HGP-A

WELLHEAD GENERATOR PROJECT

WELL TEST REPORT

JANUARY 3 - 18, 1980

Department of Energy Contract

DE-AC03-78ET28420

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Engineering Group
University of Hawaii Hawaii Geothermal Project

I. Introduction

The HGP-A well at Puna, Hawaii underwent a two-week flow test in January, 1980:

1) To verify the quantity of steam flow for a 3-MW power plant.
2) To verify the quantity of non-condensible gases and percentage of H_2S, which are critical in the design of condensers and H_2S abatement system.
3) To prove out the effectivenesses of the caustic/peroxide H_2S abatement system and the noise abatement system of the rock pit.
4) To check out the steam collection system which will be used in the final power plant operating system.

The test is judged to be a success because it has accomplished most of our objectives. The following summarizes the Engineering Group's effort of the well test. Separate reports will cover the results of the reservoir fluid chemistry and H_2S abatement experiments.

II. Responsibilities of the Hawaii Geothermal Project

The Hawaii Geothermal Project (HGP) staff was responsible for the operation of the well test under the direction of the well test manager. Figure 1 shows the organization of the well test.

Specifically the Engineering Group of the HGP was responsible for:

A. Providing a test supervisor and a test data recorder 24 hours per day throughout the test period. The test supervisor had the overall responsibility of maintaining the operation of the well test under the direction of the well test manager.

B. Maintaining a record of all well flow, pressure and temperature data.

C. Maintaining a well test log including any complaints from the residents.

D. Maintaining a chemical injection log including caustic dilution records.

E. Checking the performance of the separator by steam calorimeter.

F. Implementing the safety plan.

G. Conducting downhole temperature and pressure measurements prior to the well test and after the well test.

H. Monitoring the noise level to measure the effectiveness of the rock pit muffler.

III. Results

A. Well flow vs. wellhead pressure

Due to the incorrect sizing of the steam control valve, it was not possible to control a steady flow much beyond 161 psig at the separator, therefore we were not able to obtain meaningful data beyond that point. Table 1 summarizes the well flow data vs. the separator pressure. Table 2 is an abbreviated version of the well flow data performed in 1977 duplicated here for comparison purposes.

In general, the wellhead pressure is approximately 10 to 15 psi higher than the separator due to line loss and higher separator elevation. Notice that the steam flow rate does not differ much from the previous flow test but water flow rate is much higher. This is due partially to the improper design of the weir measuring methods employed in the previous test measurements.

The final plant design calls for approximately 160 psig at the separator. The metered steam flow will adequately generate 3 MW of electricity.

B. Calorimeter

An Ellison U-Path Steam Calorimeter was used to check the effectiveness of the separator by measuring the steam quality of the separated steam. Due to the placement of the calorimeter, there was a 10 ft. length of inlet pipe between the steam line and the calorimeter. It was very difficult to insure adiabatic condition in the inlet pipe even though the pipe was insulated.

Nevertheless, calorimeter measurements were attempted and no better than 96% quality was consistently obtained. These data do not match up to the results of the chemistry chloride method employed by the HGP Chemistry Group. Their measurements consistently show very little chloride in the steam and showed better than 99.9% steam quality. Thus, we feel that the separator is performing adequately and the performance of 99.9% separation is satisfactory.

C. Chemical Injection Rates

Throughout the test, we were able to maintain very constant peroxide injection rate but were unable to maintain very constant caustic injection rate without constant adjustment. The caustic metering pump and its air actuator must be repaired. A separate report covers the results of the H_2S abatement experiments.

D. Noise

Sound level measurements were taken to test the efficiency of the newly installed rock muffler system. The measurements were taken at various stations around the well site, 1/2 mile up and

down the adjacent Pohoiki Bay Road and 1/2 mile up into the Leilani Estates area. Initial measurements were obtained with the well flashing through the twin stacks only. Later sound level measurements were obtained with the rock muffler in operation.

The muffler system consisted of an earthen pit upon which rocks were placed. Steam from the H_2S treatment system was discharged into the pit. Some of the steam condensed in the earthen pit and emptied into the percolation pond. The uncondensed steam rose up through the rock pile and disbursed into the atmosphere.

The rock muffler proved to be an effective noise abatement system. At many stations over 30% noise level reductions were experienced. Figure 2 is a diagram of the well site and indicates the stations at which noise level readings were taken. Table 3 lists the noise level measurements obtained at each station. As added information, noise level readings of previous flashings are included in Table 3.

E. Temperature and Pressure Profiles

Prior to the start of the two week flow test at HGP-A in January 1980, a temperature-pressure profile was taken where the temperature profile showed high temperatures at 4300 and 6250 feet -- in the order of 320°C. The temperature and pressure plots are shown in Figures 3 and 4. No other downhole tests were conducted during the flow test until after the well was shut-in.

The HGP-A well was reworked in September, 1979 to restore the casing cement competency. The original 9 5/8" casing was set from the surface to ∿2200 ft. below casing head flange. Before the repair work the well temperature profile showed high temperatures all the way up to ∿1500 ft. During rework several attempts were

made to squeeze off zones around 2200 ft. and 1500 ft. The cement bond logs showed only approximately 80% bond at best. Subsequently, a new string of 7" casing was run from surface to 3000 ft. The temperature peaks at 1500 ft. and 2200 ft. on the temperature profile prior to flashing reflect the zones where the conduction of heat from outside of the casing exists.

Since the well shutdown, five temperature profiles have been conducted. Two profiles taken immediately after shutdown have shown the flashing profile characteristics (semi-vertical straight-line), while five days later, the temperature profile started to show similarities to the preflash profile. The ten and thirty-one day profiles display, in general, cooling in the upper sections and heating in the lower sections. These plots are presented in Figure 3.

F. Water Level Recovery

Water level recovery after the two week flow test followed similar patterns of other recoveries after production flow. This is shown in Figure 5. Approximately twenty-three days after shutdown, the water level was at ground level. This recovery was faster than previous recoveries following production flows of similar time length. It is thought that the lengthening of the casing of HGP-A to 3000 feet, thus closing the suspected cooler water influx, may have increased the recovery rate.

G. Other Results

1. During the two-week test, Hawaii was hit by a severe storm and the well site suffered numerous and long power outages. During these periods, it was not always possible to chemically treat the steam to remove hydrogen sulfide and to operate the equipment

in the normal noise suppression mode. The final power plant must have adequate stand-by power for noise and odor suppression in the event of power outages.

2. During these periods where noise and odor were not suppressed, we received several complaints from the nearby residents. However, after the power was restored and the normal test operation with full odor and noise abatement resumed, no further complaints were received.
3. During the two-week test, several weaknesses in the instrumentation were discovered. These are:
   a. Defective separator water level indicator and level controller.
   b. Continuous plugging of the venturi pressure sensing ports.
   c. Defective badgemeters for mixing caustics.
   d. Lack of weatherproofing of instruments and gages.
4. The maximum growth of the wellhead during flow is approximately 5 inches.

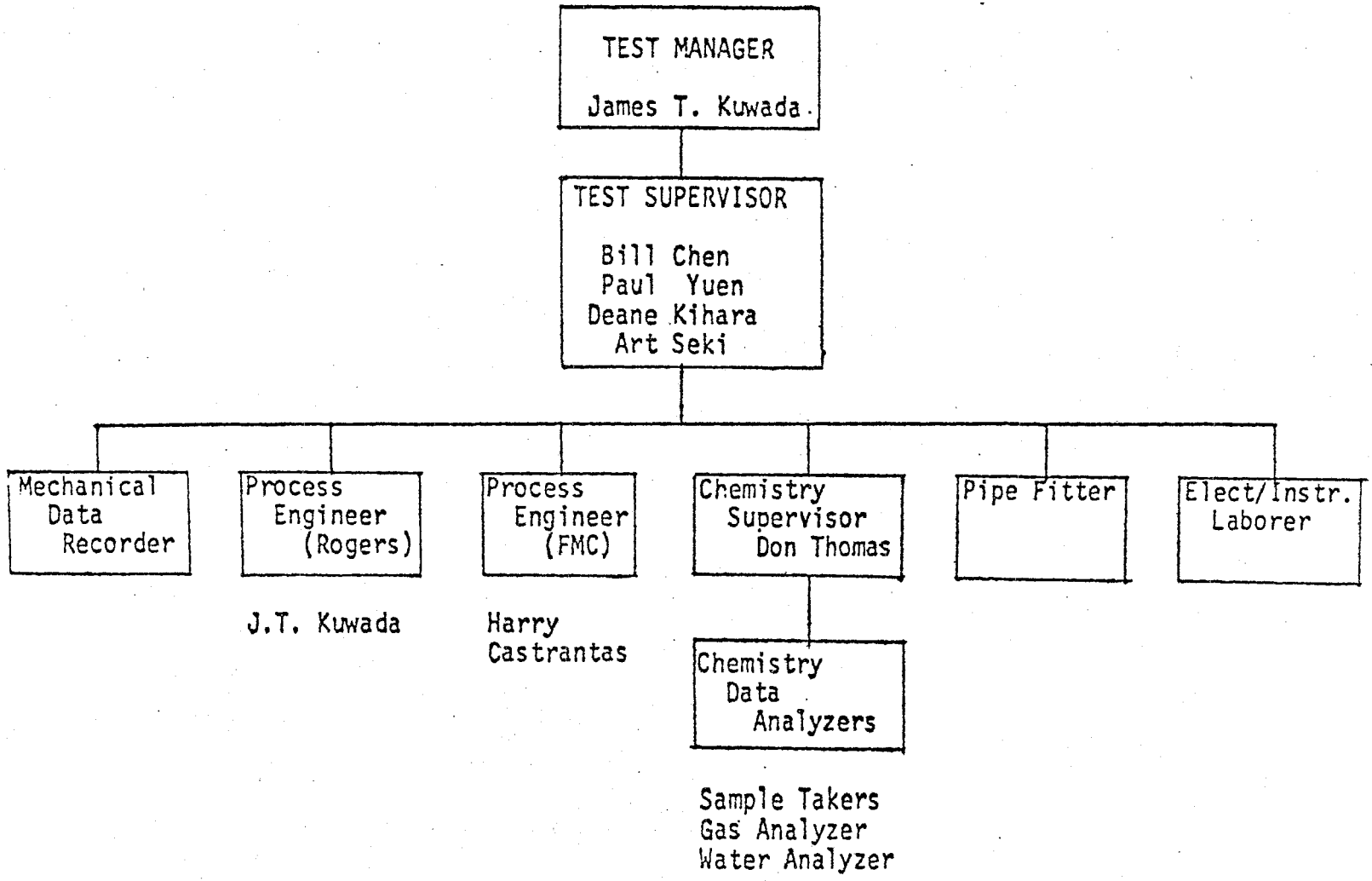
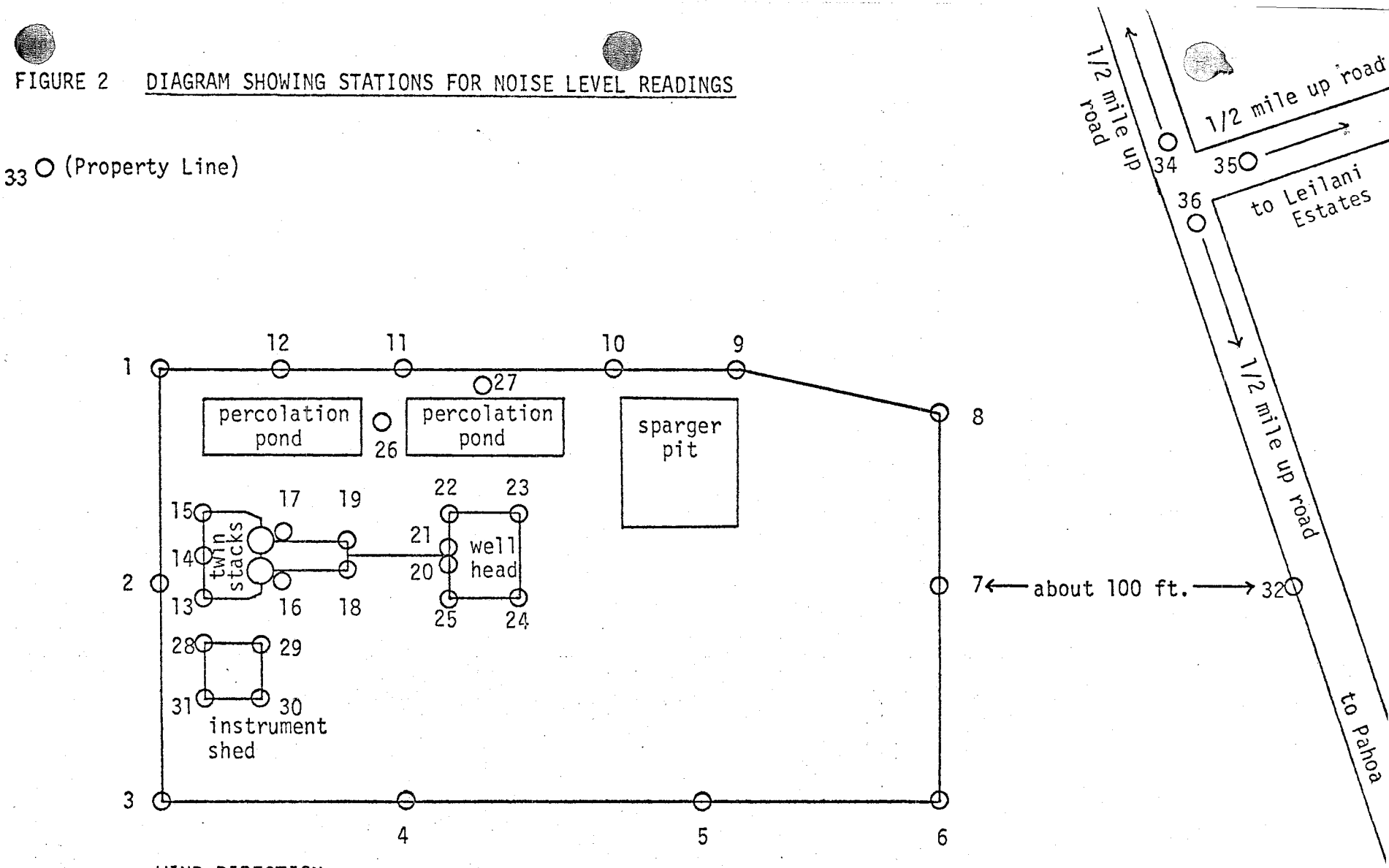

TEST MANAGER
James T. Kuwada
TEST SUPERVISOR
Bill Chen
Paul Yuen
Deane Kihara
Art Seki
Mechanical Data Recorder
Process Engineer (Rogers)
J.T. Kuwada
Process Engineer (FMC)
Harry Castrantas
Chemistry Supervisor Don Thomas
Chemistry Data Analyzers
Sample Takers
Gas Analyzer
Water Analyzer
Pipe Fitter
Elect/Instr.
Laborer

Figure 1

FIGURE 2 DIAGRAM SHOWING STATIONS FOR NOISE LEVEL READINGS



WIND DIRECTION

12/28/79	↑
1/3/80	
10:00 - 10:30A	↗
11:00 - 11:30A	↗
2:25 - 2:55P	↗
6:00 - 6:30P	↗

11/3/76	↑
1/26/77	←
1/7/80	↙

(diagram is not to scale)

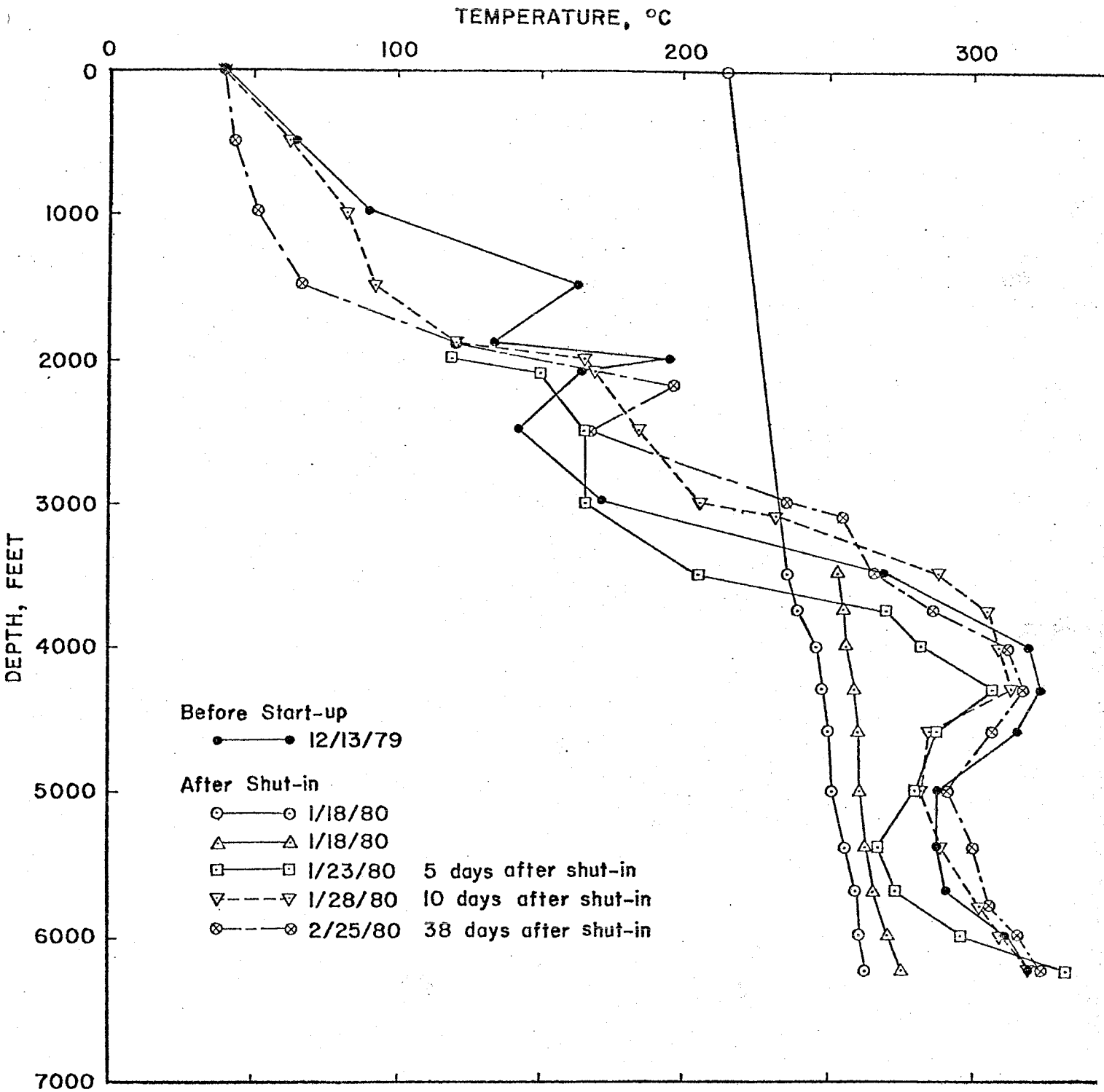

TEMPERATURE, °C
0
100
200
300
0
1000
2000
3000
4000
5000
6000
7000
DEPTH, FEET
Before Start-up
12/13/79
After Shut-in
1/18/80
1/18/80
1/23/80 5 days after shut-in
1/28/80 10 days after shut-in
2/25/80 38 days after shut-in

Figure 3

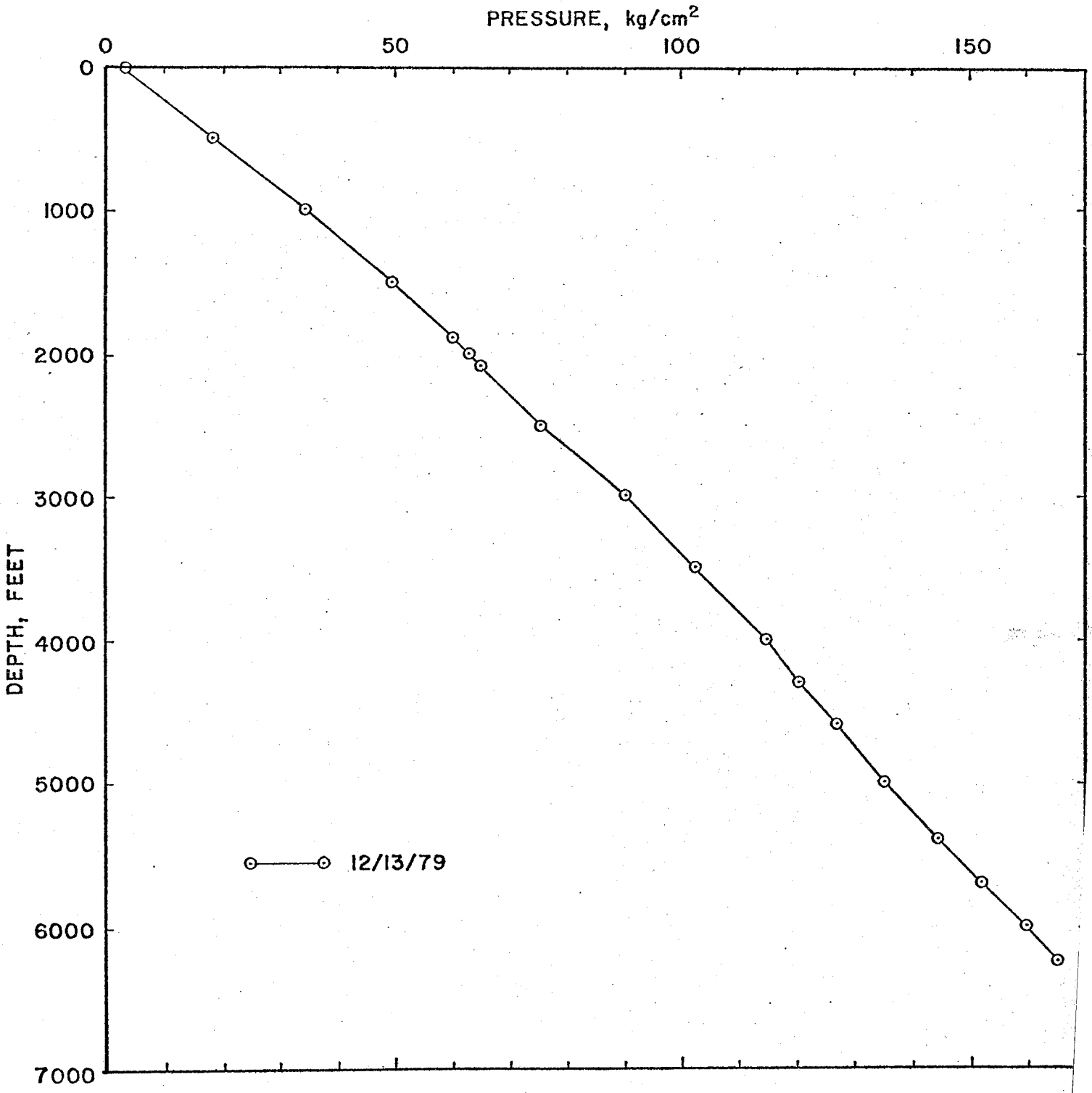

PRESSURE, kg/cm²
0
50
100
150
0
1000
2000
3000
4000
5000
6000
7000
DEPTH, FEET
12/13/79

Figure 4

Figure 5

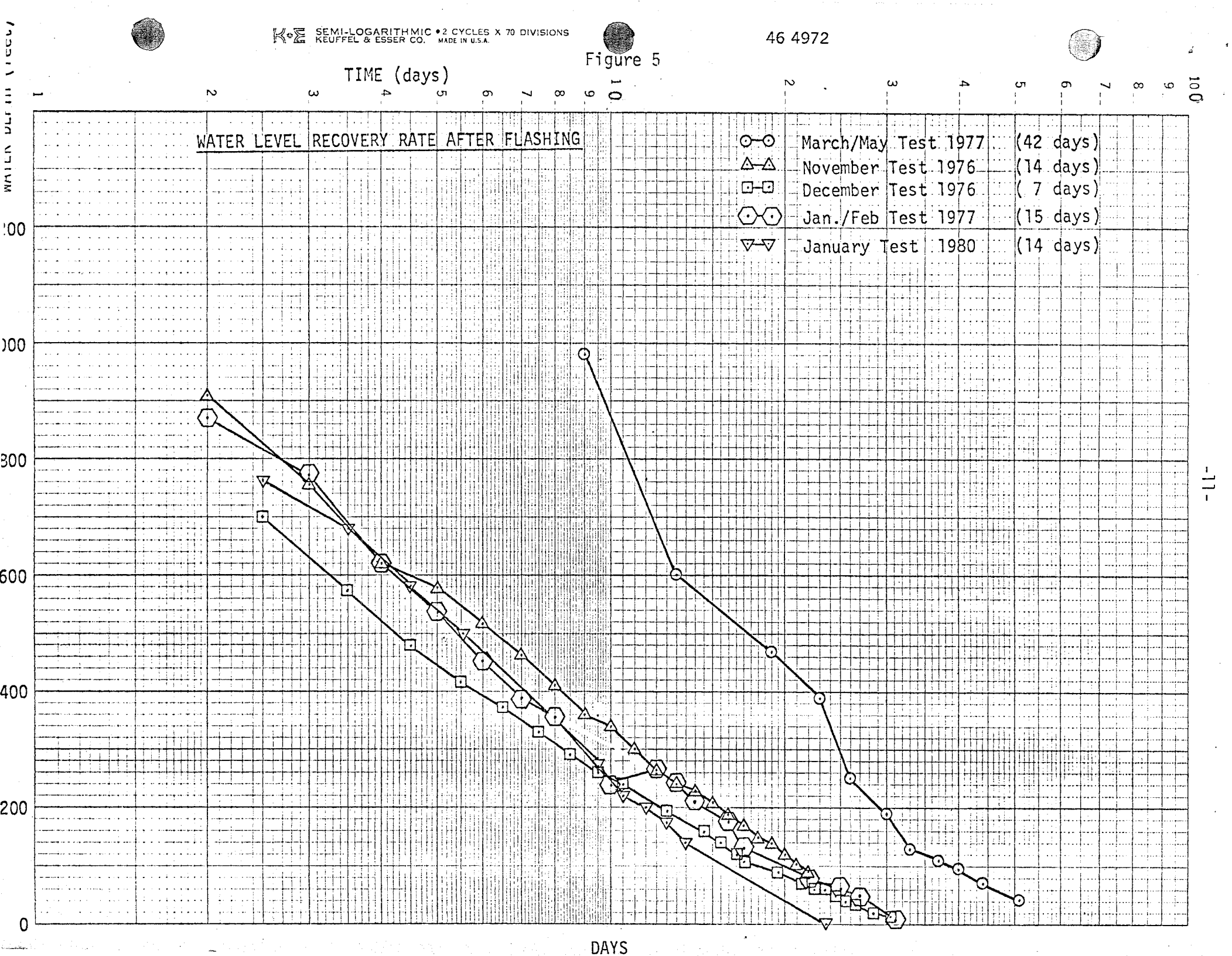

TIME (days)
1
2
3
4
5
6
7
8
9
10
2
3
4
5
6
7
8
9
100
WATER LEVEL RECOVERY RATE AFTER FLASHING
March/May Test 1977 (42 days)
November Test 1976 (14 days)
December Test 1976 (7 days)
Jan./Feb Test 1977 (15 days)
January Test 1980 (14 days)
00
00
300
600
400
200
0
DAYS

Table I
Throttled Flow Data 1/3/80-1/18/80

Separator Pressure (PSIG)	Total Mass Flow Rate (Klb/hr)	Steam Flow Rate (Klb/hr)	Water Flow Rate (Klb/hr)	Steam Quality (%)
56	111.5	70.9	40.6	63.6
110	110.3	64.7	45.6	58.7
132	108.0	61.0	47.0	56.5
161	105.9	56.6	49.3	53.4

Table 2
Throttled Flow Data 1/26/77-2/10/77

Wellhead Pressure (PSIG)	Total Mass Flow Rate (Klb/hr)	Steam Flow Rate (Klb/hr)	Water Flow Rate (Klb/hr)	Steam Quality (%)
54	99	65	34	66
100	93	57	36	64
165	89	54	35	60

TABLE 3

NOISE LEVEL READINGS ON DBA SCALE

STATION	NO ABATEMENT			PARTIAL ABATEMENT		PREVIOUS FLASHING		ABATEMENT
	12/28/79	1/3/80		1/3/80		11/3/76	1/26/77	1/7/80
		10:00-10:30A	11:00-11:30A	2:25-2:55P	6:00-6:30P			
1	93	91	94	75	73	100	96	57
2	99	100	99-100	82	78	104	100	66
3	84	83	82	65	75	98	93	51
4	75	--	84-85	70	70	98	96	64
5	86	--	--	--	--	97	--	--
6	79	--	76	64	63	98	89	50
7	88	--	82	67	64	96	90	52
8	75	83	78	63	80	98	91	46
9	82	--	76-78	67	67	99	93	52
10	81	--	91	71	80	98	94	57
11	86	--	--	--	--	99	96	--
12	88	--	--	--	--	100	90	--
13	100	--	100	84	82	107	100	69
14	101	--	102	85	83	110	103	60
15	98	96	98-99	81	79	107	100	56
16	100	98/99	103	--	--	106	102	--
17	102	100	103	83	82	104	101	71
18	102	--	--	84	80	110	103	68
19	104	--	--	--	--	110	101	--
20	99	--	--	--	--	--	--	--
21	98	94	--	--	--	103	99	--
22	98	--	96	82	80	104	98	67
23	93	--	92	73	71	100	94	63
24	91	94	94	76	75	99	95	69
25	97	--	99	82	80	106	95	74
26	94	--	94	74	73	106	93	58
27	93	--	--	--	--	100	96	--
28	97	--	96	81	--	106	100	68
29	98	97	97	80	--	110	102	70
30	96	92	83	77	--	96	91	72
31	94	--	93-94	75	--	108	101	66
32	79	83	83	60-62	--	87	80	44
33	--	94-95	94	73	--	--	--	56
34	--	41-42	42	41	--	--	--	37
35	--	50	48	40	--	--	--	34
36	--	40-42	38	36	--	--	--	42