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**COMPLETION AND STIMULATION OF FIVE
NEW YORK STATE ENERGY RESEARCH AND
DEVELOPMENT AUTHORITY WELLS
ALLEGANY AND CATTARAUGUS COUNTIES,
NEW YORK**

A. Rdissi

November 1981

Work Performed Under Contract No.: DE-AC21-79MC08382

For
U. S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Gruy Federal, Inc.
Houston, Texas

**Technical Information Center
Office of Scientific and Technical Information
United States Department of Energy**



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Morgantown, West Virginia 26505

By
Gruy Federal, Inc.
Houston, Texas 77063

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EXECUTIVE SUMMARY

In order to evaluate the potential of the Devonian Shales as a source of natural gas, DOE/METC in Morgantown, West Virginia has undertaken the Eastern Gas Shale Program (EGSP); not only to characterize and identify the resource but, also, to enhance and improve the productivity of wells completed in the shale. One of the methods used to achieve improved productivity is hydraulic fracturing and, more specifically, foam fracturing.

The efforts by DOE/METC included completion and stimulation of five New York State Energy Research and Development Authority (NYSERDA) wells; located in western Allegany County and southeastern Cattaraugus County, New York. The five wells were drilled by NYSERDA on high school and college properties during the months of June and July 1981. Each well was drilled by spudding with a cable tool rig which drove a 12-3/4 inch O.D. conductor pipe through the glacial drift. Following that, a rotary rig was moved on location and completed the drilling operations using air as a drilling fluid. In each well, 8-5/8-inch O.D. surface casing was run to approximately 500 feet. The wells were completed by drilling through the Marcellus Shale of Devonian Age, at which point 4-1/2-inch O.D. production casing was set through the shale and cemented.

DOE/METC's contribution to the program funded the stimulation and completion of the wells. This work was done under the engineering and field supervision of Gruy Federal, Inc. as contractor to DOE. The completion work took place in the months of July and August 1981. This consisted of running a cement bond log in each well. All logs showed good bonding. This was followed by perforating the Marcellus Shale through the 4-1/2-inch casing. During the next phase, the formation was broken down with 1500 gallons of regular HF acid and, then, foam fractured using 50,000 gallons of foam consisting of water and nitrogen; the fractures were propped with 60,000 pounds of sand. After the cleanout operations, open flow potentials and rock pressures were measured in each well. None of the wells had a gas show before fracturing but, after fracturing, open flow ranged from a low of 19 Mcf/D to a high of 73 Mcf/D.

DESCRIPTION OF FIELD ACTIVITIES

The locations of the five wells in Allegany and Cattaraugus Counties, New York are shown on Figure 1. DOE-funded field work under Gruy Federal's supervision began in mid-July 1981 and was completed in late August 1981. A summary of the completion and stimulation work is given on Table 1 for each well. Detailed discussions of the work on each well and a well diagram for each well are included in the Appendix. The following are abbreviated summaries of the more detailed material.

Portville Central School Well No. 1:

The service rig moved on location on July 17, 1981, and Schlumberger ran the CBL-VDL cement bond log, which showed good bonding. The casing was swabbed dry to 4176 feet and perforated in the Marcellus Shale with a 3-3/8-inch Hyperjet II hollow carrier from 4142 to 4176 feet, using 19 shots. On July 20th, Halliburton performed an acid treatment that consisted of breaking down the formation with 1500 gallons of 15 percent regular HF acid, during which thirty perforation ball sealers were dropped. The formation broke down at 4800 psi. At the end of the ball out, instantaneous shut-in pressure was 3100 psi, which resulted in a calculated bottomhole treating pressure of 4649 psi. The well was unloaded shortly after the job was finished and died five minutes thereafter. It was then swabbed down in preparation for the foam fracturing.

The foam fracture treatment was performed on July 21st, using 50,000 gallons of a 70 percent quality foam; 10,000 pounds of 80/100 mesh sand and 50,000 pounds of 20/40 mesh sand. The foam was pumped at a rate of 16 barrels per minute. The average nitrogen rate was 22,300 scf/min with a total nitrogen volume of 1,320,000 scf. The average pumping pressure was 4396 psi and the initial shut-in pressure (ISIP) was 4000 psi. Shortly after the end of the job, the well was opened up on a 1/8-inch choke which was later replaced by larger chokes until the well was wide open. The flowback period continued through July 22nd. Only 46 barrels of water were recovered on back flow.

On July 23, a service rig moved back on the well. When the hole was checked, 70 feet of sand was found in the bottom of the hole. A sand pump was used to clean out the sand to final total depth of 4190 feet. Swabbing and bailing operations continued until July 27th, with very little additional water recovery. The final recorded open flow potential was 21,700 scf/D, with a rock pressure of 1680 psi after 312 hours of shut-in.

Saint Bonaventure University Well No. 1:

On July 18, 1981, Schlumberger ran a CBL-VDL cement bond log, after which the well was swabbed dry to 3630 feet. On July 21st, the casing was perforated in the Marcellus Shale with 18 shots from 3568 to 3630 feet, with a 3-3/8-inch Hyperjet II hollow carrier. The acid ball out was performed on

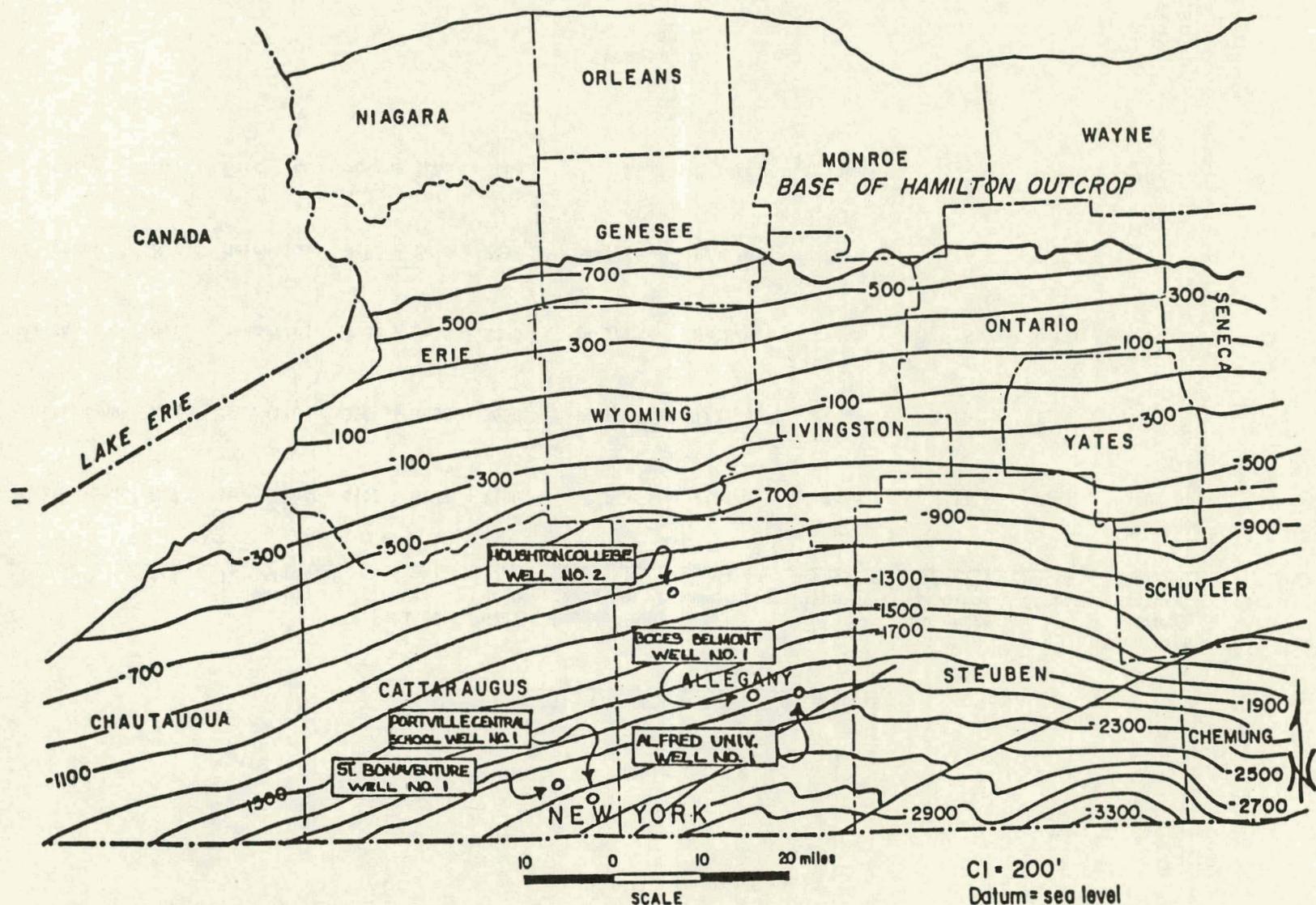


Figure 1

Structure contour map on the base of Marcellus/top of Onondaga in western New York. After Van Tyne, et al. (1980).

Table 1
NYSERDA WELLS

SUMMARY OF STIMULATION AND COMPLETION RESULTS

Well Name	County	State	Producing Formation	Perforated Interval (ft)	Total Depth (ft.)	Production Casing (O.D.)	Completion Date	Type Of Fracture	Fracture Gradient (Psi/ft)	Open Flow Before Fracture (Mscf/D)	Open Flow After Fracture (Mscf/D)	Rock Pressure (Psi)	
Portville Central School #1	Cattaraugus	N.Y.	Marcellus	4142 - 4176	4190	4-1/2"	7/29/81	Foam	1.11	0.97	0	22	1680/312
Saint Bonaventure Well #1	Cattaraugus	N.Y.	Marcellus	3568 - 3630	3655	4-1/2"	7/31/81	Foam	1.29	1.12	0	19	1080/183
Alfred University Well #1	Allegany	N.Y.	Marcellus	3932 - 3970	3979	4-1/2"	8/08/81	Foam	0.94	0.82	0	40	1560/189
Houghton College Well #2	Allegany	N.Y.	Marcellus	2382 - 2416	2452	4-1/2"	8/10/81	Foam	1.18	1.03	0	23	1220/184
Boces Belmont Well #1	Allegany	N.Y.	Marcellus	3242 - 3282	3284	4-1/2"	8/18/81	Foam	1.12	0.97	0	73	1600/115

July 23rd, and consisted of squeezing 1500 gallons of 15 percent regular HF acid. Thirty perf balls were dropped during the injection, which successfully balled out the perforations. The ISIP at the end of the job was 3100 psi. Since the displacement fluid was water, this resulted in a calculated bottomhole treating pressure of 4672 psi. The water and acid were swabbed from the well shortly after the ISIP was recorded.

The foam fracture treatment for this well was designed to be identical with the treatment used in the Portville Central School; i.e., 50,000 gallons of a 75 percent quality foam, 10,000 pounds of 80/100 mesh sand and 50,000 pounds of 20/40 mesh sand. The average pumping pressure was 4330 psi and the ISIP was 3800 psi. Since the injection pressure was approaching the burst pressure of the casing, a foam injection rate of 12 barrels per minute was used in lieu of 20 barrels per minute, as originally designed.

The well was flowed back on successively increasing size chokes, starting with a 1/8-inch choke until the well was finally wide open. Of the 310 barrels of water used during the treatment, only 123 barrels were recovered during the flowback period. On July 29th, a service rig was placed on the well, and cleanout and swabbing operations began. Eleven feet of sand found covering the bottom perforations was pumped out with a mechanical sand pump. On August 6th, the open flow potential of the well was measured to be 18,800 scf/D, with shut-in rock pressure of 1080 psi after 183 hours of shut-in.

Alfred University Well No. 1:

The field activities on this well began July 30, 1981, when Schlumberger ran the CBL-VDL cement bond log. The casing was swabbed dry to 3970 feet. On July 31st, a 3-3/8-inch Hyperjet II hollow carrier was used to perforate the Marcellus from 3932 to 3978 feet. The acid ball out was equivalent in design to the previous wells and was performed by Halliburton on July 31st. The ISIP was 2000 psi and the corresponding bottomhole treating pressure was 3720 psi. At the end of the job, the water and acid were swabbed from the casing.

The foam fracture treatment, which was identical to the two previous fracture treatments, was performed on August 4th. Initial shut-in pressure at the end of the treatment was 3800 psi. The well was unloaded, starting with a 1/8-inch choke which was progressively made larger as pressure decreased. Only 84 barrels of water were recovered when the well stopped producing fluid. No sand was covering the perforations. Very little additional water was recovered during the cleanout operations. The final measured open flow was 40,000 scf/D, with a rock pressure of 1560 psi after 189 hours of shut-in.

Houghton College Well No. 2:

A cement bond log was run on this well August 3, 1981. The log showed good cement bonding, and the hole was swabbed down to 2416 feet. A Hyperjet II hollow carrier perforated the 4-1/2-inch casing in the Marcellus, from 2382

to 2416 feet, with 17 shots. The acid breakdown took place August 5th, when Halliburton squeezed 1500 gallons of 15 percent regular HF acid, with 30 perf balls dropped to ball out the perfs. The ISIP at the end of the job was 1800 psi, which resulted in a bottomhole treating pressure of 2846 psi or a fracture gradient of 1.18. The hole was swabbed dry after the acid treatment.

The foam fracture was performed on August 6th. The treatment design was identical to the previous wells as far as the amount of foam and sand pumped. The volume of nitrogen used was 1,205,000 scf. The average treating pressure at the surface was 3388 psi and the ISIP was 2700 psi. The foam injection rate was 20 barrels per minute. Shortly after the end of the treatment, the well was flowed back through a positive choke, beginning with a 1/4-inch choke size that was later increased as pressure dropped. No sand flowback was observed. During the flowback period, 170 barrels of water were recovered which corresponded to 55 percent recovery of water used. On August 9th, a service rig moved on location and checked the hole for sand. Bottom was found at 2452 feet, well below the bottom perforation. Swabbing operations continued for two days, with little additional water recovered. On August 20th, the final open flow was recorded as 23,000 scf/d. The shut-in wellhead pressure was 1220 psi after 184 hours.

Boces Belmont Well No. 1:

The field activities began by running the cement bond log on August 10th. The fluid in the hole was swabbed down following this operation, and the 4-1/2-inch casing was perforated with a hollow carrier in the Marcellus Shale from 3242 to 3282 feet, with 21 shots. On August 11th, the acid ball out was performed. This was identical to the previous acid treatments. The ISIP was 2250 psi. A calculated bottomhole treating pressure of 3675 psi indicated a fracture gradient of 1.12 psi/ft. The acid and flush were swabbed out prior to foam fracturing.

On August 15th, the well was foam fractured, using a treatment similar to that used in the other four wells. Foam injection rate was 19,000 scf/min, with a total volume of nitrogen injected of 1,285,000 scf. The foam pumping rate was 20 barrels per minute. The ISIP was 3400 psi and the average surface pumping pressure was 3800 psi. The well was flowed back through a 1/8-inch choke, and the choke was later replaced by larger sizes. On August 15th, the service rig moved on location, checked the hole and began the swabbing operations. Some sand had to be pumped out of the bottom of the casing. The final flow measured 72,500 scf/D, and the rock pressure was 1600 psi after 115 hours of shut-in.

CONCLUSIONS

Technically, all the completion phases of the program were successful:

1. The quality of the cement bond ranged from good to excellent, which precluded any communication or migration of treating fluids behind the casing.
2. The casing was perforated with a hollow carrier, where the impact of the firing was absorbed by the gun rather than the casing.
3. The casing was empty when perforated, which resulted in a pressure differential into the wellbore rather than into the formation; hence, no formation damage.
4. During the course of the acid treatment, the perforations were balled out with perforation ball sealers. This operation was very successful as manifested by the high and sudden pressure increase when the balls sealed the holes. This is particularly illustrated in the Alfred University well, where all the ball sealers were later removed during bailing operations. The number of balls showing surface marks of balling out matched the number of holes in the casing.
5. The foam fracture treatments were conducted almost exactly as planned, with the foam quality being near 75 percent; all the sand volume prescribed for the job was utilized. The surface treating pressures were somewhat higher than originally predicted; in order to comply with the casing specifications and stay within the safe range of its burst pressure, the foam injection rate on two of the five wells was slightly reduced.
6. All five wells were flowed back after treatment through positive chokes. The choke sizes were increased steadily when very little or no sand flowback was observed.
7. The only unexpected result was the limited water recovery on backflow. The maximum recorded water recovery was 60 percent. Even during bailing and swabbing operations, little water flowed into the wellbore. This was probably due to the poor productivity of the wells and to the low velocity of the fluids inside the 4-1/2-inch casing.
8. Because of the low open flow rates of these wells and because a major portion of the frac fluid was still in the formation, it is recommended that a siphon string be run, consisting of 1-1/4-inch tubing in all five wells, to achieve faster cleanup and maintain adequate gas production rates. The surface facilities should include a small volume separator to separate water from the gas.

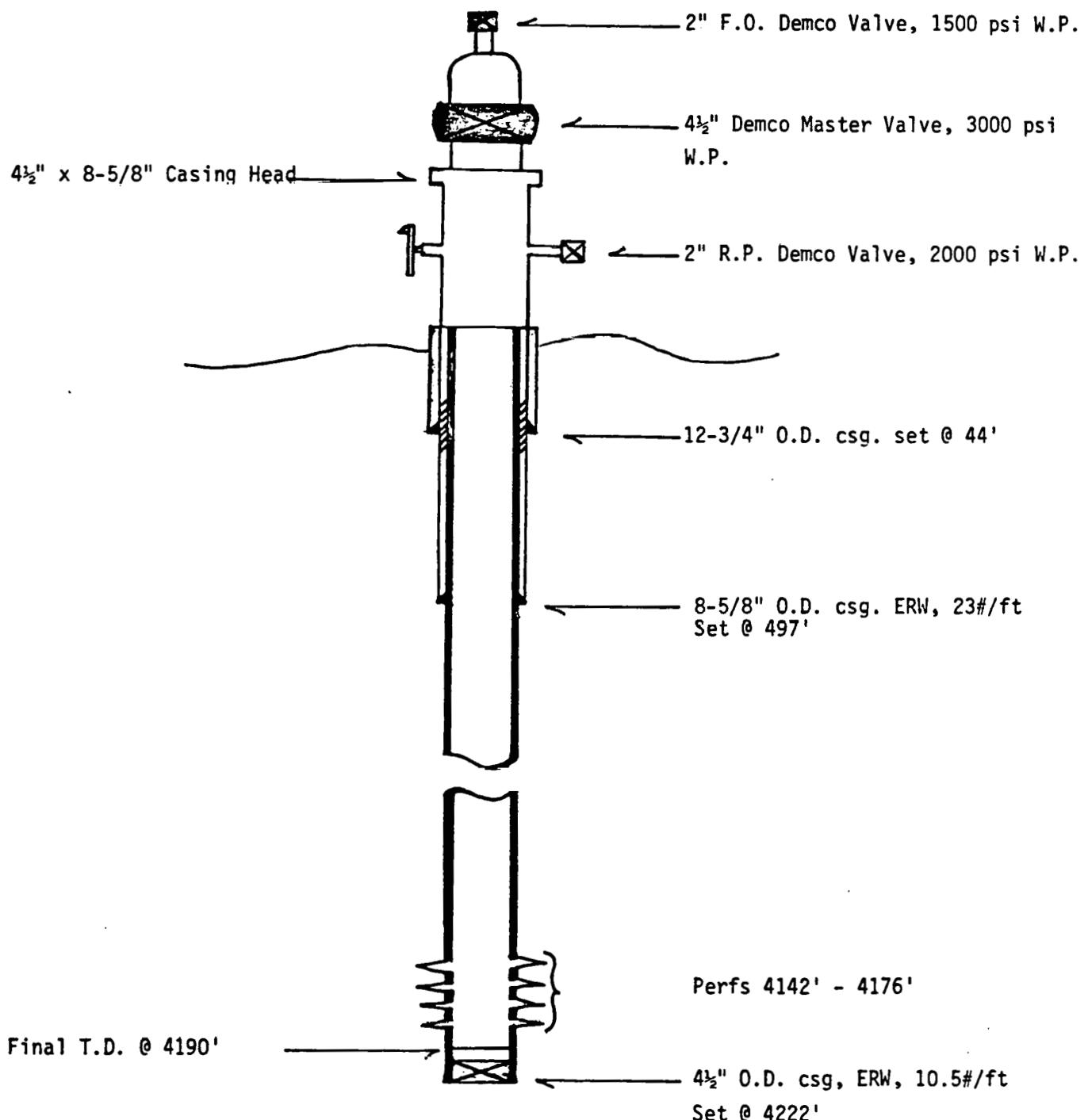
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APPENDIX

PORTVILLE CENTRAL SCHOOL WELL NO. 1

WELL DIAGRAM AFTER COMPLETION



Note: All measurements are K.B.
K.B. is 10' above G.L.

PORTVILLE CENTRAL SCHOOL - WELL NO. 1

Cement Bond Log and Perforations

July 17, 1981

- 17:00 - Moved the service rig to Portville Central School Well No. 1 from St. Bonaventure Well No. 1. Rigged up Schlumberger and rig.
- 18:30 - Began running down the hole with the CBL-VDL correlation logs.
- 21:00 - Finished the logging. Note: CBL-VDL looked good.

July 18, 1981

- 7:00 - Began swabbing the hole.
- 11:00 - Finished swabbing the 4½" casing dry to the would be lowermost perforation.
- 13:00 - Ran in the hole with the first run consisting of two guns (Hyperjet-II, 3-3/8" carrier). Perforated from 4160 to 4176 ft (9 shots).
- 15:30 - Ran in the hole with the second run consisting of two guns. Perforated from 4142 to 4158 ft (9 shots). Ran a CCL after perforations.
- 17:00 - Finished all the logging operations. In conclusion, the perforated interval was 4142 to 4176 ft.

Acid Ball Out

July 20, 1981

- 8:30 - Halliburton on location.

July 20, 1981 cont'd.

- 9:45 - Tested the lines at 4600 psi.
- 9:55 - Began pumping acid (750 gal pumped).
- 10:00 - Began dropping a perf ball each 0.5 bbl of acid to follow. Finished acid and perf balls. Dropped a total of 30 perf balls. Continued displacement with water.
- 10:15 - Injection pressure started building up. Broke down formation at 4800 psi. Acid rate = $Q_A = 0.75 \text{ BPM}$.
- 10:25 - Shut pumps down to let perf balls drop to bottom. 15.3 bbls of acid were already squeezed into the formation at this point. The instantaneous shut in pressure = I.S.I.P. = 2800 psi. The calculated frac gradient = 1.11 psi/ft. The calculated bottom hole treating pressure = BHTP = 4649 psi. Stress Ratio = 0.965.
- 10:40 - After 15 minute shutdown, resumed pumping acid at 8 BPM. Squeezed an additional 20 barrels of acid which is the rest of the 35.7 barrels of acid needed for the total job.
- 10:44 - Finished squeeze. I.S.I.P. = 3100 psi.
- 10:49 - S.I.P. after 5 minutes = 3,050 psi.
- 10:54 - S.I.P. after 10 minutes = 3,020 psi.
- 11:00 - Open the well wide open to unseat the perf balls and to unload the water and acid.
- 11:10 - Well dead, started swabbing the hole.
- 14:30 - Finished swabbing the water and acid.
- 15:00 - Rigged down.
- 16:00 - Moved rig to St. Bonaventure Well No. 1

Foam Frac

July 21, 1981

8:00 - Halliburton on location. Rigged up.

10:20 - Tested the lines at 5,000 psi. The line parted. Replaced one Halliburton connection.

10:25 - Retested the line. Electric line to the pressure recorder was shorted. Repaired it.

11:15 - Tested the line at 5,000 psi again.

11:17 - Began loading the hole with foam pad.

11:30 - 2200 gal of liquid in. Nitrogen rate = $Q_{N2} = 22,500 \text{ SCF/mn}$
Water rate = $Q_w = 4 \text{ BPM}$.

11:40 - Shut pumps down, leak in the line. Repaired the leak. Resumed pumping.

11:45 - Started sand at 1 lb per gal of foam. Injection pressure = $P_I = 4400 \text{ psi}$.

11:55 - Started sand at 1.5 lb per gal of foam.

12:10 - Reduced the quality of the foam to 0.68 because one nitrogen pumper was down.

12:20 - Started 2 lbs of sand per gal of foam.

12:30 - Started flush.

12:35 - Finished flush. I.S.I.P. = 4000 psi. Disconnected Halliburton head, hooked up wellhead and choke. See Tables 1 & 2.

13:30 - Open the well on 1/8" choke.

16:00 - Shut the well in because of a leak downstream of the choke. Inspected the choke, it was opened up by the sand to about 13/64". Replaced it by another 1/8" choke.

July 21, 1981 cont'd.

16:45 - Opened the well back up.

17:30 - The 3" by 2" swage downstream of the choke got washed out by the sand. Could not completely shut the master valve because of a leak.

17:55 - Flowing pressure = P_f = 2900 psi.

18:10 - P_f = 2700 psi.

18:35 - P_f = 2400 psi. Well blowing N_2 water and some sand.

19:00 - P_f = 2050 psi.

19:15 - P_f = 1850 psi.

20:00 - P_f = 1450 psi.

21:00 - P_f = 1150 psi.

22:00 - P_f = 1100 psi.

July 22, 1981

7:00 - P_f = 300 psi.

7:15 - Shut well in, replaced the 1/8" choke with a 3/8" size choke. Note: the 1/8" choke opened up to about $\frac{1}{4}$ ".

7:55 - Opened well up. Before the well was opened back up, the pressure built up to 900 psi.

9:15 - P_f = 80 psi. Shut well in. Removed the choke. Well now wide open on 2". P_f = 0 psi. Well stopped bringing fluid.

16:30 - Attempted to flare the gas; it flared. Still lots of N_2 .

17:00 - Shut well in. Recovered in the tanks a total of 46 bbls of water.

Well Clean Out

July 23, 1981

6:30 - S.I.P. = 1480 psi.

7:30 - S.I.P. = 1520 psi.

7:45 - Blew the well down. The well brought back N_2 , gas and some water.

16:00 - Rigged up service rig.

17:30 - Ran a bailer down the hole. Fluid level appeared to be at 3400 ft. The sand top was found at 4129 ft. Therefore, there was about 70 ft of sand in the hole.

18:00 - Began sand pumping.

19:00 - Shut well in.

July 24, 1981

7:00 - S.I.P. = 800 psi in 12 hours. Opened the well up to blow the fluid down.

7:15 - Began sand pumping.

17:00 - Finished cleaning out sand to TD of 4190 ft. Swabbed down to the top perf at 4142 ft and bailed down the well dry. Shut the well in.

July 25, 1981

7:00 - S.I.P. = 700 psi in 14 hours. Blew the well down. Checked fluid level. The well built up 400 ft of fluid overnight. It's an approximate water influx of 0.19 gal per hour. Bailed the well dry. Waited 30 minutes; well built up 50 feet of water or 1.1 gal per minute. Rechecked the hole. The second 30 minutes there were 25 feet of water or .56 gal per minute of water influx. The third 30 minutes built up 20 ft of water or 0.5 gal per minute of water influx. Gaged the well using a 4" orifice well tester and through a 1"

July 25, 1981 cont'd.

orifice plate. The open flow at that point was 56,000 SCF/D, total N₂ and gas. Shut well in.

July 27, 1981

7:00 - S.I.P. = 1000 psi in 39 hours. Blew the well down. Check the fluid level. 400 ft of fluid in the hole. Swabbed it. Swabbed the well dry. After 8 hours of flow, gaged the open flow rate of the well which was 50 MCF/D this is the total gas and N₂ combined.

July 29, 1981

7:00 - Well was flowing overnight. The open flow potential = O.F.P. = 21,700 SCF/D.

August 14, 1981

7:00 - The well was still shut in. S.I.P. = 1680 psi in 312 hours.

SUMMARY OF ACID AND FRAC TREATMENTS
 FOR THE
 PORTVILLE CENTRAL SCHOOL WELL NO. 1
 PORTVILLE, NEW YORK

Table 1

	Acid Treatment	Foam Frac Treatment
Regular HF Acid	1500 Gal	
Foam Rate	8 BPM	16 BPM
Foam Quality		70 %
Water Volume		12,500 Gal
Nitrogen Volume		1,320,000 SCF
Nitrogen Rate		22,300 SCF/mn
N ₂ To Liquid Ratio		5,575 SCF/Bbl
Foamer HC2		70 Gal
Cla-Sta		13 Gal
Corrosion Inhibitor HAI-50	3 Gal	
Sand 80/100		60,000 Lbs
Sand 20/40		
Perf. Balls	30 (S.G.=1.3)	
Buffer HLX-287		30 Lbs
Average Pressure	3,000 Psi	4,396 Psi
I.S.I.P.	3,100 Psi	4,000 Psi
5mn Pressure	3,050 Psi	3,600 Psi
10mn Pressure	3,025 Psi	3,590 Psi
15mn Pressure		3,550 Psi

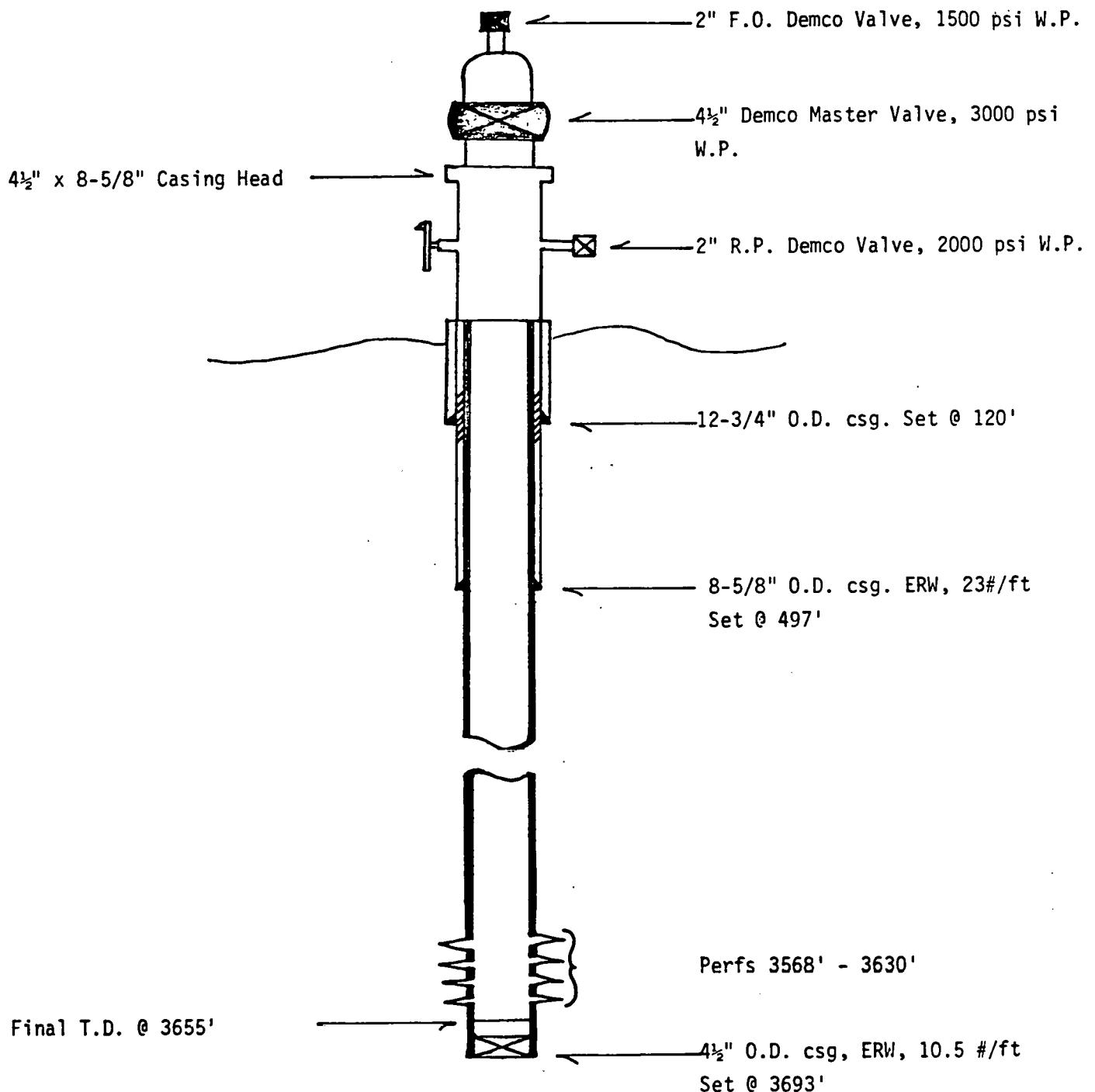
FOAM FRAC TREATMENT SCHEDULE
FOR THE
PORTVILLE CENTRAL SCHOOL WELL NO. 1

Table 2

STAGE	GAL OF FOAM	SAND CONC LBS/GAL FOAM	SAND LBS	SIZE	GAL LIQUID	CUM GAL LIQ + SAND	SAND CONC LBS/GAL LIQ	LIQ + SAND RATE BPM
1	10000	0.0	0		2500	2500	0	4
2	10000	1.0	10000	80/100	2500	5453	4	4.74
3	20000	1.5	30000	20/40	5000	11812	6	5.12
4	10000	2.0	20000	20/40	2500	15218	8	5.49
5 disp1.	2790	0.0	0		700	15918	0	4

ST. BONAVENTURE WELL NO. 1

WELL DIAGRAM AFTER COMPLETION



Note: All measurements are K.B.
K.B. is 10' above G.L.

ST. BONAVVENTURE WELL NO. 1

Cement Bond Log and Perforations

July 18, 1981

- 18:00 - Schlumberger logging truck and mast truck arrived on location.
- 20:00 - Ran in the hole with the CBL-VDL correlation logs.
- 21:30 - Finished the logging. Note: CBL-VDL was good.

July 21, 1981

- 9:00 - Began swabbing the hole dry to 3630 ft.
- 12:00 - Perforated on the first run from 3614 ft to 3630 ft (9 shots) using a 3-3/8" Hyperjet II hollow carrier.
- 13:30 - Perforated on the second run from 3602 ft to 3612 ft and from 3568 ft to 3572 ft (9 shots). In conclusion, the perforated interval was 3568 ft to 3630 ft.

Acid Ball Out

July 23, 1981

- 8:00 - Halliburton on location.
- 8:55 - Tested the line at 5000 psi.
- 9:00 - Began loading acid into the casing; 20.7 bbls of acid were pumped.
- 9:10 - Continued acid, dropping a perf ball every 0.5 bbl of acid pumped (30 perf balls total).

July 23, 1981 cont'd.

9:17 - Finished the rest of the acid, that is 15 bbls more.

9:25 - After 21 bbls of water followed the acid, the formation broke down at 3100 psi. Pressure built up to 3600 psi with the ball out action.

9:30 - Finished the squeeze. I.S.I.P. = 3100 psi.

9:35 - S.I.P. after 5mn = 3000 psi.

9:40 - S.I.P. after 10mn = 2975 psi.
The BHTP was calculated to be 4672 psi, the frac gradient 1.29 psi/ft and the stress ratio = 1.12.

10:00 - Opened the well wide open to unseat the perf balls and unload the acid.

10:15 - Began swabbing the well to the top perf at 3568 ft.
Bailed the well dry to 3630 ft.

14:30 - Rigged down service rig.

15:30 - Moved the rig to the Portville well.

Foam Frac

July 28, 1981

7:30 - Halliburton arrived on location.

9:00 - Tested the lines at 5000 psi.

9:05 - Began job with the pad. P_I built up to 4600 psi maximum allowable pressure. Reduced the injection rate of the foam from 16 BPM to 12 BPM.

9:25 - 2500 gal of liquid in. Started sand 1 lb/gal of foam, 80/100 mesh. P_I = 4400 psi; Q_w = 3 BPM; Q_{N2} = 14200 SCF/mn.

9:45 - Started 1.5 lbs/gal sand, 20/40 mesh. P_I = 4400 psi.

July 28, 1981 cont'd.

10:24 - Started 2 lbs/gal sand, 20/40 mesh.
 $P_I = 4200$ psi, $Q_w = 3$ BPM, $Q_{N2} = 11,500$ SCF/mn.

10:45 - Finished sand. Began flush.

10:50 - Finished flush. Shut pumps down. I.S.I.P. = 3800 psi.

10:55 - S.I.P. after 5mn = 3400 psi.

11:00 - S.I.P. after 10mn = 3600 psi.

11:05 - S.I.P. after 15mn = 3400 psi. See Tables 1 & 2
Disconnected Halliburton wellhead manifold.
Hooked up flow back equipment.

12:00 - Opened the well back on 1/8" choke.

13:30 - $P_f = 3000$ psi. Shut well in; replaced the choke
with $\frac{1}{4}$ ".

15:00 - $P_f = 2050$ psi. Well flowing, water, N_2 and little
sand.

15:30 - $P_f = 1650$ psi.

16:00 - A hole developed into the flow line to the flow
back tank.

16:30 - $P_f = 1150$ psi.

17:00 - $P_f = 1075$ psi.

17:30 - $P_f = 975$ psi.

17:45 - Shut well in. Welded a new tee to the flow line. To
this point, 110 bbls of water were recovered.

18:15 - S.I.P. = 1640 psi. Replaced the $\frac{1}{4}$ " choke with a
3/8" choke. Note: The $\frac{1}{4}$ " choke removed opened
up to 9/32" from the upstream side and to $\frac{1}{2}$ " from
the downstream side. Opened the well back up into
the flow back tank.

July 28, 1981 cont'd.

19:00 - P_f = 520 psi.

20:30 - P_f = 290 psi.

20:40 - P_f = 240 psi. Shut the well in; changed the choke to 3/4".

20:45 - Opened the well back up. To this point recovered 123 bbls of flow back water.

21:40 - P_f = 45 psi. Shut the well in. Removed the 3/4" choke and opened the well wide open on 2".

22:00 - P_f = 0 psi.

Well Clean Out

July 29, 1981

7:00 - Well still flowing N_2 , water mist and natural gas.

7:15 - Shut the well in for 15mn. Pressure built up to 200 psi.

7:30 - Opened the well back up.

13:00 - G.F.S. service rig moved on the well and rigged up.

14:00 - Checked the hole. Top of the sand was found at 3619 ft. Therefore, 11 ft of perfs were covered with sand.

15:00 - Finished cleaning out the sand with a sand pump to 3655 ft, the final total depth.

15:30 - Ran the swabs; recovered very little water.

19:15 - Shut well in.

July 30, 1981

7:15 - S.I.P. = 2180 psi after 12 hrs. Blew the well down. Found fluid level at 3550 ft; only 100 ft of water in the well. Bailed the well down.

16:00 - Finished bailing.

July 31, 1981

7:00 - Began swabbing and bailing operations.

16:00 - Finished clean out operations. Rigged down. Left well open.

August 01, 1981

16:00 - Measured O.F.P. = 34,000 SCF/D after the well was flowing for 24 hrs. still some N₂ with the gas.

August 06, 1981

Measured O.F.P. = 18,800 SCF/D after the well was opened for 24 hrs.

August 14, 1981

S.I.P. = 1080 psi in 183 hrs.

SUMMARY OF ACID AND FRAC TREATMENTS
 FOR THE
 ST. BONAVVENTURE WELL NO. 1
 OLEAN, NEW YORK

Table 1

	Acid Treatment	Foam Frac Treatment
Regular HF Acid	1500 Gal	
Foam Rate		12 BPM
Foam Quality		75 %
Water Volume		12,500 Gal
Nitrogen Volume		1,428,000 SCF
Nitrogen Rate		10,400 SCF/mn
N ₂ To Liquid Ratio		3,467 SCF/Bbl
Foamer HC2		70 Gal
Cla-Sta		13 Gal
Corrosion Inhibitor HAI-50	3 Gal	
Sand 80/100		10,000 Lbs
Sand 20/40		50,000 Lbs
Perf. Balls	30 (S.G.=1.3)	
Buffer HLX-287		70 Lbs
Average Pressure	3100 Psi	4,330 Psi
I.S.I.P.	3100 Psi	3,800 Psi
5mn Pressure	3000 Psi	3,400 Psi
10mn Pressure	3000 Psi	3,600 Psi
15mn Pressure		3,400 Psi

FOAM FRAC TREATMENT SCHEDULE

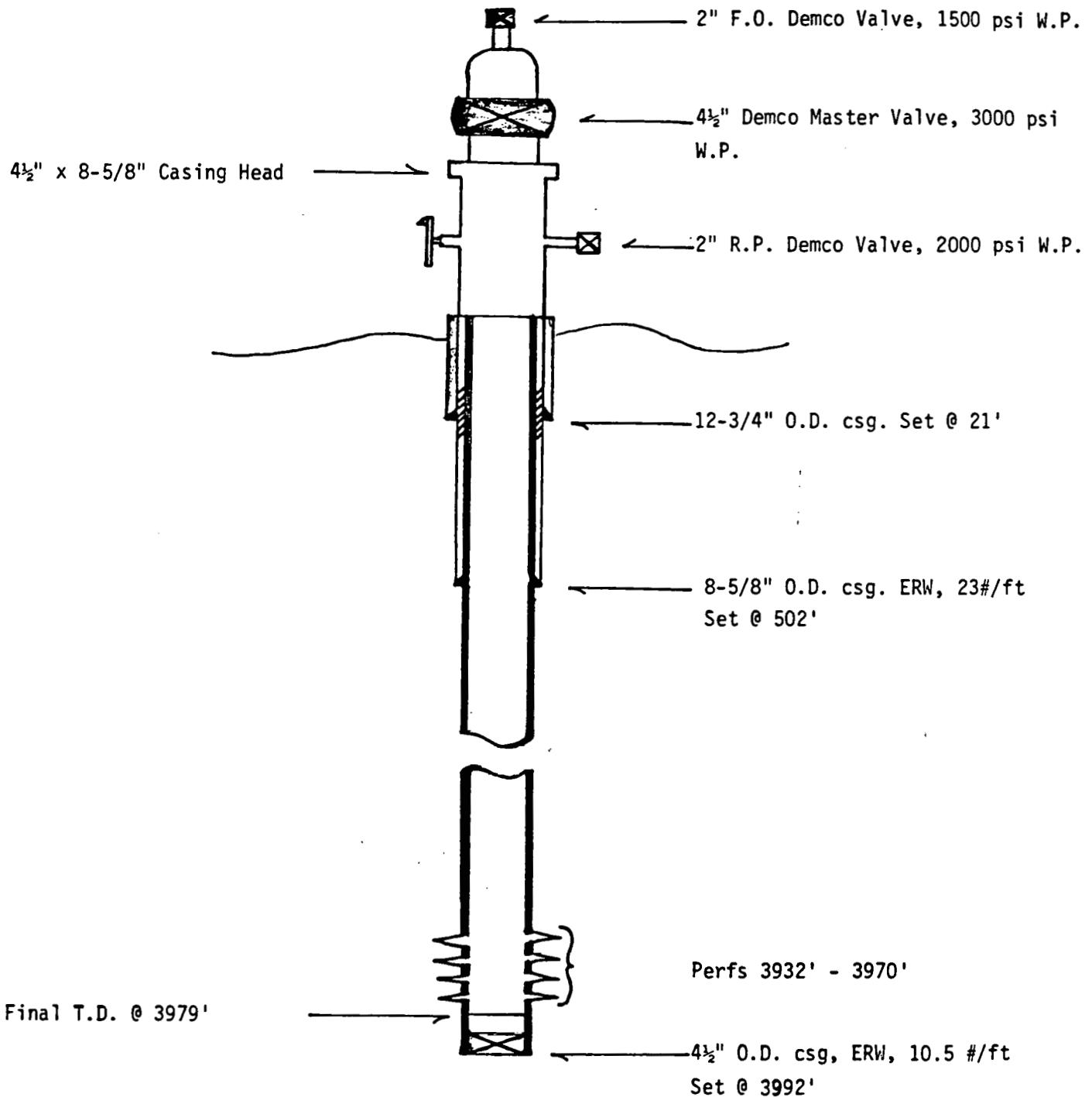
FOR THE

ST. BONAVENTURE WELL NO. 1

Table 2

STAGE	GAL OF FOAM	SAND CONC LBS/GAL FOAM	SAND LBS	SIZE	GAL LIQUID	CUM GAL LIQ + SAND	SAND CONC LBS/GAL LIQ	LIQ + SAND RATE BPM
1	10000	0.0	0		2500	2500	0	3.00
2	10000	1.0	10000	80/100	2500	5453	4	3.56
3	20000	1.5	30000	20/40	5000	11812	6	3.84
4	10000	2.0	20000	20/40	2500	15218	8	4.12
5 displ.	2425	0.0	0		606	15824	0	3.00

ALFRED UNIVERSITY WELL NO. 1
WELL DIAGRAM AFTER COMPLETION



Note: All measurements are K.B.
K.B. is 10' above G.L.

ALFRED UNIVERSITY WELL NO. 1

Cement Bond Log and Perforations

July 30, 1981

- 7:00 - Rigged up G.F.S. service rig and Schlumberger. Schlumberger encountered some problems with their generator. Waited on another logging truck.
- 13:30 - Began running the CBL-VDL correlation logs.
- 16:30 - Finished logs. Note: CBL-VDL looked good.
- 16:45 - Began swabbing the hole.
- 20:00 - Finished swabbing to the would be lowermost perforation.

July 31, 1981

- 7:00 - Schlumberger arrived on location.
- 8:00 - Ran in the hole with the first run to perforate. Perforated with a 3-3/8" hollow carrier Hyperjet II gun from 3952 ft to 3970 ft (10 shots).
- 10:30 - Ran in the hole with the second run. Perforated from 3930 ft to 3948 ft (9 shots).
- 11:00 - Pulled out of the hole. Only the shot at 3930 ft did not fire. In conclusion, the perforated interval in the Marcellus was 3932 ft to 3970 ft (18 shots).

Acid Ball Out

July 31, 1981

- 12:00 - Halliburton arrived on location for the acid job.

July 31, 1981 cont'd.

13:00 - Tested the line at 4500 psi.

13:25 - Began loading the acid (15% HF). After pumping 16 bbls of acid, began dropping a perf ball every 0.5 bbl of acid that followed. Finished 35.7 bbls of acid.

13:45 - Began displacing the acid with water.

13:48 - Began squeeze of acid into the formation which broke down at 3250 psi. After 20 bbls of acid were squeezed, the pressure built up to 4500 psi (ball out effect).

13:50 - Shut pumps down to let perf balls drop to bottom.

14:00 - Resumed squeeze. Perfs still balled out.

14:10 - Flowed back 1 bbl of water to help unseat the balls.

14:11 - Resumed squeeze at 10 BPM. $P_I = 2500$ psi.

14:14 - Finished squeeze. Shut pumps down. I.S.I.P. = 2000 psi. The BHTP (calculated) = 3720 psi. Frac gradient = 0.94 psi/ft. Stress ratio = 0.82.

14:19 - S.I.P. after 5mn = 1900 psi.

14:24 - S.I.P. after 10mn = 1900 psi.

14:25 - Flowed the well back. Fluid stopped flowing.

14:30 - Began swabbing the hole dry.

17:00 - Finished swabbing.

Foam Frac

August 04, 1981

7:30 - Halliburton on location.

August 04, 1981 cont'd.

9:10 - Tested lines at 5000 psi.

9:14 - Began loading the hole with foam pad.

9:18 - Foam on bottom. $P_I = 4000$ psi.

9:30 - Started 80/100 mesh sand at 1 lb/gal of foam,
 $P_I = 4400$ psi, $Q_{N2} = 22,000$ SCF/mn, $Q_w = 5$ BPM.

9:39 - Started 20/40 mesh sand 1.5 lbs/gal of foam.

10:03 - Started 20/40 mesh sand at 2 lbs/gal of foam.

10:14 - Finished sand. Began flush.

10:17 - Finished flush. Shut pumps down.
I.S.I.P. = 3800 psi, 5mn S.I.P. = 3600 psi, 10mn
S.I.P. = 3600 psi, 15mn S.I.P. = 3500 psi. See
tables 1 & 2

11:15 - Opened the well up on 1/8" positive steel choke,
flowing into a flow back tank. S.I.P. before opening
= 3100 psi.

11:50 - $P_f = 2900$ psi.

13:15 - Shut well in. Changed the choke from 1/8" to $\frac{1}{4}$ ".
Note: The 1/8" choke was not enlarged by the sand.

13:30 - $P_f = 2000$ psi. Well flowing water, N_2 and little
sand.

14:45 - $P_f = 1000$ psi. Shut well in. Changed the choke from
 $\frac{1}{4}$ " to 3/8". Note: The $\frac{1}{4}$ " choke removed was not en-
larged by the sand.

15:25 - $P_f = 400$ psi. Shut well in. Changed choke from
3/8" to 3/4". Recovered 48 bbls of water to this
point. Opened well up.

16:30 - $P_f = 75$ psi. Shut well in. Removed the 3/4" choke
and opened well up on 2", flowing into the tank.

August 04, 1981 cont'd.

16:45 - $P_f = 35$ psi.

18:00 - $P_f = 35$ psi. Recovered 57 bbls of water to this point, that is after almost 7 hours flow back.

Well Clean Out

August 05, 1981

9:00 - Moved service rig on location. Well stopped bringing fluid. Recovered a total of 84 bbls of water into the tank to this point.

11:00 - Checked the hole. No sand on bottom. T.D. = 3979 ft. Recovered in the bailer 28 perf balls, 18 of which had marks of ball out.

11:30 - Swabbed the hole. Fluid level was found at 2800 ft.

17:00 - Finished swabbing.

August 06, 1981

7:00 - Resumed the swabbing operations.

16:00 - Finished swabbing. Recovered about 10 bbls of water.

August 07, 1981

7:00 - Resumed swabbing.

16:00 - Finished swabbing, recovered very little water.

August 08, 1981

7:00 - Resumed swabbing.

16:00 - Finished swabbing. Recovered very little water. Measured O.F.P. = 28,800 SCF/D. Rigged down.

August 11, 1981

9:00 - Measured O.F.P. = 36,000 SCF/D after 24 hours flowing.

August 13, 1981

9:00 - Well shut in. S.I.P. = 1190 psi in 48 hours.

August 19, 1981

12:00 - S.I.P. = 1560 after 189 hours.

August 20, 1981

10:00 - O.F.P. = 40 MCF/D. Shut well in.

SUMMARY OF ACID AND FRAC TREATMENTS
 FOR THE
 ALFRED UNIVERSITY WELL NO. 1
 ALFRED, NEW YORK

Table 1

	Acid Treatment	Foam Frac Treatment
Regular HF Acid	1500 Gal	
Foam Rate	8 BPM (Acid)	20 BPM
Foam Quality		75 %
Water Volume		12,500 Gal
Nitrogen Volume		1,376,500 SCF
Nitrogen Rate		22,000 SCF/mn
Nitrogen To Liquid Ratio		4,400 SCF/Bbl
Foamer HC2		70 Gal
Cla-Sta		13 Gal
Corrosion Inhibitor HAI-50	3 Gal	
Sand 80/100		10,000 Lbs
Sand 20/40		50,000 Lbs
Perf. Balls	30 (S.G.=1.3)	
Buffer HLX-287		70 Lbs
Average Pressure	2500 Psi	4,390 Psi
I.S.I.P.	2000 Psi	3,800 Psi
5mn Pressure	1900 Psi	3,600 Psi
10mn Pressure	1900 Psi	3,600 Psi
15mn Pressure		3,500 Psi

FOAM FRAC TREATMENT SCHEDULE

FOR THE

ALFRED UNIVERSITY WELL NO. 1

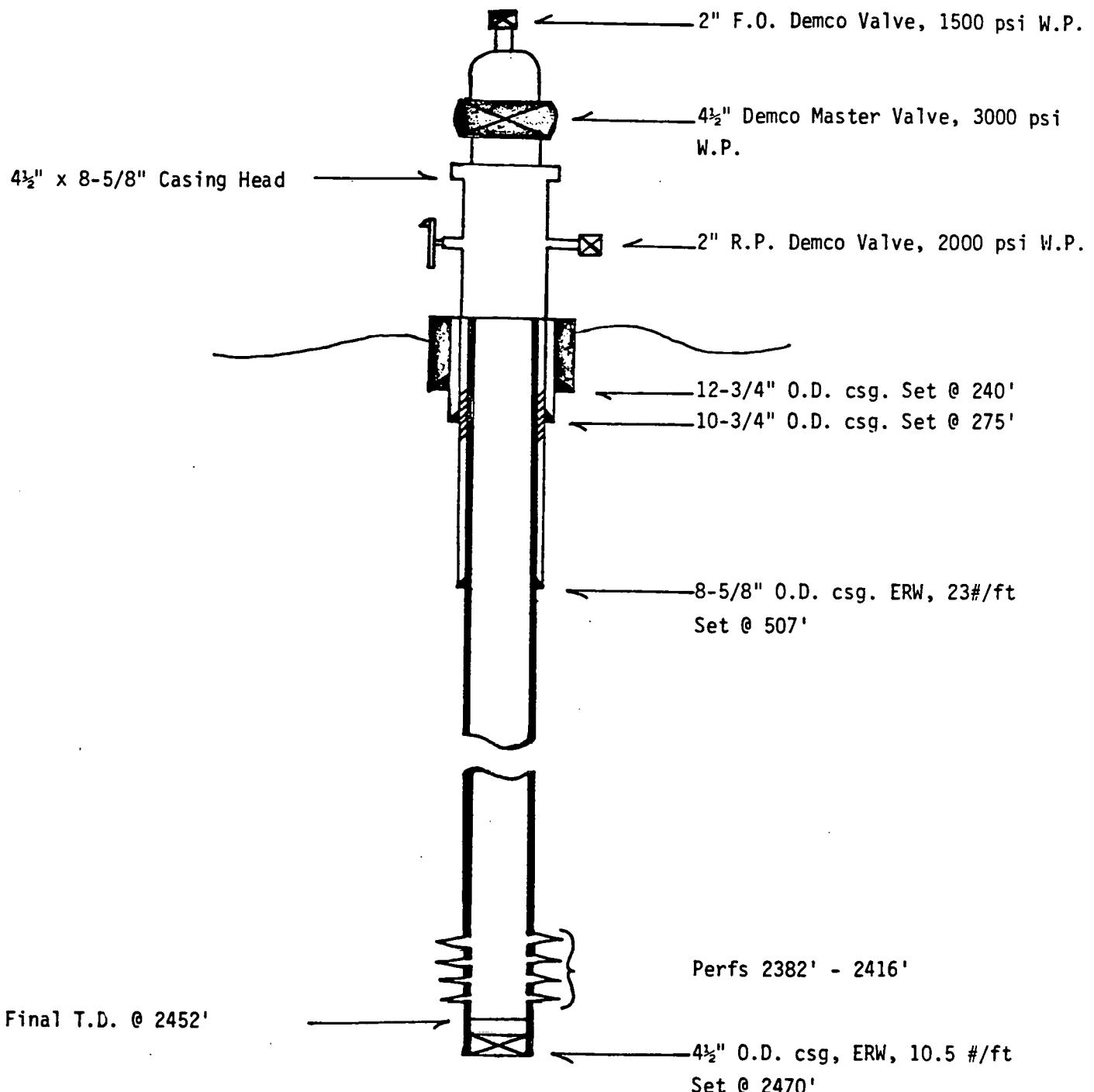
ALFRED, NEW YORK

Table 2

STAGE	GAL OF FOAM	SAND CONC LBS/GAL FOAM	SAND LBS	SIZE	GAL LIQUID	CUM GAL LIQ + SAND	SAND CONC LBS/GAL LIQ	LIQ + SAND RATE BPM
1	10000	0.0	0		2500	2500	0	5.00
2	10000	1.0	10000	80/100	2500	5453	4	5.91
3	20000	1.5	30000	20/40	5000	11812	6	6.36
4	20000	2.0	20000	20/40	2500	15218	8	6.81
5 displ.	2650	0.0	0		663	15881	0	5.00

HOUGHTON COLLEGE WELL NO. 2

WELL DIAGRAM AFTER COMPLETION



Note: All measurements are K.B.
K.B. is 10' above G.L.

HOUGHTON COLLEGE WELL NO. 2

Cement Bond Log and Perforations

August 03, 1981

- 7:00 - Rigged up GFS service rig and Schlumberger.
- 8:00 - Began running CBL-VDL correlation logs.
- 10:00 - Finished logging. Note: CBL-VDL looked good.
- 12:00 - Finished swabbing the hole to the would be lowermost perforation at 2416 ft.
- 13:00 - Perforated the 4½" casing in the Marcellus shale in one run using the hollow carrier 3-3/8" Hyper-jet II from 2382 ft to 2416 ft.
- 14:00 - Pulled out of the hole. Only one perf at 2386 ft did not fire. Therefore, 17 shots fired and the perforated interval = 2382 ft - 2416 ft.
- 15:00 - Finished all logs.

Acid Ball Out

August 05, 1981

- 8:30 - Halliburton arrived on location.
- 9:45 - Tested lines at 4500 psi.
- 9:50 - Began loading the hole with acid. Pumped 750 gal.
- 10:00 - Continued the acid dropping a perf ball every 0.5 bbl of acid which followed.
- 10:11 - Finished the additional 750 gal of acid. Began displacement with water.

August 05, 1981 cont'd.

10:13 - Began squeeze; $Q_w = 10$ BPM. Formation broke down at 2250 psi.

10:15 - Balled out perfs. $P_t = 4700$ psi. Shut pump down to let perf balls drop to bottom 20 bbls of acid already squeezed, 16 bbls to go.

10:25 - Resumed squeeze at 8 BPM.

10:27 - Finished squeeze. I.S.I.P. = 1800 psi. The calculated BHTP = 2846 psi. The frac gradient = 1.18. The stress ratio = 1.03.

10:32 - S.I.P. = 1750 psi after 5mn.

10:37 - S.I.P. = 1725 psi after 10mn.

10:50 - Opened the well up.

11:00 - Began swabbing the hole dry.

13:30 - Finished swabbing.

Foam Frac

August 06, 1981

8:00 - Halliburton on location.

9:45 - Tested line at 5000 psi.

9:48 - Began loading the hole.

9:50 - Fluid reached the bottom. $P_t = 3400$ psi, $Q_w = 5$ BPM, $Q_{N2} = 8500$ SCF/mn.

10:00 - Finished foam pad. Began 80/100 mesh sand at 1 lb/gal of foam.

10:10 - Started 20/40 mesh sand at 1.5 lbs/gal of foam.

10:39 - Started 20/40 mesh sand at 2.0 lbs/gal of foam.

August 06, 1981 cont'd.

10:50 - Finished sand. Began flush.

10:52 - Finished flush. I.S.I.P. = 2900 psi,
5mn S.I.P. = 2700 psi,
10mn S.I.P. = 2700 psi,
15mn S.I.P. = 2700 psi.

11:20 - Hooked up flow back equipment. S.I.P. before opening the well = 2450 psi.

11:25 - Opened well up on a $\frac{1}{4}$ " choke. Well flowing into a flow back tank.

12:00 - P_f = 2100 psi.

13:00 - P_f = 1925 psi.

13:09 - A small leak developed in the flow line to the tank. Repaired the leak.

13:30 - Reopened the well on $\frac{1}{4}$ " choke. S.I.P. before opening = 2250 psi.

14:30 - P_f = 1725 psi. Recovered a total of 46 bbls of water to this point.

16:30 - P_f = 1375 psi. Recovered a total of 86 bbls to this point..

17:30 - P_f = 1200 psi. Recovered a total of 103 bbls to this point.

18:50 - P_f = 950 psi.

18:55 - Changed choke to 3/8". Note: The $\frac{1}{4}$ " choke opened up to about 3/8". Opened well up. Recovered a total of 120 bbls of water to this point.

21:00 - P_f = 300 psi. Shut well in; changed choke from 3/8" to 3/4". Recovered 136 bbls of water to this point. Opened well up.

21:25 - P_f = 65 psi. Shut well in. Removed the choke. Well wide open on 2".

22:00 - P_f = 20 psi. Left well flowing overnight.

Well Clean Out

August 09, 1981

7:00 - Moved the service rig on location.
8:00 - Checked the bottom of the hole. Found T.D. at 2452 ft. Therefore, there is no sand covering the perforations. Recovered a total of 170 bbls of frac water into the tank; that is a 55% recovery.
8:30 - Began the swabbing operations.
16:00 - Finished the swabbing.

August 10, 1981

7:00 - Began the swabbing operations. Well making very little water.
16:00 - Finished the swabbing. Measured O.F.P. = 27,400 SCF/D. Rigged down. Shut well in.

August 13, 1981

15:00 - Well shut in. S.I.P. = 860 psi after 47 hours.

August 19, 1981

Well shut in. S.I.P. = 1220 psi after 184 hours.
Blew the well down. Left open.

}

August 20, 1981

7:15 - O.F.P. = 23,000 SCF/D.
Shut well in.

SUMMARY OF ACID AND FRAC TREATMENTS
 FOR THE
 HOUGHTON COLLEGE WELL NO. 2
 HOUGHTON, NEW YORK

Table 1

	Acid Treatment	Foam Frac Treatment
Regular HF Acid	1500 Gal	
Foam Rate		20 BPM
Foam Quality		75 %
Water Volume		12,500 Gal
Nitrogen Volume		1,205,000 SCF
Nitrogen Rate		18,500 SCF
N ₂ To Liquid Ratio		3,700 SCF/Bbl
Foamer HC2		63 Gal
Cla-Sta		13 Gal
Corrosion Inhibitor HAI-50	3 Gal	
Sand 80/100		10,000 Lbs
Sand 20/40		50,000 Lbs
Perf. Balls	30 (S.G.=1.3)	
Buffer HLX-287		50 Lbs
Average Pressure	2700 Psi	3,388 Psi
I.S.I.P.	1800 Psi	2,700 Psi
5mn Pressure	1750 Psi	2,700 Psi
10mn Pressure	1725 Psi	2,700 Psi
15mn Pressure		

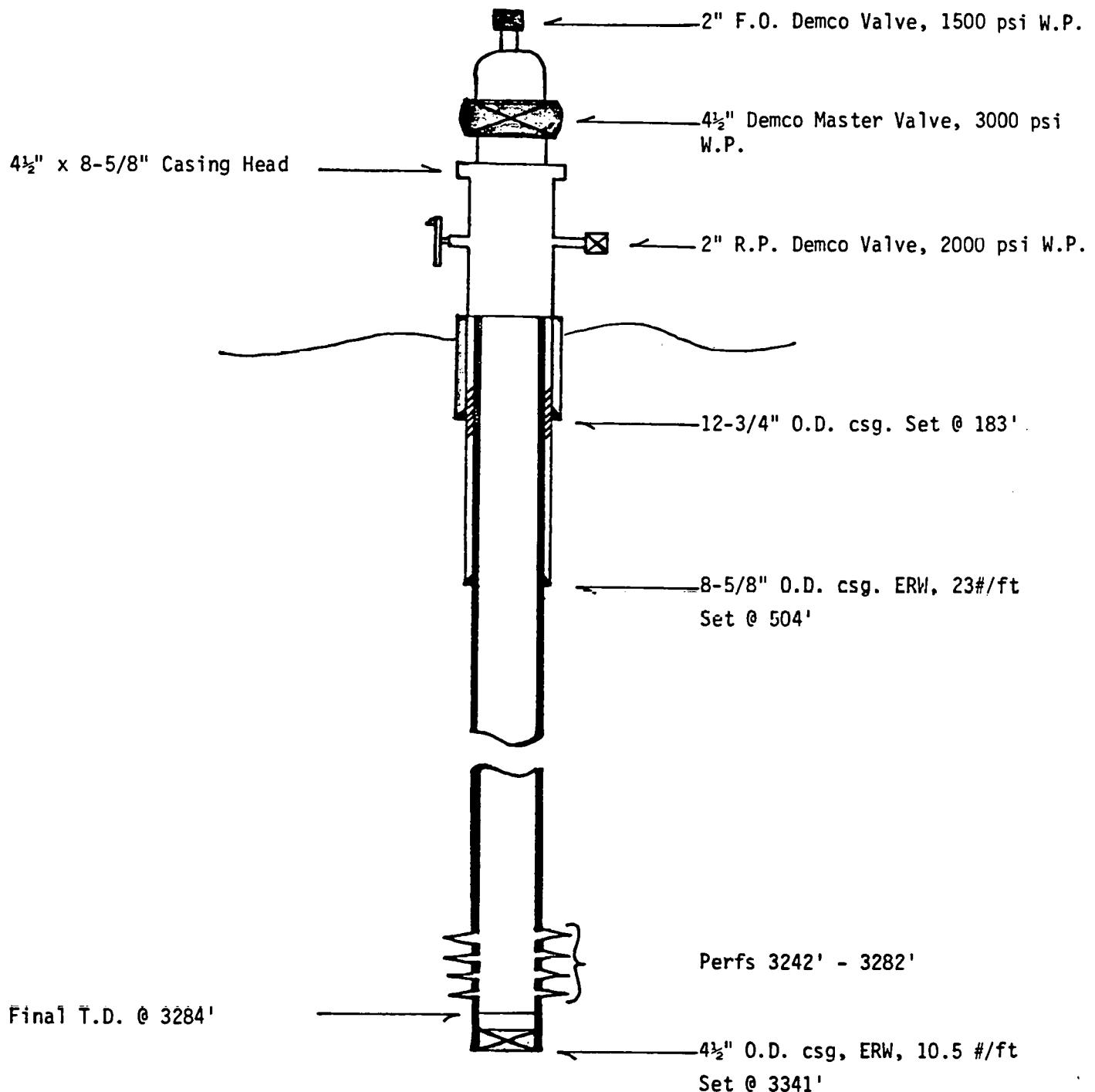
FOAM FRAC TREATMENT SCHEDULE
FOR THE
HOUGHTON COLLEGE WELL NO. 2

Table 2

<u>STAGE</u>	<u>GAL OF FOAM</u>	<u>SAND CONC LBS/GAL FOAM</u>	<u>SAND LBS</u>	<u>SIZE</u>	<u>GAL LIQUID</u>	<u>CUM GAL LIQ + SAND</u>	<u>SAND CONC LBS/GAL LIQ</u>	<u>LIQ + SAND RATE BPM</u>
1	10000	0.0	0		2500	2500	0	5.00
2	10000	1.0	10000	80/100	2500	5453	4	5.91
3	20000	1.5	30000	20/40	5000	11812	6	6.36
4	10000	2.0	20000	20/40	2500	15218	8	6.81
5 displ.	1620	0.0	0		405	15623	0	5.00

BOCES BELMONT WELL NO. 1

WELL DIAGRAM AFTER COMPLETION



Note: All measurements are K.B.
K.B. is 10' above G.L.

BOCES BELMONT WELL NO. 1

Cement Bond Log and Perforations

August 10, 1981

- 7:00 - Rigged up Schlumberger and service rig.
- 8:30 - Began CBL-VDL correlation logs.
- 12:30 - Finished the logging. Note: The CBL-VDL looked good.
- 15:00 - Finished swabbing the 4½" casing to the would be lowermost perforation.
- 16:00 - Ran in the hole with the 3-3/8" Hyperjet II hollow carrier gun to perforate the Marcellus in one run. Shots did not fire. Pulled out. Inspected the tools.
- 19:00 - Ran back in the hole.
- 20:00 - Perforated the Marcellus shale from 3242 ft to 3282 ft (21 shots).
- 21:00 - Finished all the logging operations.

Acid Ball Out

August 11, 1981

- 8:00 - Halliburton arrived on location.
- 9:15 - Tested lines at 5000 psi.
- 9:20 - Began loading the hole with acid (15% HF).
- 9:27 - After 750 gal of acid were pumped, continued acid dropping a perf ball each 0.5 bbl of acid which followed.

August 11, 1981 cont'd.

9:38 - Finished pumping acid. Began acid squeeze with water. Formation broke down at 2400 psi.

9:42 - $P_I = 5600$ psi (1100 psi above the instructed allowable pressure of 4500 psi). Perfs balled out. Shut pumps down to unseat perf balls. 18 bbls of acid already squeezed into the formation.

9:50 - Resumed squeeze at $Q_w = 8$ BPM.

9:52 - Finished the rest of the 35.7 bbls of acid squeeze. Shut pumps down. I.S.I.P. = 2250 psi; the calculated BHTP = 3675 psi. The frac gradient = 1.12 psi/ft. The stress ratio = 0.97. S.I.P. after 5mn = 2200 psi. S.I.P. after 10mn = 2175 psi.

10:00 - Opened the well up. Began swabbing the water and acid out.

14:00 - Finished the swabbing.

Foam Frac

August 15, 1981

7:00 - Halliburton on location.

8:59 - Began loading the hole with foam pad.

9:01 - A leak developed in the bleed off valve. Shut pumps down.

9:16 - Resumed pumping foam pad. $P_I = 3600$ psi, $Q_w = 5$ BPM, $Q_{N2} = 19,600$ SCF/mn.

9:20 - Started 80/100 mesh sand at 1 lbs/gal of foam.

9:36 - Started 20/40 mesh sand at 1.5 lbs/gal of foam. $P_I = 3800$ psi, $Q_{N2} = 20,500$ SCF/mn, $Q_w = 5$ BPM.

August 15, 1981 cont'd.

10:00 - Started 20/40 mesh sand at 2 lbs/gal of foam.

10:12 - Finished sand. Began flush with foam.

10:15 - Finished flush. Shut pumps down.
I.S.I.P. = 3400 psi
S.I.P. after 5mn = 3250 psi,
S.I.P. after 10mn = 3200 psi,
S.I.P. after 15mn = 3200 psi.

10:47 - Opened the well up on 1/8" choke. Before opening, the S.I.P. was 2950 psi.

11:30 - P_f = 2750 psi.

12:00 - P_f = 2650 psi. Shut well in. Changed choke from 1/8" to $\frac{1}{4}$ ".

13:00 - P_f = 2500 psi. Recovered in the flow back tank 46 bbls of water to this point.

15:30 - P_f = 1350 psi. Recovered 90 bbls of water to this point.

15:50 - P_f = 1200 psi. Shut well in. Changed the choke from $\frac{1}{4}$ " to 3/8". Opened well up.

17:00 - P_f = 450 psi. Recovered 110 bbls of water to this point.

17:05 - Shut well in. Changed the choke from 3/8" to 3/4".

18:00 - P_f = 55 psi. Recovered 135 bbls of water to this point.

18:05 - Shut well in. Removed choke. Opened well up on 2". Left well flowing into the flow back tank overnight.

Well Clean Out

August 16, 1981

11:00 - Moved G.F.S. (Gas Field Specialists) service rig on the well.

August 16, 1981 cont'd.

12:00 - Checked the bottom of the hole. Began the swabbing operations.

16:00 - Finished the swabbing operations for the day. Left well open to the atmosphere.

August 17, 1981

7:00 - Checked the hole. Found 1000 ft of water. Also, found the top of the sand at 3254 ft.

8:00 - Began sand pumping. Cleaned out the sand to a T.D. of 2484 ft, 2 ft below the bottom perf.

16:00 - Resumed swabbing.

17:00 - Finished swabbing for the day. Left well open.

August 18, 1981

7:00 - Checked the hole. T.D. = 3284 ft. Swabbed the hole which was making little water.

15:00 - Measured the O.F.P. = 72,500 SCF/D, all of it gas.

16:00 - Rigged down. Shut well in. Moved off location.

August 23, 1981

11:30 - S.I.P. = 1600 psi after 115 hours.

SUMMARY OF ACID AND FRAC TREATMENTS
 FOR THE
 BOCES BELMONT WELL NO. 1
 BELMONT, NEW YORK

Table 1

	Acid Treatment	Foam Frac Treatment
Regular HF Acid	1500 Gal	
Foam Rate	8 BPM	20 BPM
Foam Quality	—	75 %
Water Volume		12,500 Gal
Nitrogen Volume		1,285,000 SCF
Nitrogen Rate		19,000 SCF/mn
N ₂ To Liquid Ratio		3,800 SCF/Bbl
Foamer HC2		70 Gal
Cla-Sta		26 Gal
Corrosion Inhibitor HAI-50	3 Gal	
Sand 80/100		10,000 Lbs
Sand 20/40		50,000 Lbs
Perf. Balls	30 (S.G.=1.3)	
Buffer HLX-287		
Average Pressure	2600 Psi	3,800 Psi
I.S.I.P.	2250 Psi	3,400 Psi
5mn Pressure	2200 Psi	3,250 Psi
10mn Pressure	2175 Psi	3,200 Psi
15mn Pressure		3,200 Psi

FOAM FRAC TREATMENT SCHEDULE
FOR THE
BOCES BELMONT WELL NO. 1

Table 2

STAGE	GAL OF FOAM	SAND CONC LBS/GAL FOAM	SAND LBS	SIZE	GAL LIQUID	CUM GAL LIQ + SAND	SAND CONC LBS/GAL LIQ	LIQ + SAND RATE BPM
1	10000	0.0	0		2500	2500	0	5.00
2	10000	1.0	10000	80/100	2500	5453	4	5.91
3	20000	1.5	30000	20/40	5000	11812	6	6.36
4	10000	2.0	20000	20/40	2500	15218	8	6.81
5 disp1.	2192	0	0		548	15766	0	5.00