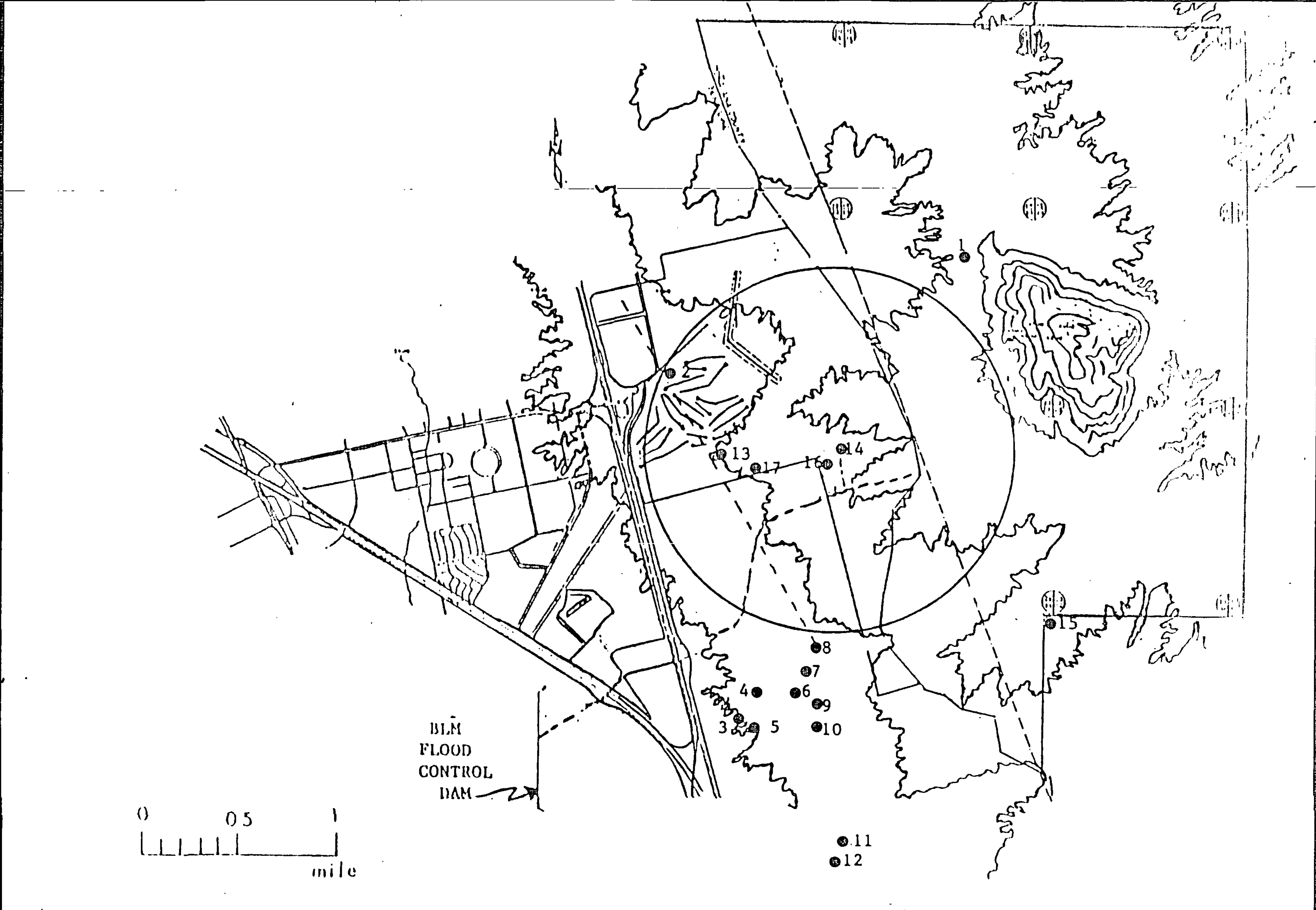
About five miles of pipeline connects the system, which will be used to provide hot water for 12 buildings and hot water and heat for two others.

Also, it is hoped that the project will heat both an indoor and an outdoor swimming pool on the campus.

The contract, funded by $829,000 appropriated by the Legislature, calls for the project to be in operation by July.

However, a spokesman Wednesday said the project is well ahead of schedule and it may be in operation by late February or early March.

The project, the first of its kind at NMSU, is under the direction of Roy Cuniff, senior geothermal engineer for the Physical Science Laboratory, located on the NMSU campus.



LOCATION OF WELLS ON AND NEAR N.M.S.U. LAND

Figure 1

TABLE 1

SUMMARY OF DATA ON WELLS IN LAS ALTURAS AND SURROUNDING AREA
(Numbering of wells same as Fig. 1)

Well No.	Year of Drilling	Owner and Location (Past and Present)	Maximum Temperature	Water Level (ft.)	Total Depth	Total Dissolved Solids PPM	Remarks
1	1960	NMSU Near Antenna Towers NW Tortugas Mtns.	Hot	Dry	200	N/A	Dry; hot well, "Tools too hot to hold in hand"
2	1961-1962	NMSU - Golf Course	24°C	-	630	1575	Abandoned due to high salinity
3	1957	Soules Las Alturas Estate	25°C	161	296	500+	Estimated from specific conductivity
4	1963	L. R. Evans	Hot	174	332	500+	Estimated from specific conductivity
5	1964	Wm. Evans/Partridge	Hot	-	256	500+	Estimated from specific conductivity
6	1964	Rowan	36.7°C	190-200	342	500+	Estimated from specific conductivity
7	1964	White/Cutcher	34°C	190	311		Well plugged & abandoned
8	1964	Nations/Huddleston	45°C	240	335	1960	Well not in service
9	1964	Husand/Kinzer	42.5°C	180	348	520	
10	1956	Tellyer	27°C	180	486	500+	
11	1975	Charles Jordan	46°C	200	330	597	4" casing being used for drinking water
12	1966 to 1969	Wayne Johnson	70°F	165	280	(1) 776 (2A) 701	4" PVC being used for domestic purposes on Trailer Park, 2000 gallons per day from two wells
13	1979	NMSU-PG-2	118°F	278	505	1575	20 gpm flow tested
14	1979	NMSU-PG-1	141°F	255	860	1900 - 2000	200 gpm flow tested
15	1948-49	Clary & Ruther State No. 1	Hot	526	2573	N/A	No report of water analysis
16	1978	NMSU - DG - 2	145°F	265	1000	1900 - 2000	Geothermal gradient well
17	1978	NMSU - DG - 1	122°F	265	1200	1900 - 2000	Geothermal gradient well

Form G-103
Adopted 10/1/74

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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

2. Name of Operator: New Mexico State University

8. Farm or Lease Name: NMSU

3. Address of Operator: P.O. Box 3545, New Mexico State University, Las Cruces, NM 88003-3545

9. Well No.: 4

4. Location of Well: Unit Letter D 300 Feet From The West Line and 600 Feet From The North Line, Section 21 Township 23S Range 2E NMPM.

10. Field and Pool, or Wildcat: NMSU

15. Elevation (*Show whether DF, RT, GR, etc.*): 4954 feet above MSL

12. County: Dona Ana

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

NOTICE OF INTENTION TO:

- PERFORM REMEDIAL WORK ☐
- PLUG AND ABANDON ☐
- TEMPORARILY ABANDON ☐
- PULL OR ALTER CASING ☐
- CHANGE PLANS ☐
- OTHER ______ ☐

SUBSEQUENT REPORT OF:

- REMEDIAL WORK ☒
- ALTERING CASING ☒
- COMMENCE DRILLING OPNS. ☐
- PLUG & ABANDONMENT ☐
- CASING TEST AND CEMENT JOB ☐
- 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.

A casing liner was installed consisting of a casing string of 6-inch inside diameter, schedule 40, welded steel pipe, with Johnson steel screen, #50 mesh.

Because of variations between the actual well, and the 20-year old schematic, the installed liner differs somewhat from the proposed action previously submitted. Following is a tabulation of the modifications as made.

Setting Depth	Liner Material	Results
2 feet above ground surface, to 350 feet	6-inch inside diameter schedule 40 steel pipe	Top of liner bolted to casing top by 6-inch weld neck flange.
350 to 380 feet	6-inch steel screen, #50 mesh	1/4" by 1 1/2" straps welded to screen for support, on 120° centers.
380 to 400 feet	6-inch steel pipe	
400 to 410 feet	6-inch steel screen	

Well completed by inserting 4-inch steel pipe inside the 6-inch pipe, leaving 1-inch annular space open to atmosphere. The 4-inch pipe is connected to the disposal pipeline.

depth of 4"?

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

SIGNED Roy A. Cunniff *Roy A Cunniff* TITLE Geothermal Project Director DATE 15 December 1981

APPROVED BY *Carl Ulvog* TITLE SENIOR PETROLEUM GEOLOGIST DATE *Dec 18, 1981*

CONDITIONS OF APPROVAL, IF ANY:

NEW MEXICO STATE UNIVERSITY
Physical Science Laboratory
BOX 3-PSL, LAS CRUCES, NEW MEXICO 88003
AREA (505) 522-9100 TWX 910-983-0541

13 May 1981

Mr. Joe D. Ramey
Director
Oil Conservation Division
P. O. Box 2098
State Land Office Building
Santa Fe, NM 87501

Dear Mr. Ramey,

Reference is made to my letter of May 8, 1981, in which an application was made to convert our NMSU #4 water well to a geothermal disposal well.

A comparitive analysis of the geothermal water from NMSU-PG-2, President's well, was inadvertantly excluded from the data package. Please treat the enclosed tabular data as an addendum to the original application.

Sincerely,

Roy A. Cunniff
Project Director
NMSU Campus Geothermal Project

1 Encl
a/s

RAC/sg

GEOTHERMAL WATER ANALYSIS
NMSU PG-2 (President's House)

Well	Date	Na	K	Ca	Mg	Cl	SO_4, SiO_2, HCO_3 plus trace elements	TDS
PG-2	8-14-79	382	19	175	27	422	799	1704
PG-2	4-6-81	450	51	188	21	610	750	2070

Remarks

1. The earlier analysis was performed during pumping tests in this well shortly after is was completed. At that time, the CO_2 content was not suspected, and the sample apparently was allowed to stand for a considerable time before analysis. Material which then separated was apparently assumed to represent suspended solids, and was not included in the total dissolved solids.

2. Subsequent current analyses from this well, and the other geothermal wells, take into account this CO_2 mechanism, and care is taken to assure the sample is analyzed quickly after it is taken.

NEW MEXICO STATE UNIVERSITY
Physical Science Laboratory
BOX 3-PSL, LAS CRUCES, NEW MEXICO 88003
AREA (505) 522-9100 TWX 910-983-0541

5 March 1982

Oil Conservation Division
Main Office and Geothermal Section
State Land Office Building
P.O. Box 2088
Santa Fe, NM 87501

Dear Mr. Ulvog:

Enclosed are the reports required by Rule 208 and Rule 210 of the "State of New Mexico Energy and Minerals Department Rules and Regulations: Forms GG-108 (Monthly Geothermal Production Report) and Form G-110 (Monthly Geothermal Injection Report)."

Sincerely,

Roy A Cunniff
Project Director

Enclosure

RAC/sm

Reports G-108 & G-110 filed in production file

NEW MEXICO STATE UNIVERSITY
Physical Science Laboratory
BOX 3548, LAS CRUCES, NEW MEXICO 88003-3548
AREA (505) 522-9100 TWX 910-983-0541

February 22, 1982

Mr. Carl Ulvog
New Mexico Oil Conservation Division
P.O. Box 2088
Santa Fe, N.M. 87501

Dear Mr. Ulvog,

Enclosed please find properly completed copies of the G-104 through G-107 for the NMSU Geothermal Disposal Well. Also included is the Technical Report, January 1982 which contains all available information covering testing and remedial action on this well.

Sincerely,

Roy A. Cunniff

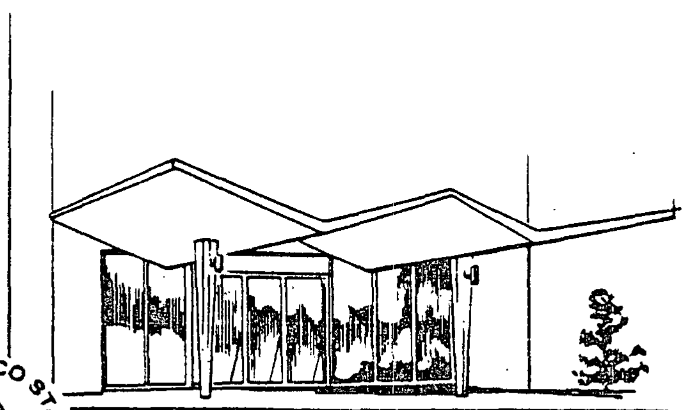
Enclosures
G-104
G-105
G-106
G-107
Technical completion Report, Testing and Repair, NMSU Geothermal Disposal Well. (Old Golf Course Well)

TECHNICAL COMPLETION REPORT

TESTING AND REPAIR, NMSU GEOTHERMAL DISPOSAL WELL

(Old Golf Course Well)

January, 1982



NEW MEXICO STATE UNIVERSITY

Physical Science Laboratory

BOX 3548, LAS CRUCES, NEW MEXICO 88003–3548
AREA (505) 522–9100 TWX 910–983–0541

TECHNICAL COMPLETION REPORT

TESTING AND REPAIR, NMSU GEOTHERMAL DISPOSAL WELL
(Old Golf Course Well)

Roy A. Cunniff
and
Charlie Houghton
with
Mary Clanton

January, 1982

The work from which this material is drawn was conducted with the support of the New Mexico Energy and Minerals Department. However, the authors remains solely responsible for the content of this material.

NOTICE

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The New Mexico Energy Research and Development Program is funded by the New Mexico Energy and Minerals Department, P.O. Box 2770, Santa Fe, NM 87501.

Research projects are administered by the New Mexico Energy Research and Development Institute.

ABSTRACT

This report provides the details of a methodical research program conducted to test the old NMSU Golf Course Well to determine its geothermal parameters, to determine its useability as a geothermal disposal well, and actions taken to repair and test the well for disposal service.

The research established that this well shares a common origin with the NMSU geothermal wells, and contains dissolved minerals and gases similar to the existing three geothermal production wells. With a measured temperature of 95°F, the well is cooler than the other wells, but its production zone is much shallower than the other wells, and intersects cooler ground water zones. The well contains a significant volume of H_2S, which exceeds current EPA allowable standards, and as a consequence the well has only utility as a disposal well. Testing establishes the well will safely accept the design disposal rate of 250 gallons per minute of geothermal water. However, the well is 20 years old, and minor perturbations which are occurring during continual test operations dictate that a regular program of surveillance be conducted to assure long-term compliance with the Geothermal Disposal Order under which disposal operations are permitted. Contingency planning is underway which could lead to drilling a new disposal well.

ACKNOWLEDGEMENTS

This work was carried out under an appropriation from the New Mexico Legislature, supplemented by an award from the New Mexico Energy and Minerals Department to assess geothermal parameters. The authors wish to thank Mr. Pat Rodriguez and Mr. George Scudella of that department for their valuable assistance.

Measurements and data acquisition pertinent to conductivity determination were designed and acquired by Mary Clanton. Acquisition and analysis of dissolved gases was performed by Mr. Carl Bernhardt, of New Mexico Institute of Technology. A team headed by Dr. Arden Baltensperger of the NMSU Department of Agronomy is conducting long term research designed to establish parameters for safe use of the geothermal water for possible use in irrigating the NMSU Golf Course.

The authors especially want to thank Darlene Bassford and her staff in the Physical Science Laboratory Word Processing Section for administrative support, and Bud Allen for graphics support.

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INTRODUCTION

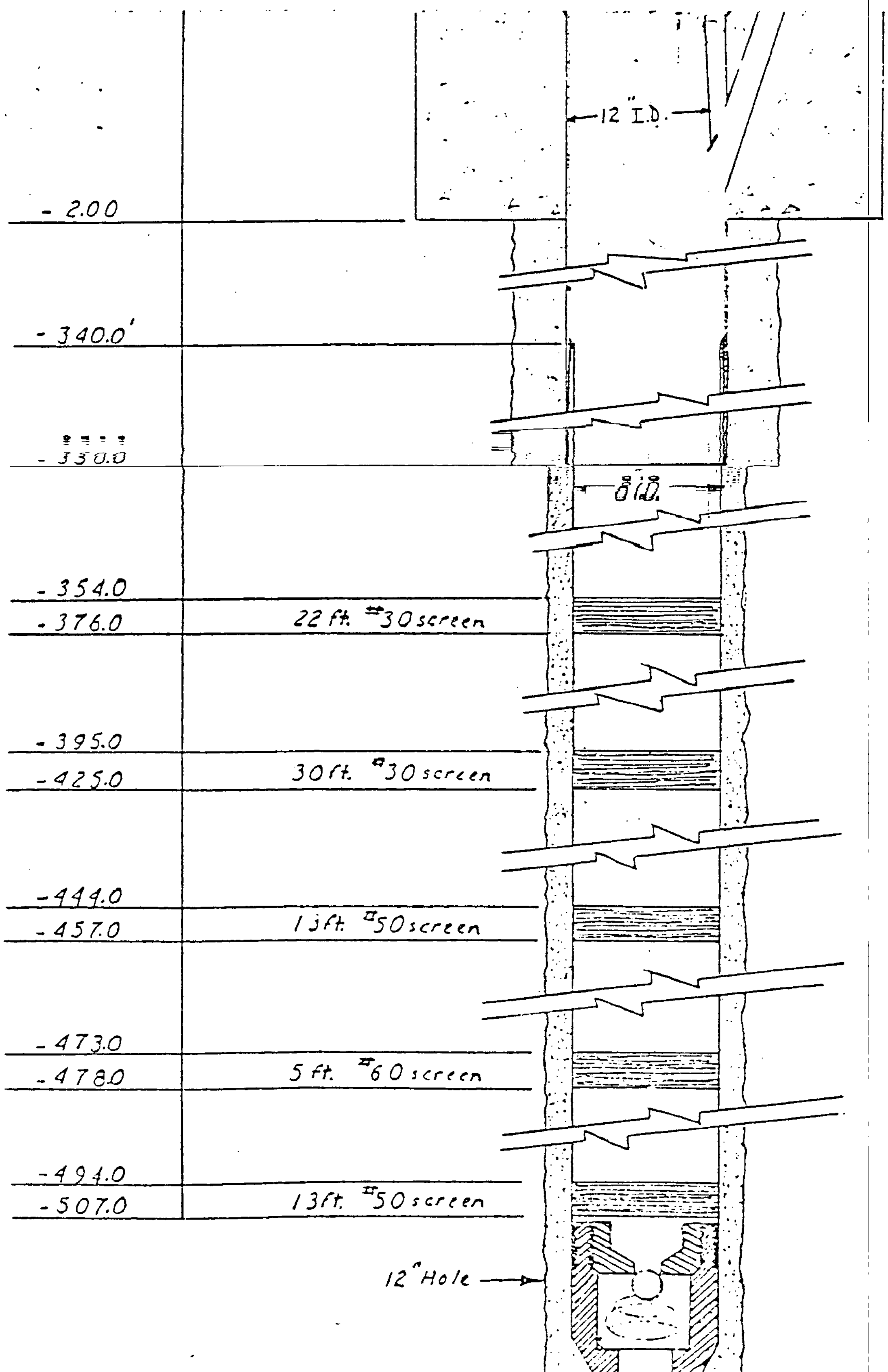
The NMSU Golf Course Well was drilled in 1961, and completed in early 1962. The well was placed into production in early 1962, and was taken out of production in late 1971. Because of the mineralization of the water, vegetation on the golf course was growth-stunted, and in some cases killed by the water. Particular damage was experienced by shrubs and trees, and the putting surfaces. The well was placed in an inactive status in 1971, and the pump was removed.

From limited records available at NMSU, the well was drilled to a depth of 606 feet, and the lowest 100-feet section of uncompleted hole was sealed off by a Johnson well-closure, consisting of a wooden plug with a metal spring and ball closure. The screen section provided for perforated zones from 354 to 376 feet, from 395 to 425 feet, from 444 to 457 feet, from 473 to 478 feet, and 494 to 507 feet of depth. All depths are measured from a point two feet above ground level. (See Figure 1 for a schematic of the completed well.)

Based on earlier research, a Disposal Order was issued by the New Mexico Oil Conservation Division, which allowed testing of this well as a disposal well. Implicit in this approval were the requirements that only gravity reinjection was initially allowable, and that verification of disposal facilities was necessary before placing the well in service.

This well will be used to dispose of 100 to 250 gpm of geothermal water after the heat has been extracted. In the future, should other research so indicate, the geothermal water might be used to irrigate the golf course. In the interim, additional research was required to meet the conditions of the disposal order. Moreover, a more precise definition was needed of geothermal parameters of this well, as an aid to expanding knowledge of the NMSU geothermal field so as to encourage geothermal commercialization.

Construction of the geothermal demonstration project had progressed to a point that a decision was needed as to the useability of the golf course well for disposal operations. Before this judgment could be made, additional tests were necessary, and these tests had to be completed before an irrevocable decision



Golf Course Well Schematic

Figure 1

was made to construct a disposal pipeline. The construction schedule dictated early completion of pumping tests, dissolved minerals and dissolved gas analysis, a strict test of the integrity of the old well casing, a long duration controlled reinjection test, and necessary repairs. At all steps in the data acquistion, water temperature was to be recorded.

DESIGN OF EXPERIMENTS

From available data, it appears this well is warmer now than when it was in production as an irrigation well. If this information was correct, it was expected that the higher temperature might be paralleled by an increase in salinity over earlier values. To assess geothermal parameters, the research was designed to gather key data on water temperature, dissolved gas content, dissolved minerals, and formation transmissibility for reinjection. In addition, if research substantiated that the well was in fact open to its original drilled depth of 606 feet, plans were made to install a submersible pump and conduct step-drawdown tests to determine geothermal parameters for temperature, flow rate and water quality, from depths down to 600 feet.

Available information on well parameters during its first ten years was very sparse and incomplete. In addition, an earlier trial reinjection test had used more than 100,000 gallons of domestic water, reinjected into the well. This domestic water contains only 400-500 ppm dissolved minerals. Accordingly, the research plan provided for a means to pump the well so as to restore base line parameters that might have existed prior to the trial reinjection.

Once this condition was attained, water samples were to be analyzed for dissolved minerals and dissolved gases. Then, a test fixture was to be installed designed to assess, if possible, mechanical integrity of the 20-year old casing. If conditions permitted, a small diameter pump column was to be inserted through the test fixture, to acquire additional samples by jetting samples. Then, after baseline data was acquired, a 120-hour controlled reinjection test was to be conducted to determine transmissibility of the aquifier in a reinjection mode. Concurrently, using one of the existing geothermal production wells, a controlled experiment was to be started to assess the long term effects of the geothermal water on golf course vegetation using sprinkler irrigation.

PUMPING TESTS

This well had not been pumped for ten years. It had been left uncovered, inside a maintenance building, under unknown conditions. Moreover, in February, 1981, a trial injection test had been performed, and more than 100,000 gallons of domestic water (400-500 ppm TDS) had been flowed into the well.

For these reasons, the water quality of the aquifer could not be accurately assessed. A need existed to pump the well for as long as possible, or until stable conditions could be met for water temperature and conductivity, with the latter value equivalent to probable salinity as total dissolved solids.

Because of the unknown length of time that the pumping would require, it was not practical or economic to consider a contractor - operated test pump. The only choice remaining was to use the small hot water submersible pump serving the geothermal well at the University Center. This is a 3.5 Hp pump, which has capability for only 22 gpm. Because the pump could be made available, decision was made to relocate the pump temporarily in the Golf Course Well.

The pump was installed, using 1.5-inch PVC column, and set at 240 feet of depth to pump bowls. This setting provided at least 20 feet of water over the pump bowls. The pump discharge was then connected to 300 feet of temporary pipeline to a drainage area. A turbine flowmeter and electronic temperature monitoring points were installed, and the probes were connected to strip chart recorders.

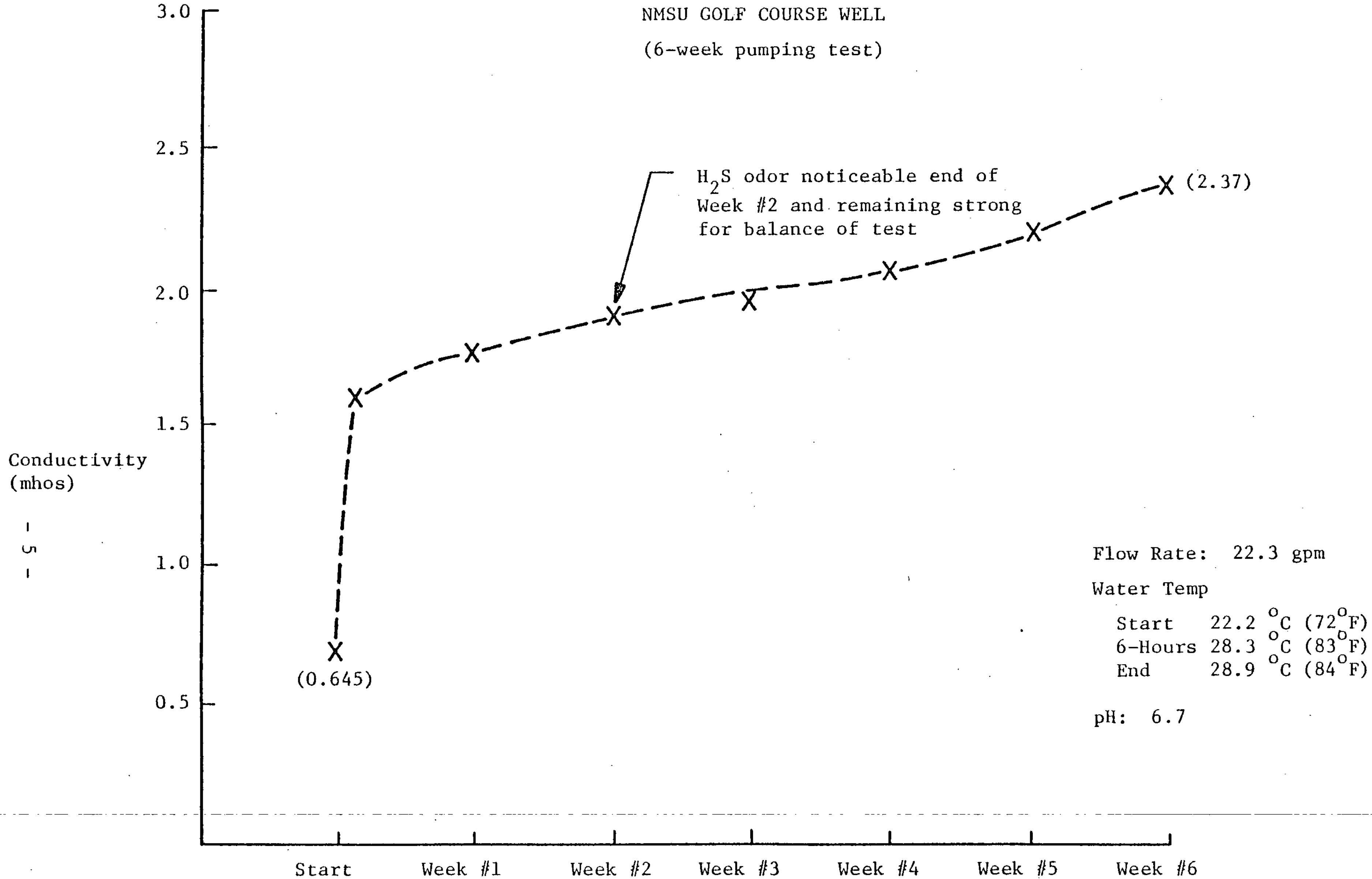
Figure 2 is a plot of conductivity values versus time. As can be seen, initially the conductivity values were low, equivalent to a TDS of less than 1,000 ppm. Initial water temperature was 72°F. Drawdown was less than one foot at 22 gpm. Fluid velocity was approximately 12 fps. Hence, the pump was merely pulling water from the upper zones of the well. As pumping continued, conductivity values increased sharply, and a noticeable odor of H_2S became very pronounced. Water temperatures increased to 84.5°F, and remained relatively constant.

Figure 2

CONDUCTIVITY MEASUREMENTS

NMSU GOLF COURSE WELL

(6-week pumping test)



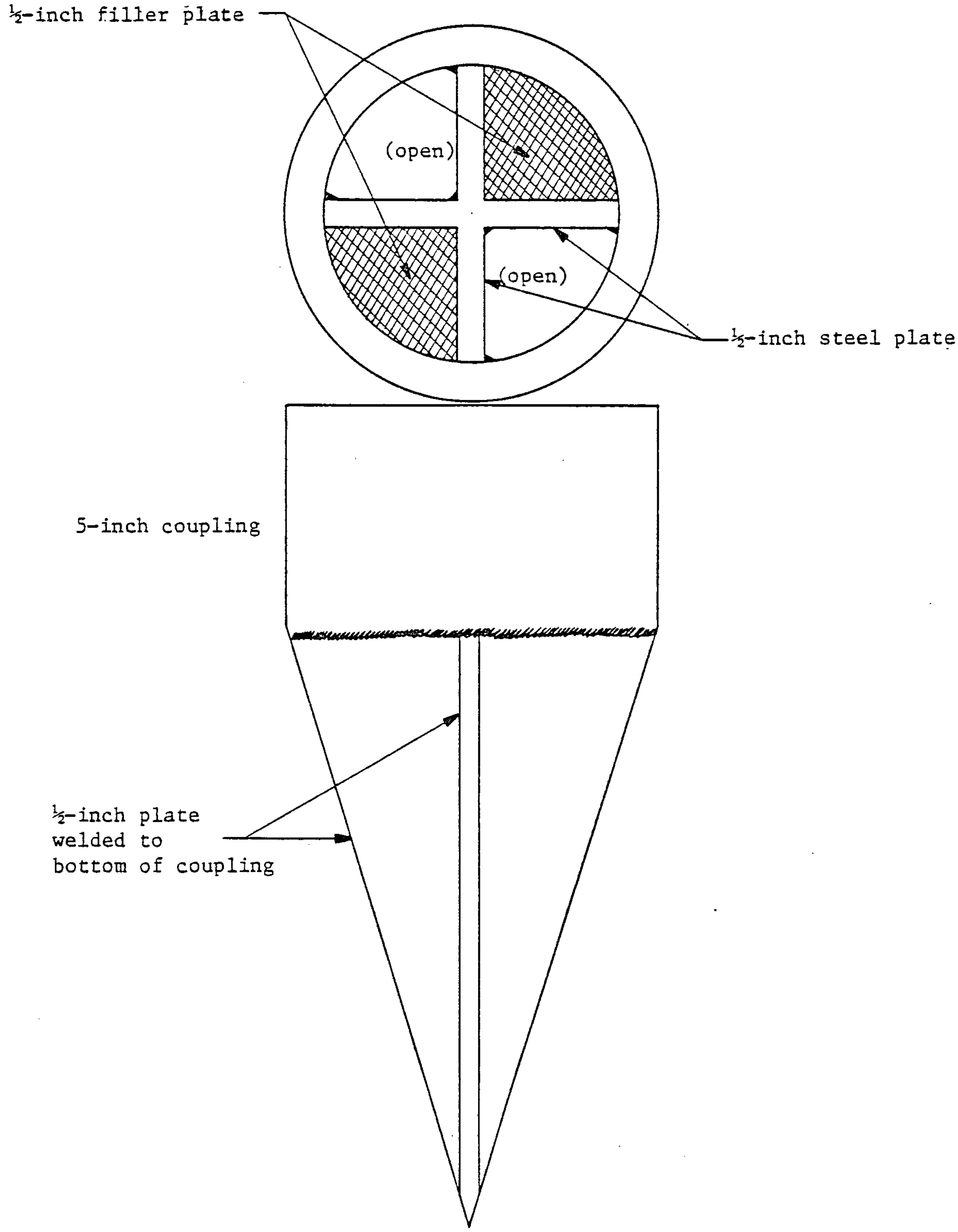
Conductivity values continued to increase, but were not stable. A time constraint then occurred, and the Disposal Order for the Golf Course Well required a formal reinjection test, witnessed by OCD representatives. Accordingly, a decision was made to acquire water samples for detailed analysis for dissolved minerals and gases. Conductivity values at the time of sampling were equivalent to approximately 1,575 ppm of total dissolved solids. The pH of the samples was 6.8. From the slope of the curve in Figure 2, it is likely that an increased pumping rate, or a longer time period of pumping would have produced higher conductivity values.

REINJECTION TEST

A. Test Fixture: After the small submersible pump was withdrawn, an attempt was made to acquire a temperature log. The hole was bridged at roughly 350 feet of depth, and a complete log could not be acquired. This same problem arose on an earlier test. Moreover, concern existed about the integrity of the closure valve originally installed at 507 feet of depth. In order to pierce the bridge, and to explore the condition of the well bottom, a special test fixture was designed. Details of this fixture are depicted in Figure 3. In turn, the fixture was designed to be threaded on the bottom of heavy wall, 5-inch inside diameter pipe, and lowered into the well.

B. Insertion of Test Fixture: The fixture and steel pipe were lowered into the well on a day when ambient air temperature was 65°F. The weight of the steel pipe, and the sharp-pointed fixture very easily cleared the small bridge at 350 feet of depth. A second more substantial bridge was encountered at 385 feet of depth, and also was cleared. Existence of these two bridges could mean the pumping test involved only water movement from the top screen section at 354 to 376 feet of depth, with possible minor seepage from lower sections.

At 488 feet of depth, the fixture encountered an unknown mass. With the weight of the column (approximately 8500 pounds) resting on the mass, it was not possible to rotate the column. When the column was raised only an inch, it was possible to rotate the column. Inadvertently, due to a mix-up in crane signals, the entire 8500-pound weight was suddenly dropped



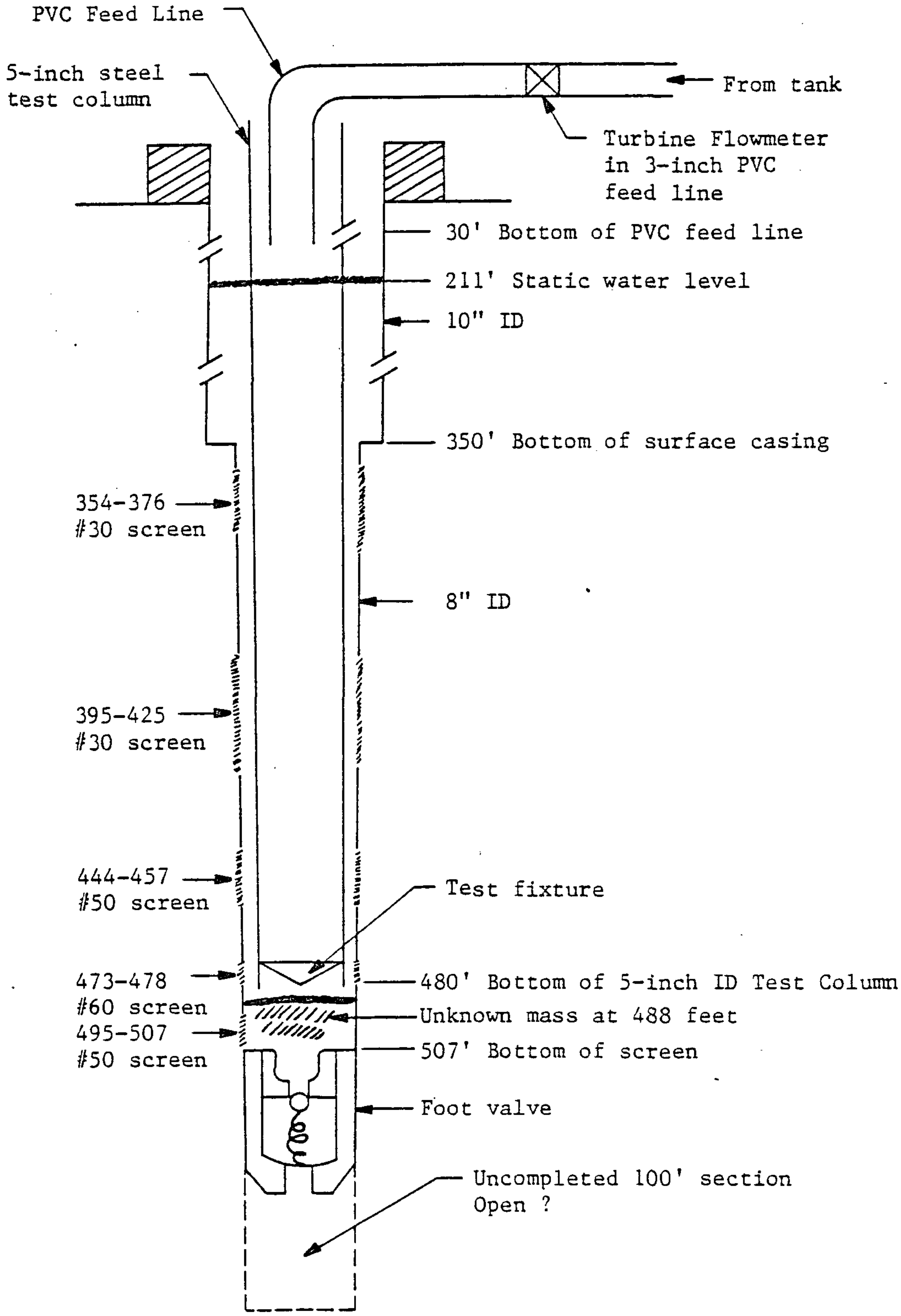
Test fixture, screwed onto bottom of
5-inch steel column, NMSU Golf Course Well

Figure 3

8-10 feet on the mass. The test fixture did not penetrate the mass. The conclusion reached was that this unknown mass probably was a fused mixture of debris, rust and scale which had collected over the past 20 years. This conclusion leads to two other observations. First, the screen section between 495 to 505 feet of depth probably is blocked, with a possiblity that it might allow minor flow (leakage) of fluid. Secondly, the closure device probably still is intact. Subsequently, it was determined that the valve was fabricated of cypress wood, which is quite long-lived, and relatively resistant to rot. This fact also supports the belief the foot valve is intact.

Because it appeared to be impossible to pierce or remove the blockage at 488 feet of depth, a decision was made to position the test fixture just above the mass at 480 test of depth. The resulting test configuration is depicted in Figure 4.

C. Reinjection Test. A need existed to test the well capability to accept in-flow of 250 gpm, which is the system design geothermal flow rate. In order to provide assurance of continuous intake of 250 gpm, a need existed to prove well capability at as high a rate above this value as could be attained. The limiting factor was the availability of static head, or mechanical assisted pumping to provide the required flow rate. At the site was a stand-by water storage tank, which could provide 44 feet of head. This tank was connected to the well by a temporary pipeline, and a short duration test was conducted. This test indicated flow rate up to 270 gpm could be attained. Prior to this test, a very low flow rate test was conducted, consisting of 20-25 gpm for 20 hours to assure the test fixture was intact, and open to flow.



NMSU Golf Course Well

Trial Injection Test

24-29 September, 1981

Flow rate: 200-275 gpm

Figure 4

CALCULATION OF TRANSMISSIBILITY

The reinjection test was conducted over a 5-day period, for a total of 115 clock hours. To attain sufficient volume of in-flow, the well was connected to a storage tank adjacent to the well. This tank provides back-up domestic water for the NMSU campus. Testing permits required gravity reinjection, so that pressure boost pumps could not be used. Because this test tank is interconnected to the main campus water system, variations in static head resulted from routine water usage. Accordingly, a steady state flow rate could not be maintained.

For the first part of the test, an attempt was made to get maximum flow. An initial rate of 270 gpm was attained, but this decayed gradually to a rate of 265 gpm as the tank static water level dropped. Well static water levels were monitored continuously, and a continuous record was maintained of flow rate using an in-line turbine flowmeter connected to a strip chart recorder. This portion of the test was conducted for four hours, and was monitored by representatives of the New Mexico Oil Conservation Division. The well appeared to attain semi-equilibrium conditions after 75 minutes.

Phase II of the test was completed by setting the in-flow rate at 228 gpm, which is close to the planned system usage rate. As before, it proved to be impossible to maintain a constant flow rate, and the rate decayed to 211 gpm during the course of the test. For the last 24 hours of this test, the in-flow rate varied from 205 to 228 gpm, as a function of campus irrigation. This erratic flow rate undoubtedly resulted in some bias to the calculated transmissibility. Detailed time logs are in Appendix A.

Using the modified Jacob-Theis formula, test results were first plotted on semi logarithmic paper. Figure 5 depicts the results.

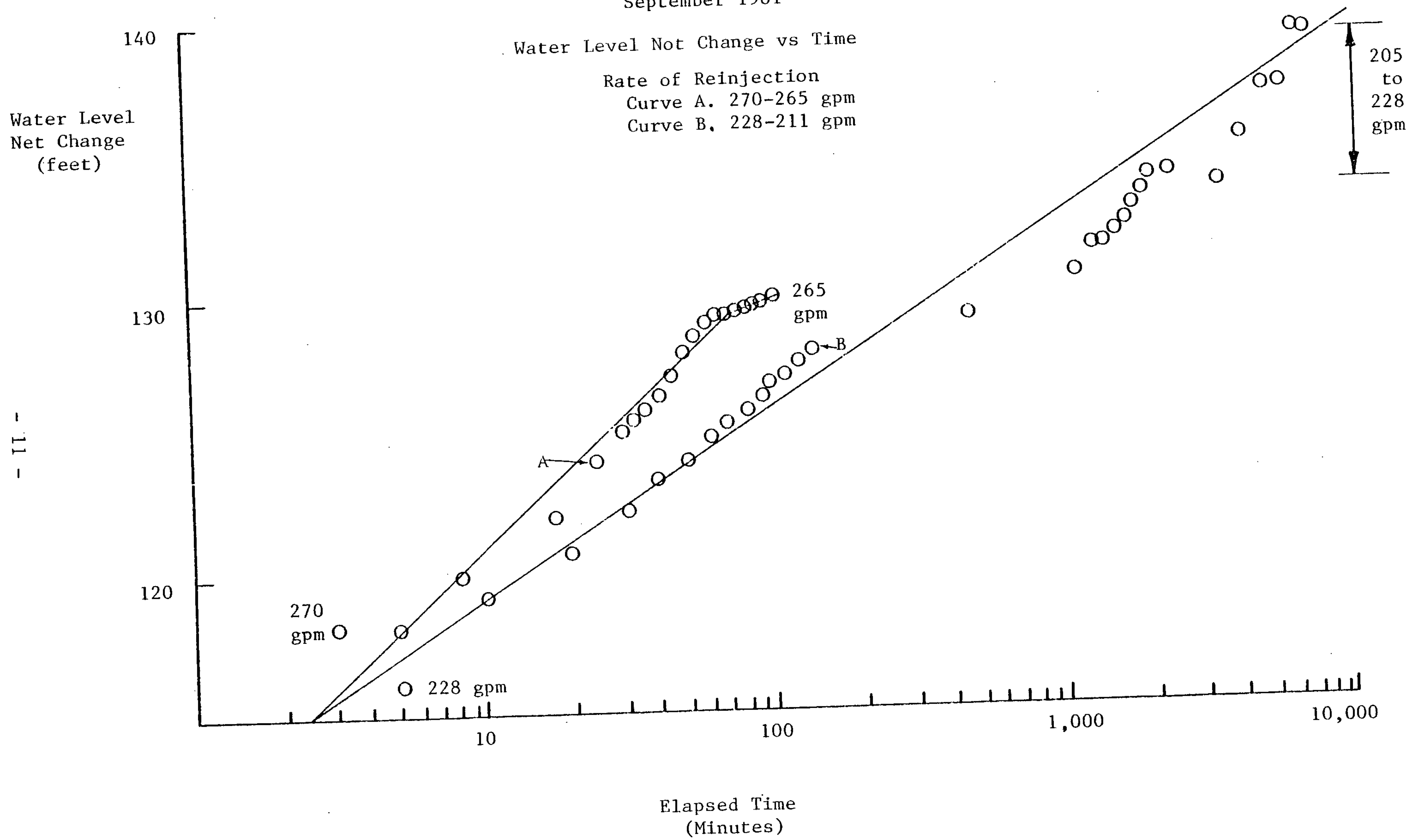
Figure 5

NMSU GOLF COURSE WELL REINJECTION TEST

September 1981

Water Level Not Change vs Time

Rate of Reinjection
Curve A. 270-265 gpm
Curve B. 228-211 gpm



Coefficient of transmissibility is then calculated from the following formula.

$$T = \frac{264Q}{\Delta S}$$

Where T = coefficient of transmissibility in gpd per foot

Q = Pumping rate in gpm

ΔS = slope of time water level net change curve

Results of these calculations are listed in Table 1, and the calculated value for transmissibility ranges from 8000 to 9260 gpd per foot. Greater confidence is given to the longer duration test (flow rate 211 to 228 gpm) which produced values varying from 8570 to 9260 gpd per foot.

Table 1
Calculated Transmissibility for Golf Course Well
(as Reinjection Well)

Curve A

Flow Rate (gpm)	T (gpd/ft)
270	8150
265	8000

Curve B

Flow Rate (gpm)	T (gpd/ft)
228	9260
205	8570

At a transmissibility of 8570 to 9260 gpd per foot of aquifer, the well in a reinjection mode compares favorably to many irrigation wells. Based on a comparison of the trial injection test in February 1981, with fragmentary data from production years tends to indicate the well can perform for reinjection almost as well as for production. This conclusion is preliminary, however, since very little hard information is available from production years. Available data indicates the well had a net drawdown change of approximately 100 feet at a yield of 550-600 gpm, with the pump bowls set at 330 feet of depth. From the February, 1980, test which used the same size screen section and casing as production years, reinjection rate of 550 gpm produced a net change of 100 feet in the static water level. Although not conclusive, the comparison seems to indicate the aquifer has the potential to accept adequate reinjection rates . Since the planned reinjection rate is 225-250 gpm, the well probably will be adequate. However, because reinjection wells tend to plug more easily than pumped wells, the water level will be monitored closely to assure that the well is not declining in in its ability to accept reinjection.

WATER TEMPERATURE

During the course of testing the Golf Course well as a disposal well, several significant elements of data have become available.

1. During production years 1961-1971, the well pumped water measuring 75°F with a salinity in the range of 1,250 ppm. This temperature is slightly warmer than normal, but not especially significant.

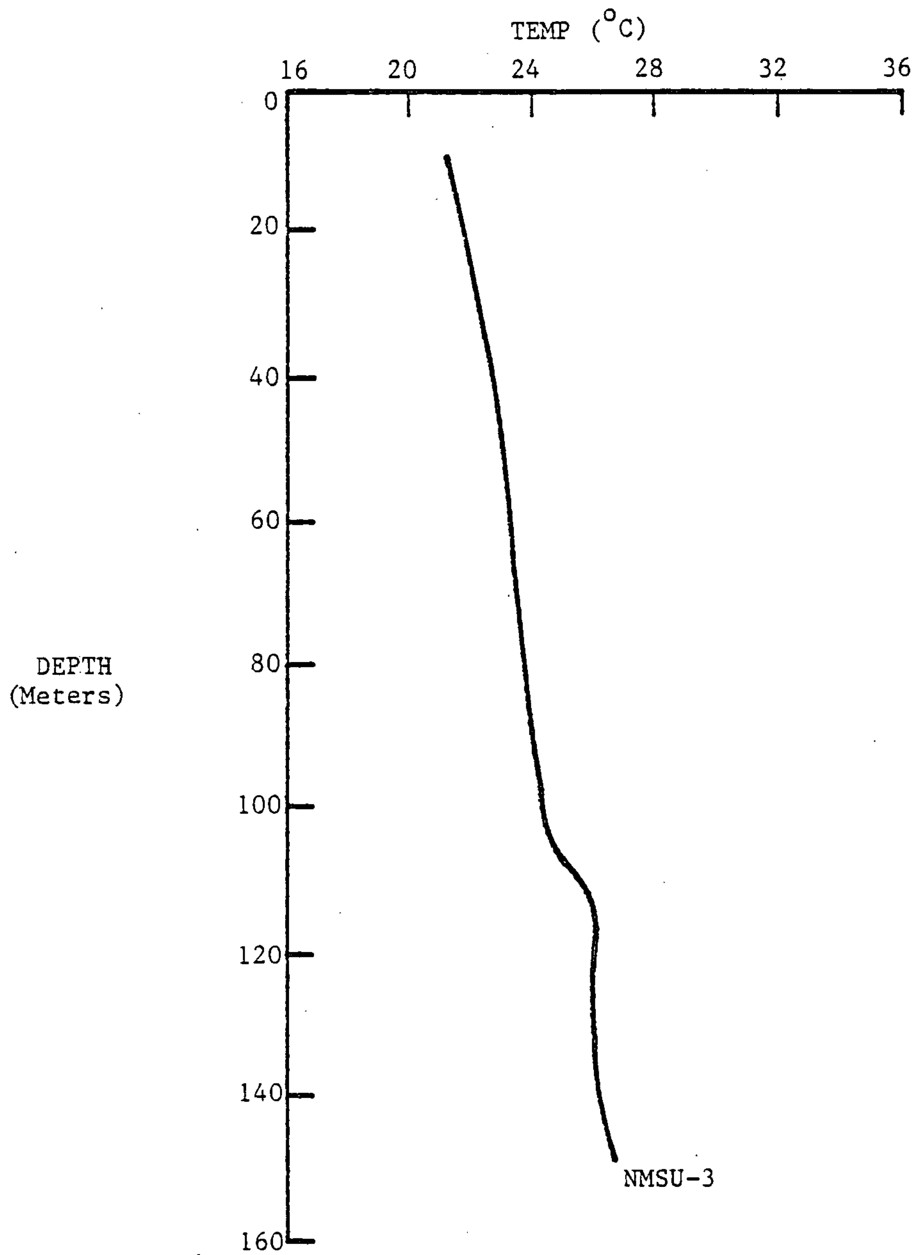
2. A temperature log acquired in 1978 by NMSU researchers indicates the peak temperature of 26°C (78.8°F) was measured at 490 feet (150 meters) of depth. See Figure 6.

3. Testing in early 1981 revealed that the well had a temperature of 92.7°F, and possibly was open to a total depth of 606 feet. (Subsequent testing has indicated the temperature probe probably was not inserted deeper than 502 feet.)

4. As part of the current cycle of testing, detailed temperature data was acquired. Before, during, and after sequential actions, temperatures were acquired using an electronic temperature probe, connected to an electronic temperature indicator and a strip chart recorder. This instrumentation was calibrated to a precision of ± 0.25°F. A representation of these data is depicted in Figure 7. Interpretation of this

Figure 6

TEMPERATURE-DEPTH PROFILE
NMSU GOLF COURSE WELL (1978-79)



Extracted from Report EMD 2-66-2211, "State Coupled Low Temperature Assessment Program, Fiscal Year 1979

Figure 7

TEMPERATURE PROFILE (Bottom Hole)

NMSU Golf Course Well

(480 feet deep)

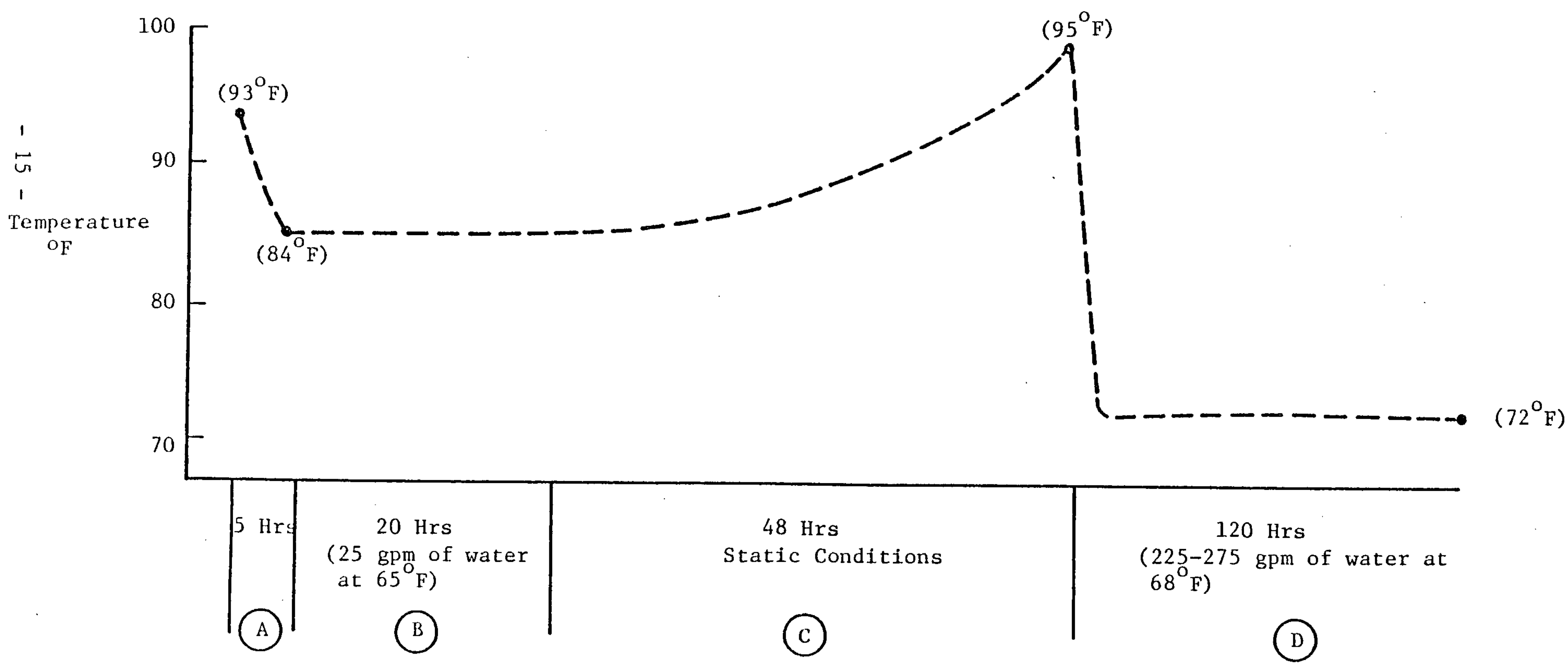


figure is keyed to the time-phased sequential actions, A through D, further described as follows:

A. The 5-inch test column, which was at 65°F temperature was inserted in the well. Five hours after the job was started, the bottom hole temperature had cooled to 84°F.

B. To assure that the test column was open, a low-flow rate test was made, consisting of 20 gpm flow for 20 hours, using in-flow water at temperature 65°F. The bottom-hole temperature remained constant at 84°F.

C. The well was left undisturbed for 48 hours, and a steady increase in temperature was recorded with a peak temperature of 95°F. The end of this 48-hour period coincided with the scheduled start of the 120-hour in-flow test, which was monitored by OCD representatives.

D. Through-out this latter test, bottom hole temperature remained constant at 72°F, which is slightly warmer than the 68°F measured average temperature of the in-flow water.

Subsequently, at periodic intervals, the well was temperature logged. The peak temperature of 83.7°F, measured after one week, remained constant for 60 days after completion of the test. The fact that the temperature had declined from the peak of 95°F suggests that the force of in-flow water had acted to seal some of the minor interstices which apparently had opened in the past years. These minor interstices are believed to be the source of the current temperature, which is higher than the 75°F reported during production years.

It is also significant that the temperature probe was able to penetrate to, but not beyond, 502 feet of depth. The unknown mass at 488 feet had been dissipated by the force of the in-flow water. From the behavior of the temperature log, it appears the unknown mass probably was an amalgamation of rust and scale, which was broken up and forced back into the lower well screen sections. Quite possibly, the two lowest screen sections are effectively plugged by rust and scale, and only the top 65 feet of screen section are fully open.

ANALYSIS OF DISSOLVED MINERALS

Analysis of water samples for the pressure and amount of dissolved minerals is a key test. The type and quantity of those minerals can help significantly in the evaluation of commonality of aquifers. In addition, the ratio of selected dissolved minerals is used in estimating geothermometers as to possible geothermal source temperature. Moreover, chemical analyses are useful in assessing environmental effects of the geothermal water.

As mentioned previously, the golf course well was placed into service in 1962, was used for nine to ten years, and was placed in an inactive status in 1971. Although it is possible that numerous water analyses were made, only two partial analyses have been located. These two analyses contain unexplained variances, but are in general agreement about the total amount of dissolved solids, roughly 1,250 ppm.

After the well had been test-pumped for six weeks, and elevated values had been obtained for conductivity, samples were acquired for analysis. In order to compare this well with the other geothermal wells, a complete analysis was performed. This analysis included all heavy metals as well as the many salts. Results of this analysis are tabulated in Table 2.

In reviewing the tabulated data, heavy metals concentrations in all the wells are comparable. As would be expected from the fact that the golf course well intercepts shallower water zones, the bicarbonates, sodium, potassium, and sulfates show lower values than the hotter wells. The golf course well had an elevated iron content in comparison with the other wells. It is significant that the pH of the sampled water was very consistant across all four wells.

TABLE 2

Comparison of Dissolved Minerals
NMSU Geothermal Wells
(mg/l)

	PG-1*	PG-2*	PG-3	GCW *
Ca	138	188	138	131.7
Mg	19	21	17.4	23.0
Na	488	450	488	321.4
K	57.9	51	52	33.6
C_l	590.6	610	546	391.4
CO_3	0	0		0
HCO_3	612.6	508.9		547.9
SO_4	285	226.2		147.5
As	0.002	0.013		0.003
Ba	<0.4			<0.4
Cd	<0.005			<0.005
Cr	<0.05			<0.05
P_b	<0.005			<0.005
Hg	<0.0002			<0.0002
Se	0.002			0.002
Ag	<0.05			<0.05
NO_3-N	0.02			0.01
S_iO_2	92	57.5		60.9
F	1.31	1.31		1.52
Fe	0.28	0.55		3.95
Mn	.06	1.05		0.16
B	0.10	0.23		0.09
Cu				<0.10
Sample pH	6.8	6.8	6.8	6.7
Analysis pH	7.95	8.36		7.37

* Analysis over 60-day period; dissolved gases had escaped

Water Temp.	141°F	118°F	146°F	95°F

DISSOLVED GAS ANALYSIS

The amount of free carbon dioxide (CO_2) dissolved in the geothermal fluid is significant. This CO_2 possibly is dissolved by water flowing over or through soil where plants are growing. However, presence of CO_2 in ground water is especially significant for underground water containing calcium and bicarbonate in solution. An equilibrium solution likely exists at subsurface conditions, and when this pressure is reduced by pumping, the CO_2 is freed from solution and escapes as bubbles of gas. From page 77 of the "Ground Water and Wells" book published by Johnson Division of UOP, Inc., the amount of free CO_2 can be estimated by the following table.

TABLE 3

Free CO_2 in Ground Water vs Bicarbonate Content

Bicarbonate Alkalinity ppm as $CaCO_3$	Free Carbon Dioxide (ppm by volume) at pH = 7.0	at pH = 7.5	at pH = 8.0
100	22	6	2
200	43	12	4
300	63	17	6
400	82	22	7

In reviewing the water analysis (conducted at a pH of 7.4) and the dissolved gas analysis, an apparent anomalous condition exists. At a pH of 7.4, extrapolation from Table 3 results in an estimate for free CO_2 in the range of 35 ppm by volume for the measured Ca plus HCO_3 value of 684 ppm from the water analysis. (See Table 2 for analysis of dissolved minerals.) In fact, the dissolved gas contained 78.3 cc of CO_2 per liter of fluid, which represents 7800 ppm by volume. This concentration is vastly larger than normal ground water, even if the pH correlation is not made. Accordingly, some other source must be hypothesized for the CO_2.

From work by W. A. J. Mahon, G. D. McDowell, and J. B. Finlayson (1980), in the majority of geothermal systems world-wide, CO_2 generally represents 85% by volume of total gases present. These authors cite work by Ellis and Mahon (1977) who concluded that it was possible to correlate the overall carbon isotope composition of the gases in geothermal fluids with mixed carbonate and organic carbon sources in rocks which contact the hot fluids, but an addition of juvenile carbon to the systems could not be ruled out.

Also cited by W. A. J. Mahon, et al, is work by Muffler and White (1969), in which the authors outlined the difficulty of distinguishing the ultimate origin of carbon dioxide.

The presence of an elevated water temperature (95°F) viz 68°F normal for the area, together with the high concentration of dissolved CO_2 argues that the golf course well is connected with the geothermal reservoir which is producing 142 - 146°F fluid from the two large NMSU geothermal wells. The fact that the golf course well has a lower concentration of free CO_2 (78 cc/liter viz 180 - 200 cc/liter in the hotter wells) could be accounted for by the fact that the golf course well intersects shallower zones which are cased-off in the hotter wells. In fact, the golf course well intersects production zones at 354 to 495 feet of depth, whereas the hotter wells are producing from zones 700 to 850 feet deep. Presumably, the shallower zones are more representative of normal ground water aquifers.

Presence of hydrogen sulfide (H_2S) in the golf course well is also anomalous. The markedly high fraction of H_2S (0.33 cc/liter) compares with less than 0.038 cc/liter in the hotter wells. Thus, the golf course well has a concentration of H_2S almost tenfold larger than the other geothermal wells. Presence of this H_2S could be accounted for by the possible presence of sulfate - reducing bacteria. Conditions favorable to their growth are absence of oxygen and fairly high sulfate content. In fact, elevated sulfate levels exist in all the geothermal wells, but concentrations of sulfates in the golf course well were roughly one-half the concentration in the hotter wells (147.5 mg/l vs 285 mg/l in the hotter wells). Accordingly, some other mechanism probably accounts for the unusually high concentration of H_2S in the golf course well. It is possible that the elevated H_2S levels result from some unknown faulting action in the NMSU geothermal field.

TABLE 4

Comparison of Dissolved Gases
NMSU Geothermal Wells

	PG-1	PG-2	PG-3	GCW
Conductivity (Mhos/cm	3.11	3.17	3.16	2.37
pH	6.8	6.8	6.8	6.7
Dissolved Gases (cc/l)				
CO_2	202	182	220	78
N_2	8.6	7.6	12.65	8
H_2S	(Trace)	(Trace)	(Trace)	0.33
CH_4	750 *	0.3 *	0.25	0.24
O_2	24 *	32 *	170 *	94 *
H_e	96 *	240 *	27 *	38 *
Ne	0.98 *	0.71 *	0.26 *	1.3 *
Ar	340 *	320 *	1300 *	2200 *
K_R	0.18 *	.07 *	0.045 *	0.45 *

* Indicates by volume instead of cc/liter

COMPARISON OF GEOTHERMOMETERS

As part of the effort to acquire and analyze gas samples, the water samples were analyzed for geothermometers. These analyses and calculations were made by Carl Bernhardt at NMIMT. Results are tabulated in Table 5.

Comparison of the reported values indicates the golf course well compares favorably with the other NMSU geothermal wells for the quartz and chalcedony geothermometers. The abnormally high values reported for sodium, potassium and calcium cause the golf course well to be much lower in sodium-potassium, sodium-potassium-calcium, and sodium-calcium geothermometers. If the values from Table 4 are used, good correlation exists between all the geothermal wells using the sodium-potassium-calcium geothermometer. In addition, from other work by Norman and Bernhardt, a good correlation exists between the sodium-potassium-calcium geothermometer and the new CO_2 - CH_4 ratio. Using this latter geothermometer, the excellent correlation between all three wells suggests strongly all the geothermal wells have a common source.

TABLE 5

Comparison of Geothermometers

NMSU Geothermal Wells

(°C)

	PG-1	PG-2	GCW
Quartz	120	119	102
Chalcedony	92	90	72
Na-K	247	234	--
Na-K-Ca	202	194	174*
Na/Li	92	130	--
CO_2/CH_4	238	207	190

* The values reported by Bernhardt are much lower than those shown because of unexplained high values for dissolved Na, K, and Ca in the water analysis reported by Bernhardt. Reported by the team which analyzed dissolved gases were values of 2,400 ppm for Na, 680 for Ca, and 26 ppm for K which compare with values from a separate water analysis of 321 ppm for Na, 391 ppm for Ca, and 33.6 ppm for K as listed in Table 4. If the latter values for Na, K and Ca are used, the Na-K-Ca geothermometer is 174°C, which correlates quite well with the hotter geothermal wells. Because the water chemistry analysis in Table 4 is comparable to a year 1962 analysis from the well, and also is consistant with the estimated total dissolved solids based on conductivity values (see Figure 2), the conclusion reached is that both dissolved mineral and dissolved gas geothermometers support the theory that the golf course well shares a common geothermal origin with the hotter NMSU wells.

POSSIBLE MIXING MODEL

Based on acquired test results for water temperature, dissolved minerals, and dissolved gases, it is possible to calculate some mixing ratios which might prove useful to evaluate geothermal parameters of the golf course well.

As a starting point, data acquired during the pumping test and the insertion of the test fixture lead to certain conclusions. First, the well contained a bridge at 350 feet of depth, and a second major bridge at 380 feet of depth. These two bridges could have acted to cause pumped fluid to migrate only from the screen section at 354 to 376 feet of depth, with some minor communication from the deeper screen sections. In support of this conclusion, during the production years, the well had a reported 75°F water temperature, and a salinity of approximately 1,250 ppm. These values compare with a pumped water temperature of 84°F and a salinity of 1,500-1,575 ppm at the end of the 6-week pumping test. The original temperature and salinity of this well are both higher than other NMSU domestic wells, which have average values of 68-69°F, and 450-500 ppm salinity.

Concerning dissolved CO_2, the golf course well contains approximately one-third as much CO_2 as do the hotter NMSU wells. If this ratio is a valid measure of possible mixing, it should be possible to estimate a geothermal-ground water mixing ratio, and to estimate resulting dissolved mineral and temperature values which can then be compared with observed values. The following Table 6 depicts the measured values for CO_2, salinity, and temperature of the wells. Note that GCW_o indicates the original values for the golf course well, and GCW_n indicates "now" values.

TABLE 6

Comparitive Parameters, NMSU Geothermal Wells

	Temperature (°F)	TDS (mg/l)	Dissolved CO_2 (cc/liter)
PG-1	141.5	1,950	202
PG-3	146	1,980	220
GCW_o	75	1,250	unknown
GCW_n	84	1,500-1,575	78

Based on the values shown in Table 6, the CO_2 ratios are as follows:

$$\frac{GCW_n}{PG-1} = \frac{78}{202} = 0.3861$$

$$\frac{GCW_n}{PG-3} = \frac{78}{220} = 0.3545$$

Using these CO_2 ratios, predicted salinity is calculated as follows:

$$(PG-1)(Ratio) + (GCW_o)(1 - Ratio) =$$
$$(1950)(0.3861) + (1,250)(0.6139) =$$
$$753 + 767 = 1,520 \text{ ppm}$$

$$(PG-3)(Ratio) + (GCW_o)(1 - Ratio) =$$
$$(1980)(0.3545) + (1,250)(0.6455) =$$
$$702 + 807 = 1,509 \text{ ppm}$$

These calculated salinity values agree quite well with the measured salinity values of the golf course well under current conditions.

Similarly, using CO_2 ratios as an estimator, temperature values are calculated as follows:

$$(PG-1)(Ratio) + (GCW_o)(1 - Ratio) =$$
$$(141.5)(0.3861) + (75)(0.6139) =$$
$$54.6 + 46.0 = 100.6°F$$

$$(PG-3)(Ratio) + (GCW_o)(1 - Ratio) =$$
$$(146)(0.3545) + (75)(0.6455) =$$
$$51.8 + 48.4 = 100.2°F$$

These temperatures are higher than the observed pumping water temperature, and are higher than the observed bottom-hole temperature, 95°F. However, it is noted that the bottom-hole temperature was obtained only 48 hours after the test fixture was installed, and prior to the well attaining equilbrium. (See Figure 7). Had it been possible to leave the probe in place for a longer period, the slope of the temperature plot suggests a higher bottom-hole temperature could have been attained. As a second important consideration, if the bridging theory is correct, the abundant aquifer at 354 to 376 feet of depth would tend to mask temperature effects from the lower part of the well. Minor communication of CO_2 and dissolved minerals would be possible, and yet the low seepage rate would not permit the observation of a sizeable temperature effect. Because of these considerations, the lack of temperature-CO_2 ratio correlation does not rule out the possibility of a fluid temperature at 480 feet of approximately 100°F. It is significant that the 5-day injection test, using 68°F water at 220-275 gpm, produced a bottom-hole temperature of 72°F. This fact suggests that the heat source is large to warm this constant flow 4°F above input temperature.

If the observed temperature, or the calculated bottom-hole temperature are used, the well had a sizeable temperature gradient. With a top-of-water-level temperature of 80°F, the well had an observed gradient in water of 5.5°F per 100 feet of depth, for the 270 feet of water from 210 to 480 feet. Using the estimated temperature of 100°F, this gradient is 7.4°F per 100 feet of depth. Similarly, using the change of temperature from surface to 480 feet of depth, the observed gradient is 6.25°F per 100 feet, and the calculated gradient is 7.3°F per 100 feet of depth. These gradients are two-to-three times higher than normals for the Rio Grande Rift. Hence, a likelihood exists that deeper wells in the vicinity of the golf course well could intersect warmer strata. Certainly, the Las Cruces city water well drilled 3,000 feet North of the golf course well contained a drilling mud temperature gradient suggestive of 110-120°F fluid at 700-800 feet of depth. This temperature is consistent with the temperature increase of 5.5-7.4°F per 100 feet of depth suggested by the observed and calculated gradients in the golf course well. Although not conclusive, these data suggest the likelihood of a geothermal resource 110-120°F at depths less than 1,000 feet. In addition, the geothermometer estimates indicate the possibility of still higher temperatures at unknown greater depths.

WELL REPAIRS

A review of the test data, water and dissolved gas analyses, and the corrosion problems in the well resulted in a perceived need to insert a liner in the well casing. Purpose of this liner is to prevent loose rust and scale from falling into, and bridging the well. With an inside diameter of 8-inches in the screen section, a liner of 6-inches inside diameter could be inserted, and would provide mechanical strength to the well, in addition to solving the bridging problem. Moreover, the planned liner also would include new Johnson steel well screen for the screen section of the well.

A permit for this repair action was obtained from the Oil Conservation Division. Because of the lead time to acquire materials, and to schedule the crane and other equipment, repairs commenced on December 10, 1981. The test fixture and 5-inch steel column were removed. After only two months in the well, the steel column displayed an advanced and severe case of corrosion. Because of the CO_2 and H_2S in the well, which result in the formation of carbonic acid and sulfuric acid, it was anticipated that the portion of the test column above the water line would show significant corrosion. However, the degree of this corrosion was much more severe than anticipated. Close to, but above the static water level, rust and scale had accumulated to a depth of almost one-quarter inch. Below the water level, corrosion and scaling were even more pronounced. At one junction of the threaded portion of the column and the couplings, up to one-half inch of scale and rust had accumulated. In places, corrosion had pitted the steel pipe to a depth of more than one-eighth inch.

Two test scrapings were made, and were analysed by a commercial lab. One scraping was from a test specimen 100 feet above the static water table, in the air/vapor phase inside the well bore. The second scraping was from a test specimen 100 feet below the static water table. Results of this analysis are listed in Table 7, which follows. The values have been normalized by deleting the "loss on ignition" (LOI) percentages which were 7 percent and 9 percent, respectively. Thus, Table 7 lists only the percentage composition of the residual material.

TABLE 7

Analysis of Golf Course Well Corrosion and Scale
Primary Composition (%)

	Sample One (100' above WL)	Sample Two (100' below WL)
Fe 203	97.8	93.4
MnO_2	1.1	
ZnO	1.1	1.1
CaO		4.4
S_iO_2		1.1

After the 5-inch column was removed, the liner was installed. This liner had been pre-fabricated in 30- to 40-feet lengths, with the lowest 100-feet section consisting of alternating steel screen and sections of blank pipe. This portion of the liner was designed to match the original screen sections from 354 to 454 feet of depth. During the course of the repair operation, it was determined that the orginal schematic was not factual. As depicted on this schematic, the original well decreased from 10 inches to 8 inches inside diameter at 354 feet of depth. However, exact measurements made while inserting of sections of the new liner indicate this dimension change occurs at 340 feet of depth. Accordingly, the planned scheme was altered to provide a liner section from ground surface to 400 feet of depth. It was hoped that the screen sections and their location were accurately depicted on the original schematic, and the new liner will match the original screen intervals. The change in plan made during repairs was designed to optimize as much as possible in this uncertain situation.

The liner as finally installed is portrayed in the following table, and consists of welded sections.

TABLE 8
Disposal Well Liner

Setting Depth	Liner Material
2 feet above ground surface to 350 feet	6-inch inside diameter, schedule 40 steel pipe
350 to 380 feet	6-inch steel screen, #50
380 to 400	6-inch steel pipe
400 to 410 feet	6-inch screen section, #50

The top of the 6-inch liner was then secured by flanges to the top of the surface casing, and bolted down. The well was completed by inserting a 4-inch diameter steel pipe in the top of the 6-inch liner. This allowed one-inch open annular space around the insertion pipe, so as to assure only gravity reinjection. This insertion pipe was connected to the disposal pipeline.

ADDITIONAL TESTING

After the well repairs were completed, additional tests were conducted to verify conditions and to assure the integrity of the repairs.

An initial test at a flow rate of 300 gpm caused water to overflow from the well. Cause of this overflow is unknown, although it is suspected a temporary bridge had formed during the repair operations. Because of this problem, however, a decision was made to seal the casing liner at the well head. The change also permitted the system to use the drop in elevation between the production and disposal wells of 130 feet (less an estimated 15 feet of friction losses) as the injection motive force to assure injection without the need for an injection pump. Moreover, this design completely isolates the geothermal flow so that a blockage of the disposal well will not result in a geothermal spill. Instead, if the well is blocked, system flow will cease, and automatic controls will shut down the production well pumps.

After design changes were incorporated, a 3-hour flow test was conducted. Changes in static water level were measured by differential pressure, and flow rates were monitored by installed system flow meters at the Gas Separator tank and Heat Exchanger complex. The test was designed to assure that the well would accept up to 50 percent more flow than the system design flow rate of 200 gpm. Because automatic flow by-pass controls had not yet been installed, manual controls were used to set the flow at ± 10-15 gpm the desired rate.

Table 9 which follows is a summary of the test data. In turn, Figure 8 is a plot of water level rise (calculated from differential pressure) versus geothermal flow rate. The resulting data scatter has been overlaid by dashed lines which represent a probable range of values. From this limited test, it appears likely that the well will safely accept the planned 250 gpm disposal rate.

Subsequent testing at varying flow rates over a 30-day period has validated the conclusion from these earlier tests. However, during all but two of the tests, the water level rise in the well bore at 300 gpm was not noticeable. On the two tests, the water level rose to -142 feet, and then slowly dropped to -165 feet. This lack of stable behavior is unexplainable, and dictates continuous monitoring. If the behavior of this well does not stabilize, a new disposal well is being planned for a location adjacent to the Heat Exchanger Building, which is underlain by the geothermal aquifer, and which would facilitate disposal operations.

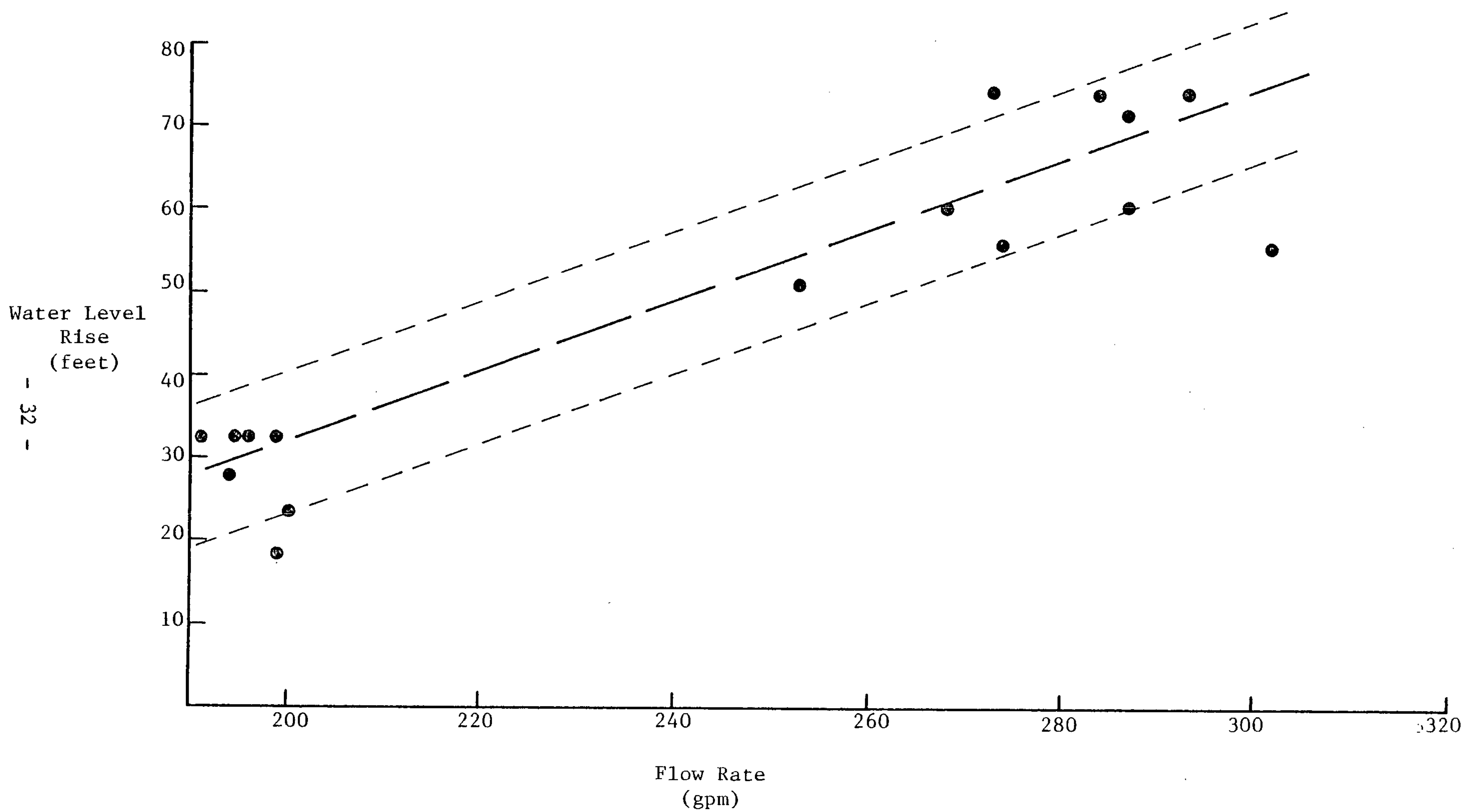
TABLE 9

Trial Disposal Test

Time	Gpm	Differential Pressure	Water Level Rise (feet)	Static Water Level (feet below ground)
13:22	0	0	0	216
13:27	199	8	18.5	197.5
13:32	200	10	23.1	193
13:37	194	12	27.7	188.3
13:42	199	14	32.3	184
13:47	196	14	32.3	184
13:52	195	14	32.3	184
13.57	191	14	32.3	184
14:00	GPM Increase			
14:02	302	24	55.4	161
14:05	287	31	71.6	144
14:10	284	32	73.9	142
14:15	273	32	73.9	142
14:25	293	32	73.9	142
14:35	278	26	60	156
15:00	274	24	55.4	161
15:07	287	26	60	156
15:30	253	22	50.8	165

Figure 8

NMSU GOLF COURSE WELL TRIAL DISPOSAL TEST



IRRIGATION TEST PLOTS

Included in written approvals obtained from the OCD was permission for surface discharge of geothermal water sufficient to irrigate test plots. This permission was necessary in order to conduct the long-term (perhaps several years) experiment to assess the effects of geothermal water on various types of grass which are or could be used for the golf course.

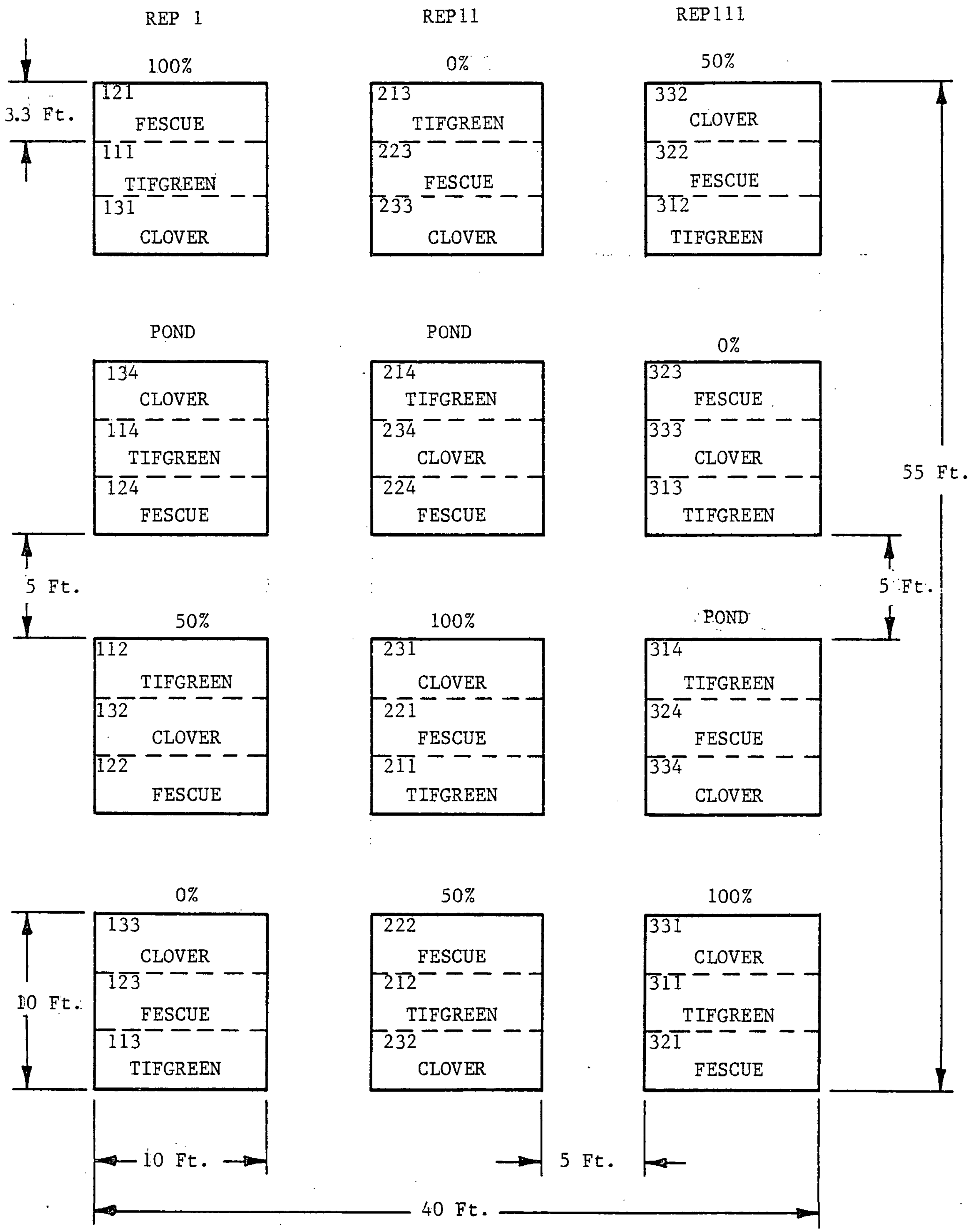
An early, limited experiment had been designed, which would have been conducted during the growing season of 1980. This experiment was cancelled because of the need to relocate the pump from the PG-2 well to the golf course well. Moreover, this early experiment lacked adequate controls, and was poorly designed.

A new experiment has been set-up, and consists of a total of 12 test plots, each containing the same three varieties of grass. A piping and sprinkler system was installed which will permit watering these test plots in individual 3-grass plots by using varying ratios of geothermal and domestic water. This experiment was designed by Dr. Arden Baltensperger of the NMSU Agronomy Department. A schematic of the test plots is shown in Figure 9. The plots have been sodded, and were brought to maturity with domestic water. Controlled growth tests will now be conducted over the next several years to assess the effects of geothermal water.

To interpret Figure 9, the percentage number above each plot indicates the mixture of geothermal water and domestic water to be used. The figure "0%" indicates all domestic water, whereas "100%" means all geothermal water. Three sets of plots have been reserved for possible future irrigation using a small test pond filled with geothermal water. If this latter phase is undertaken, the pond could be used to test various chemical additives which might be economically used for water treatment.

Figure 9

GEOTHERMAL TEST PLOT PLAN



APPENDIX A-1

Static Water Level, NMSU Golf Course Well

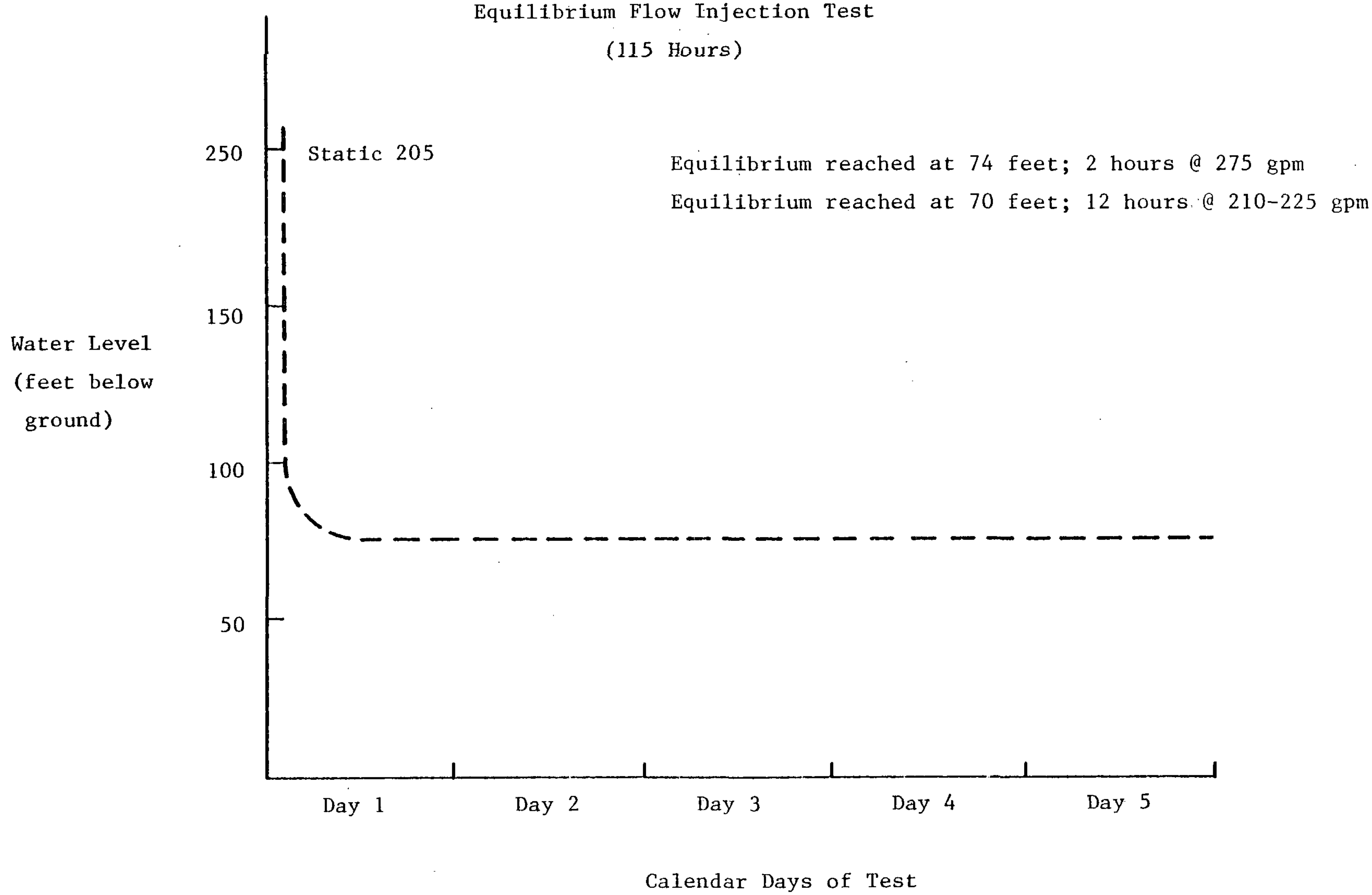
115-Hour Reinjection Test

ELAPSED TIME (Min.)	WATER LEVEL (Feet)	NET CHANGE (Ft.)
00	205 ±	
02	86.7	118.3
05	86.2	118.8
08	85	120
17	83	122
23	81.4	123.6
25	81	124
29	80	125
32	79.3	125.7
35	78.6	126.4
40	78.5	126.5
45	77.8	127.2
50	76.9	128.1
55	76.5	128.5
60	76	129
65	75.7	129.3
70	75.7	129.3
75	75.3	129.7
70	75	130
85	74.8	130.2
95	74.5	130.2
100	74	131
Decrease Flow Rate to 228 gpm		
105	88.7	116.3
115	85.8	119.2
125	84.2	120.8
135	82.7	122.3
145	81.6	123.4
155	80.9	124.1

ELASPED TIME (Min.)	WATER LEVEL (Feet)	NET CHANGE (Feet)	ELAPSED TIME (Min.)	WATER LEVEL (Feet)	NET CHANGE (Feet)
165	80.2	124.8	3540	71	134
175	79.7	125.3	3700	71.5	133.5
185	79.3	125.7	3820	71	134
195	78.6	126.4	3940	79.5	134.5
205	78.2	126.8	4100	70	135
215	77.9	127.1	4220	70	135
225	77.3	127.7	4340	69.6	135.4
235	77	128	4500	69	136
240	76.9	128.1	4620	68.5	136.5
610	76.9	128.1	4740	68.5	136.5
1180	74.5	130.5	4900	68.5	136.5
1300	73.5	131.5	5020	68	137
1420	73.5	131.5	5140	68	137
1540	73	132	5300	68	137
1700	72	133	5420	71	134
1820	71.6	133.4	5540	70	135
1940	71	134	5700	67.3	137.3
2100	71	134	5820	67.5	137.5
2220	72	133	5940	66.5	138.5
2340	70	135	6100	66	139
2500	70	135	6220	66	139
2620	71	134	6340	71	134
2740	80 ?	125	6500	70.5	134.5
2900	68	137	6620	70.5	134.5
3020	70	135	6740	70.5	134.5
3140	68	137	6900	70.5	134.5
3300	68	137			
3420	71	134			

APPENDIX A-1

NMSU Golf Course Well
Equilibrium Flow Injection Test
(115 Hours)



APPENDIX B

Pressure Head Calculations

The change in static water level in the well is a key determinant in assessing formation transmissibility, which is necessary in order to ascertain possible long term effects of the well in a disposal mode. Because of the special test fixture used for this trial injection test, however, it was not possible to make a direct comparison between the resulting water level and the static water level during an earlier test.

Based on two trial injection tests, both at 225 gpm, the resulting static water level is shown in Table B-1. As can be seen, the special test fixture apparently caused a pressure drop, and a resulting need for a higher water level to provide necessary reinjection head pressure. The estimated magnitude of this pressure drop is depicted on Table B-2.

TABLE B-1

Summary Data
Golf Course Well Reinjection Tests

Test	Static Level	Dynamic Level	Flowrate
#1 (Feb 1981) (8 hour)	211 feet	134 feet	225 gpm
#2 (Sep 1982) (115 hours)	205 feet	70 feet	225 gpm

TABLE B-2

Test Fixture Head Losses (feet)

Head Loss (feet)	Cause
9	Water flowing down 5-inch column and up annular space (nominal 1-inch space between original well casing and the outside of the 6-inch ID steel pipe) at 210 gpm.
41	Constriction from 19.675 in^2 to 2-in^2 (equivalent to 2-inch Globe valve @ 210 gpm)
14	Constriction from 50.24 in^2 to 22-in^2 in annular space at 210 gpm.
64 - TOTAL	

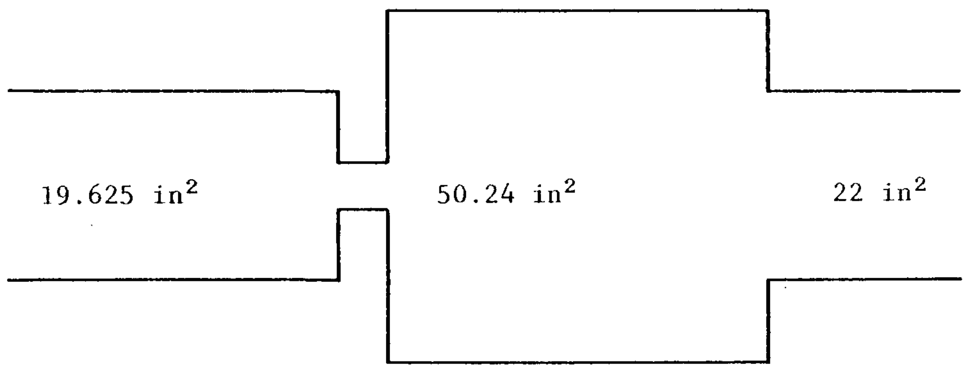
Another objective of the test fixture, in addition to assuring well casing stability during the test, was to assess the integrity of the down-hole well closure device. The test fixture was designed to be inserted to total well depth (606 feet) if the closure device at 507 feet was missing. In fact, as mentioned earlier in this report, it was physically possible to insert the fixture only to 488 feet of depth.

As a second test of the closure device, and the well casing, the test fixture was specially designed to force a jet of water onto the bottom-hole closure. As noted on Figure B-1, the fixture permitted a situation in which this water jet at approximately 44 fps velocity, was directed against the unknown mass at 488 feet of depth, for a total of 115 hours. Based on a subsequent check, the unknown mass was removed by the jet, but the closure device at 507 feet of depth remained intact.

Figure B-1

Schematic Representation of Reinjection Test Fixture

Area 1	Area 2	Area 3	Area 4
5-inch	$2 in^2$	8-inch	Annular
Test Column	Constriction	Well Casing	Space Constriction



P_1, V_1 P_2, V_2 P_3, V_3 P_4, V_4

NOTE: In addition to the constriction involved in fluid movement from area 3 to area 4, the fluid also was forced into a 180° change in direction, and would encounter extremely rough pipe walls in the 1-inch or smaller annular space between the 8-inch well casing and the 6.75-inch (OD) test column. The water also would have to flow upward before changing direction to exit from the screen sections. (See Figures 1, 3, and 4.)

$$V_1 = 275 \text{ gpm} \times \frac{\text{Min}}{60 \text{ Sec}} \times \frac{\text{Ft}^3}{7.48 \text{ Gal}} \times \frac{1}{\text{Area}(\text{Ft}^2)}$$

$$V_1 = \frac{275}{60} \times \frac{1}{7.48} \times \frac{1}{\frac{25}{144} \times \frac{\pi}{4}} = 4.49 \text{ fps}$$

$V_2 \cong 44$ fps

$V_3 \cong 1.75$ fps

$V_4 \cong 4.0$ fps