UGR File #321
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final report, Nov. 1979

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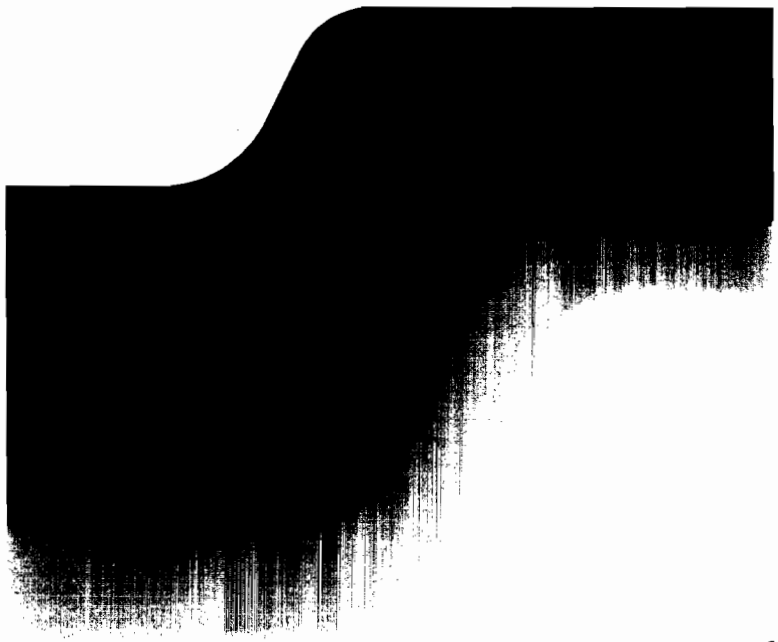
Degasification Well
Bethlehem Mines 32-13



UGR FILE #321

Final Report

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DEGASIFICATION PROJECT
BETHLEHEM MINES 32-13

Final Report

Prepared for

Bethlehem Mines Corporation

by

INTERCOMP Resource Development and Engineering Co.

November, 1979

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I. ABSTRACT

In conjunction with the Advanced Energy Systems Division of Westinghouse Electric Corporation and the U.S. Department of Energy, Bethlehem Mines Corporation drilled a well near its Cambria Mine No. 32. The purpose of the well was to predrain gas from coal beds ahead of mining and to vent gob gas subsequent to mining through the well.

The well was drilled, completed, tested and evaluated under the supervision of INTERCOMP. Fiberglass casing was set through all minable coal beds and the principal coal beds were completed and stimulated. Gas flows were measured and evaluated. Gas quality is good with 98.6% methane.

Well evaluation showed abnormally low pressures and no water production. Wellhead shut in pressure of only 26 psig was measured with the bottom completion at a depth of 900 feet. Extended deliverability is predicted to start at 20 Mcf/d and decline to 8 Mcf/d over a five year period if the well is produced.

The well design and completion procedures demonstrated at this well are significant because they allowed the same well to be used as a gas producer, to be mined through, and to be later used as a gob gas well. The use of the Hydrojet Tool to open the coal zones proved more effective and less expensive then perforating.

II. INTRODUCTION

Bethlehem Mines Corporation has over the years developed a method for draining methane emissions from the caved region (gob) that is created behind long wall mining machinery. This method is to drill vent wells that produce the methane-air mixtures to the atmosphere. Heretofore, this mixture has not been considered as a resource for energy. However, the U.S. Department of Energy (DOE) now has an ongoing effort to demonstrate the capture and utilization of methane produced from coal beds.

INTERCOMP has pioneered the research and completion technology necessary to predrain methane from coal beds. As a part of the overall DOE effort, a project was initiated by Westinghouse Electric Corporation to combine the INTERCOMP predrainage technology and Bethlehem's gob drainage techniques with a gas turbine to generate electricity from a fuel that would vary from pure methane to a poor quality methane-air mixture. This demonstration project would require a turbine that would operate on a variety of fuel concentrations and a well that could be converted from gas production to gob gas drainage.

This requirement led to special designs for both the production well and the turbine installation. This report deals only with the well design, completion, and evaluation.

Unfortunately, the well deliverability is not high enough to sustain operation of the turbine and the utilization portion of th project has been terminated.

The location of these well was in the immediate vicinity of Bethlehem's Cambria Mine No. 32. The proximity to the mine entries is shown on Figure 1. While the production well was completed in all four of the principal coal beds only one, the lower most is presently being mined at this location. Future plans call for mining the upper seams at a later time.

III. WELL DESIGN

The design of the production well involved several constraints and trade offs. The objectives were to drill and complete a well that could accomodate three totally different objectives. First, the well must be capable of being completed as a gas production well including a stimulation treatment. This means all components need a 1500-2000 psi working pressure.

Second, the well must be suitable for conversion to a gob drainage well. Bethlehem experience with gob drainage wells showed that rigid cement jobs presented problems when the mine roof collapsed after long wall mining. This is inconsistent with zone isolation and pressure requirements for completing multiple coal seams by hydraulic stimulation.

Third, the miners should be able to mine through the well at several levels with no danger to men or machinery.

Obviously, the Bethlehem developed procedure for gob gas wells was not sufficient. This procedure, is to set 8 inch I.D. casing with a chemical seal at about 400 feet and leave the remainder of the section open hole. Likewise, the use of standard oil field casing is unsuitable for either the second or third constraint.

The final solution was to use 4 1/2 inch fiberglass casing through the coal seams with 4 1/2 inch steel casing above the coal seams. This configuration gives the pressure specifications at the surface. The fiberglass could easily be milled out to make a normal gob drainage hole; or if the well were to be mined through, the fiberglass would offer no resistance to the mining equipment that would be detrimental to the machinery or create a spark such as would be the case with steel pipe.

It was believed that the well would require water removal equipment. For the depth involved the most economical installation was a submergible pump hung on 2 inch tubing.

The well as designed is shown on Figure 2. This design included cement only up about 100 feet on the steel casing. This was designed to prevent the rigid cement in the upper section which would allow movement of the section when the area caved after mining. Because of a caliper error by the logger, cement was actually circulated to surface.

IV. FIELD ACTIVITIES

The well, Behtlehem 32-13, was drilled as contracted by Bethlehem personnel in December, 1978. The coal seams were encountered as expected. Total depth was 980 feet. The coal seam depths and thicknesses are shown on Table I.

Table I
Coal Seams Encountered
Bethlehem 32-13

Seam	Depth	Seam Name
B	892-98	Lower Kittanning
C	862-66	Middle Kittanning
C'	810-12	Upper Kittanning
D	784-88	Lower Freeport
E	694-98	Upper Freeport

Operations were suspended through the winter because of bad weather and frozen ground. This prevented the installation of the security fence and excavation of the pit to hold water for the stimulation treatment.

On April 4, 1979, a rig was moved in and total depth was found at 960 feet. Schlumberger ran a Compensated Formation Density Log with Gamma Ray Caliper and an Induction-Gamma Ray Log. Logger found the depth to be 962 feet. The logs verified the location of the coal seams.

The next day, April 5, 1979, the following material was installed in the well: 4 1/2" 8rd thread guide float shoe, a male 8rd thread to female 8v thread steel changeover, a 3 ft long fiberglass 8v thread to 4 1/2" EUE 8rd thread nipple, a 4 1/2" EUE 8rd collar, 22 jt (430 ft) of heavy duty fiberglass 4 1/2" EUE 8rd thread pipe (4.00" I.D., 4.7" O.D., 5.75" O.D. upset), a 3 ft fiberglass nipple with 8v and 8rd EUE threads, 8v to 8rd steel changeover, 17 jt (504 ft) of 4 1/2" O.D. 8rd thread, 9.5 lb. per ft, K-55, range 2 casing. This casing string was set at 938 feet held in place with a 4 1/2 inch casing clamp. The hole was circulated with water and cemented with 80 sacks Haliburton light (12.7 lb/gal

slurry weight) and 230 sacks of 25/75 poz mix (14.3 lb/gal slurry weight). Cement circulated. The wiper plug was set in the float shoe at noon April 6, 1979. The float shoe held pressure and the job was complete.

Because the pit would not hold water, the completion was delayed until a new plastic liner could be installed. This was completed and the pit filled with water by early June.

On June 13, 1979, completion work was initiated. The procedure was to perforate the "B" seam and stimulate it, then pack the bottom of the hole with sand and repeat the sequence on the "C" seam. The well was logged by GO Wireline and perforated in the "B" seam. Unfortunately, after the perforation, it was impossible to pump into the formation. The zone was reperforated and we still could not pump into the formation.

A Haliburton Hydrojet Tool was then run on 2 3/8" O.D. tubing utilizing the tubing head and the zone 892-900 was cut with the Hydrojet Tool. The Haliburton Hydrojet Tool cuts pipe using a high pressure abrasive slurry, in this case 20-40 sand was used in a water slurry. This was pumped at high pressure (2000 psi) down tubing through nozzles in the tool and against the side of the pipe. The sand and cuttings are then circulated to the surface. In this case the cuttings consisted of fiberglass cuttings and coal. When cutting coal the circulated returns turn a black color from the fine coal particles. The result down hole is a vertical slot cut in the pipe extending several inches back into the coal seam.

The zone was then immediately stimulated with 59,000 gal. of water and 20,000 lbs. of 20-40 sand. The fluid was pumped down the casing-tubing annulus at an average injection rate of 18 bpm at a pressure of 1800 psig.

The zone was packed with sand and the Hydrojet Tool raised to the "C" seam and the process repeated. Table 2 shows the intervals that were cut with the Hydrojet and summarizes the stimulation treatments. Appendix A includes detailed field notes of the operation as well as the Haliburton Treatment Report. The stimulation was completed on June 15, 1979.

Table 2
Summary of Stimulation Treatments
Bethlehem 32-13

Zone ft.	Fluid Volume gal.	Sand lb.	Injection Rate, Bpm	Injection Press. psig
892-900	59,000	20,000	18	1,800
863-868	60,000	24,000	18	2,200
784-790	54,000	23,800	20	1,800
694-698	51,000	17,000	18	2,600

The completion procedure as modified should be considered a technical breakthrough. Past experience has shown similar problems particularly with these Allegheny series of coal beds in the Appalachian Basin and to a lesser extent in other Basins. The Hydrojet procedure appears to solve the problem of connecting the wellbore to the coal formation. In addition, the procedure is very economical. When the Hydrojetting is done in conjunction with stimulation, the abrasive fluid (sand slurry) can be circulated through the blender that must be in place for fracturing services. This makes the charges for Hydrojetting less than perforating charges. This procedure is recommended for any future operations.

The well was allowed to flow back until it died. The pack-off sand was cleaned from the well to a depth of 936 ft. using an air compressor circulating compressed air through tubing. The well was kept clear of water and debris by intermittently blowing the well with air for about 7 days at which time the well had ceased to produce water. An estimated 40% of the load water was recovered by June 22, 1979. The well has produced no measurable water since. Flow testing started on July 3, 1979. Flow rates of about 30 Mcf/d were observed. The data as recorded is shown on Figure 3. The data taken from July 6 through July 11 is in error caused by a partially closed valve. It is believed that the real volumes are as shown by the dashed curve on Figure 3. The entire set of field notes is included as Appendix B.

The well was flowed up the 4 1/2" casing to the atmosphere. No water was produced and the water level was checked daily through July 26, 1979. The level was consistently about 855-865 which indicates that only the C, D, and E seams were producing. The well was closed in until September 25, 1979, with a short term flow from August 1 through August 6. Water level was found at 910 feet or below all coal seams at

that time. A final flow period was started on September 25, and continued through October 15. This period was monitored with a continuous recording orifice well tester, rather than spot readings taken several times daily.

Gas composition was monitored and results are shown on Table 3.

Table 3
Gas Composition
Bethlehem 32-13

Sample Date	7/16/79	7/25/79
Methane, CH_4, mol%	88.71	98.58
Nitrogen, N_2	9.18	1.19
Oxygen, O_2	.78	0.12
Argon, A_r	0.14	0.01
Carbon Dioxide, CO_2	0.10	0.07
Ethane, C_2H_6	-	0.02
Water H_20	0.08	-

The samples show an increase in methane content with time and a decrease in N_2 and O_2 (air). It is believed that the air compressor actually injected air into the formation during the clean-up operation. As the air-methane mixture was produced, it became richer in methane and resulted in nearly pure methane when all the air had been produced.

The pressures were monitored during the shut in periods and a maximum wellhead pressure of 26 psig was observed. This is abnormally low and coupled with the absence of any water production, makes this well unique to our experience. The pressure was measured with an accurate pressure guage and was measured hourly during the early portion of the shut in periods and daily late in the shut in periods.

It was anticipated that the pressure would be close to hydrostatic which would mean that the observed presssure should be about 390 psi at 900 feet. The abnormally low pressure may be a geologic phenomenon similar to some other areas in the Appalachian Basin, but more likely it is the result of drainage caused by the extensive mining in the area.

During the early flow period, a technique was initiated to obtain more precise information on well performance. Since measurement of gas rates is difficult under the best of conditions, the well was shut in two hours daily and detailed pressure measurements were taken. The decline in these pressures taken at the same shut in times from day to day monitored the unsteady state flow characteristics of the well. These daily shut in pressures are shown in Appendix B.

The decline in pressure during the two extended shut in times is also unusual. This could be interpreted as drainage from the well into the mine. However, if the well were draining into the mine directly, the shut in curve should never increase, pass through a maximum, and then decline. The best explanation is that during producing times all four coal seams are producing into the well. During shut in times, three layers produce into the well causing the pressure to build up. Then the well pressure is high enough to begin to produce into the lower seam at a small rate causing the decrease in the observed well pressure.

The well was ultimately plugged on December 4, 1979. A volume of 18.5 bbl of cement slurry with a slurry weight of 14.2 lb/gal was used. The casing volume was approximately 15.2 bbl and after pumping the cement into the well, the well went on vacuum. Ultimately an additional four bbl of water was pumped into the well to fill the casing. This means that 7.3 bbl of cement was taken by the open zones. This is not unusual for zones that had been hydraulically stimulated, particularily when the formation is so low.

V. EVALUATION

INTERCOMP's Implicit Gas-Water Model with Adsorbed Gas Option was used to simulate the production rates during the flow test of this well. The objective was to predict future recovery rates. Little data was available on the coal from this well as no cores were taken. However, gas contents were measured in samples taken from the same coal seams about forty miles away. This data was used along with other estimated values which are normal to coal in this area to begin the simulation procedure.

Because of the uncertainty of the rates during the initial production period and because of the unusual way in which the pressure decreased during the shut in periods, it was decided to simulate the production rate during the final production period (September 25 - October 15). During this period, a continuous recording orifice well tester was used.

The model used assumed a single layer of coal 19 feet thick with a 640 foot fracture on both sides of the well. The assumed initial pressure was 36 psia, porosity of the coal was four percent (4%) and the permeability was 7.5 md. The gas in place was estimated to be approximately 39 cubic feet per ton or about 1360 Mcf/acre.

Figure 4 shows the actual production rate plotted with the simulation. A low fracture permeability was needed in the simulation to obtain this close agreement between actual and simulated production. This indicates that due to the soft coal, the fracture propant may have become imbedded in the coal. In the future, perhaps a smaller mesh (larger diameter) sand should be used in fracture treatments of this coal.

Projection with this single layer model showed that the rate would gradually fall off to 8 MCF/day at the end of five years, giving an average rate of 14 MCF/day. The deliverability profile is shown on Figure 5.

Because of the unusual decline in pressure during shut in periods, as already discussed, it is conceivable that the coal formations initially had a higher pressure and higher gas content than the above single layer mdoel showed. If this were true, other wells drilled in this area could produce at much higher rates than this well.

To investigate this possibility, the model was redesigned slightly but all of the basic parameters except two were unchanged. The 19 feet of coal was split into one 14 foot layer, 112 feet above a 5 foot layer. The bottom layer simulated the bottom coal seam (B). A well was put into the model in the last block of the 640 foot fracture. This well would simulate a leak into the existing mine due to the hydraulic fracture breaking into the mine. Since this part of the mine is inactive and inaccessible right now it is not possible to investigate this first hand.

Using this new model configuration, the behavior of the well was simulated using a higher initial pressure and by varying the permeability of the fracture in the lower 5 foot zone. Figure 6 shows the results using a starting time of the beginning of fracturing on June 13, 1979.

It can be seen by comparison with Figure 3 that the pressures are low even though the rates are a good match. The significant thing, however, is that the pressures during the shut in period of August 6 to September 25 increase to a maximum and then begin to fall off because of the leak. This simulated pressure fall off is a strong indication that there was a leak of this kind in the actual well.

It is interesting to note from the model results that when the well is producing the leak off rate is smaller (≈4 Mcf/d) than when the well is shut in (≈10 Mcf/d). This leads to the recommendation that the well should be placed on production as soon as possible, or else, temporarily plugged to prevent gas leakage from the three upper zones.

This configuration is consistent with experience of Bethlehem Mines personnel who report that the "B" seam which is being mined is not at all gassy but that the upper seams produce gas into the gob area and hence into the mine after the roof collapse which comes with long wall mining. It is also consistent with the behavior of the water level in the production well. The water level was consistently above the "B" seam for the first several weeks of production. During the extended shut in period, the frac water was gradually forced into the "B" seam initiating the postulated leak. Subsequently, the water level stabilized at just below 900 feet or just below the "B" seam.

In retrospect, it would have been advisable to do some additional tests. First, the well should have been cored and gas content measured. Second, since the low pressure and lack of mobile water are the most anomolous features of the reservoir, a drill stem test may have detected these features. However, the ultimate result would have been the same. Finally, since the well produced no water, it would have been feasible to test the individual zones using straddle packers. These tests may have added to our knowledge, but would not have changed the outcome of the well.

The only recommended improvement in the completion procedure would be to have a more certain zone isolation procedure. This could be accomplished in two ways. The easiest way would be to stimulate only one zone per day and let the well flow back completely after stimulation. This would allow the sand plug to pack more completely giving a better seal. The second method would be to space fiberglass pipe only across the coal seams and use the Halliburton baffles in steel pipe between zones. This latter method could preclude using the hydrojet perforation method.

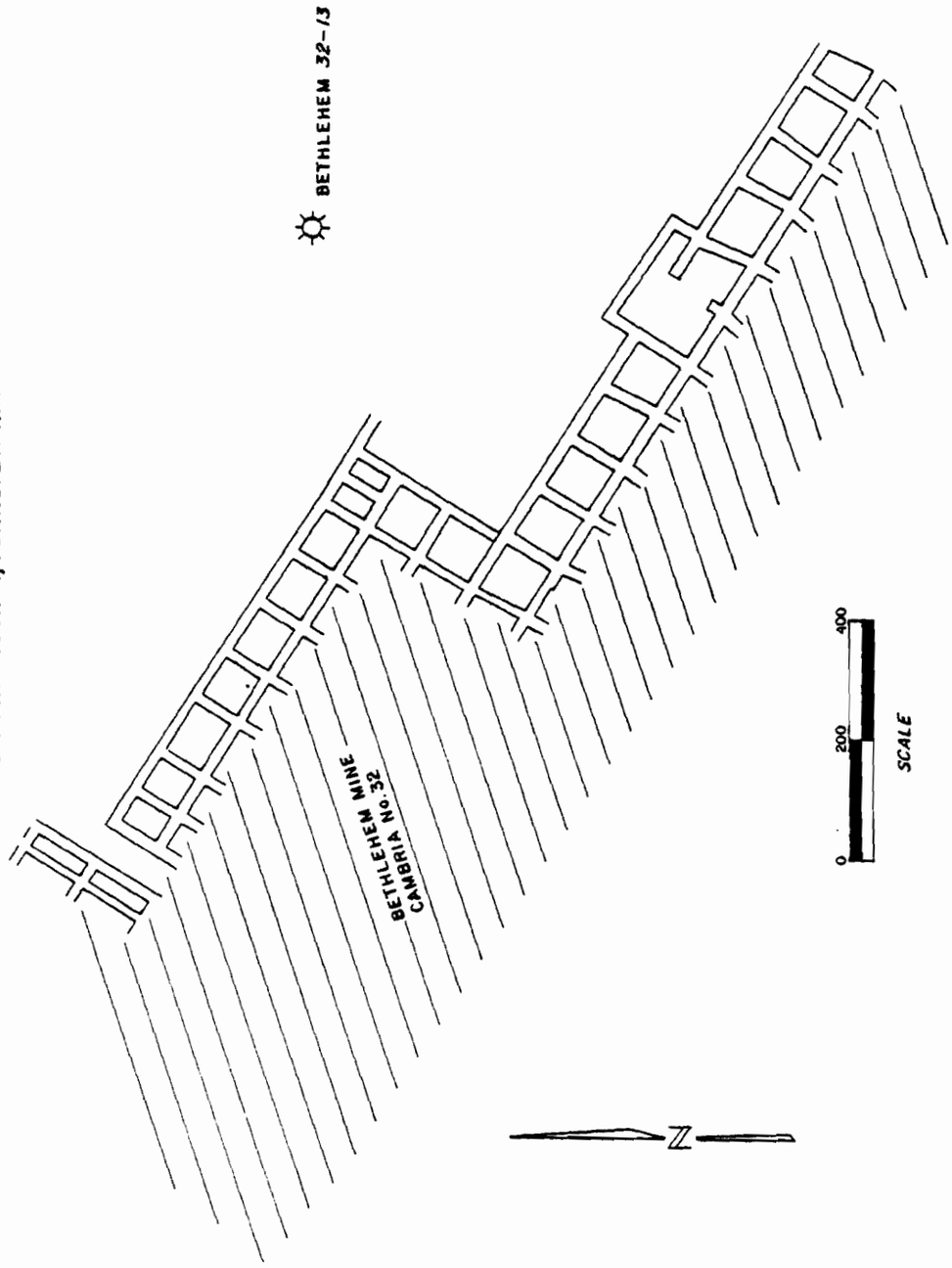
VI. CONCLUSIONS AND RECOMMENDATIONS

The field procedures and evaluation yield the following conclusions:

- The well will produce significant quantities of gas for a 5 year period.
- There is sufficient evidence to suspect leakage from the upper seams through the well into the mine.
- The area is characterized by extremely low pressure and an absence of mobile water, making this area anomolous with other degasification attempts.
- Well design and completion procedures were developed to accomodate multiple uses of the well.

These conclusions result in the recommendation that the well be connected to gas market and flowed continuously. This would utilize the gas and probably pay for any additional expense involved. Continuous flowing would minimize flow from the well into the mine. The leak could be eliminated by plugging the well if a gas market can't be secured immediately.

It is further recommended that the well design and completion procedures be made available to engineers who are designing other projects.



MINE AND WELL LOCATION
BETHLEHEM MINES
CAMBRIA COUNTY, PENNSYLVANIA

FIGURE 1

WELL DESIGN-BETHLEHEM 32-13

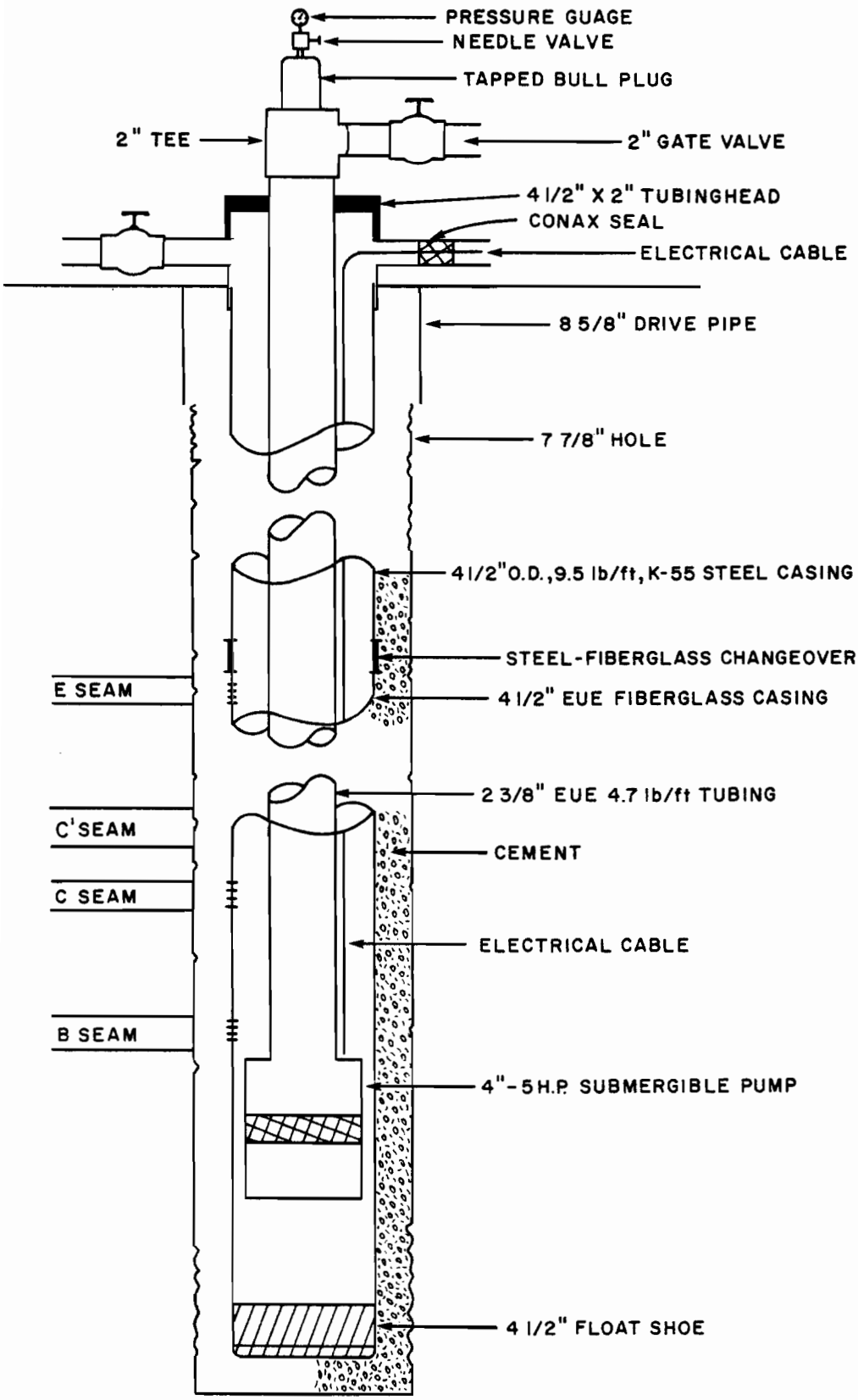


FIGURE 2

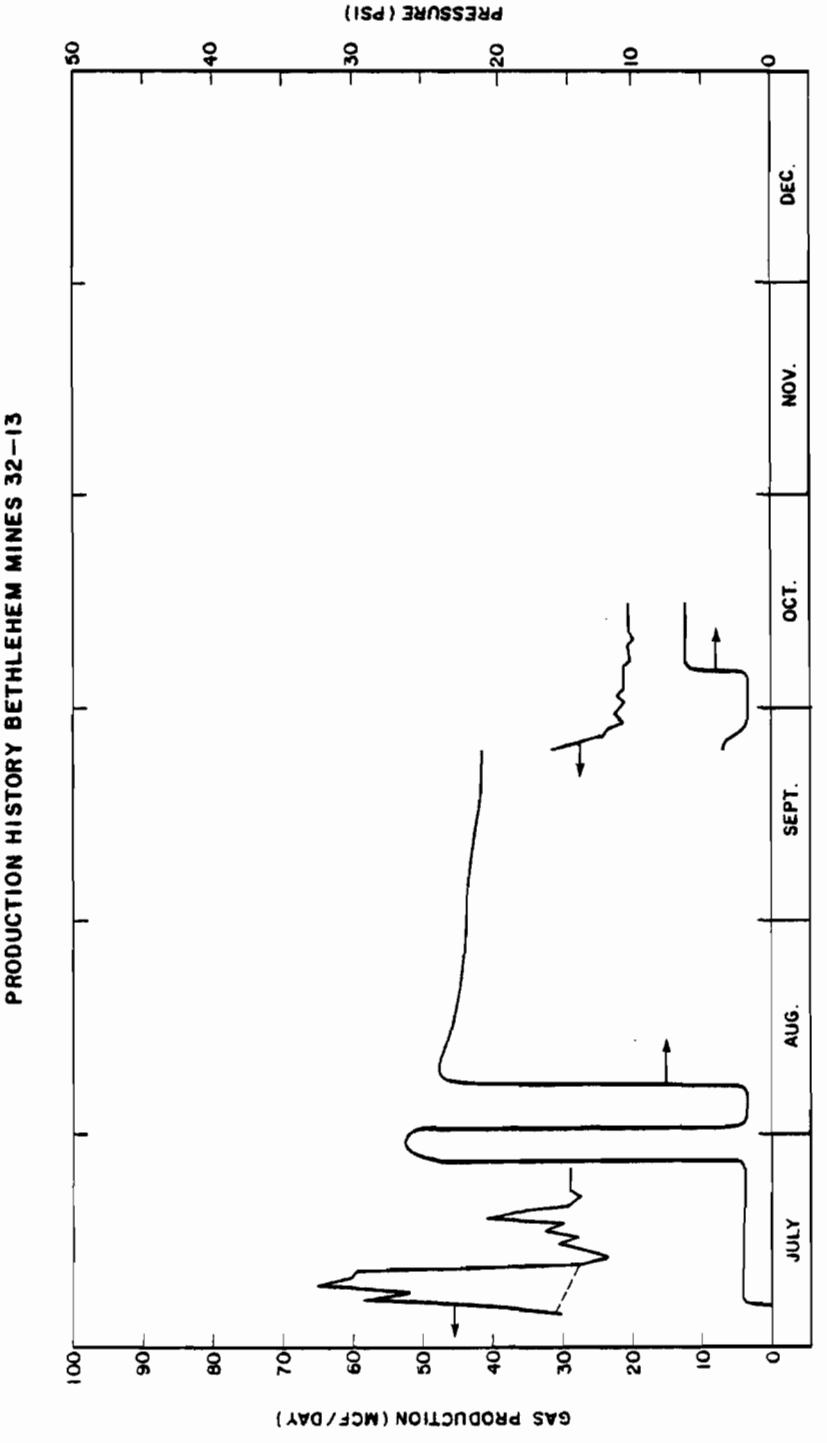

PRODUCTION HISTORY BETHLEHEM MINES 32-13
GAS PRODUCTION (MCF/DAY)
PRESSURE (PSI)
100
90
80
70
60
50
40
30
20
10
0
50
40
30
20
10
0
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.

FIGURE 3

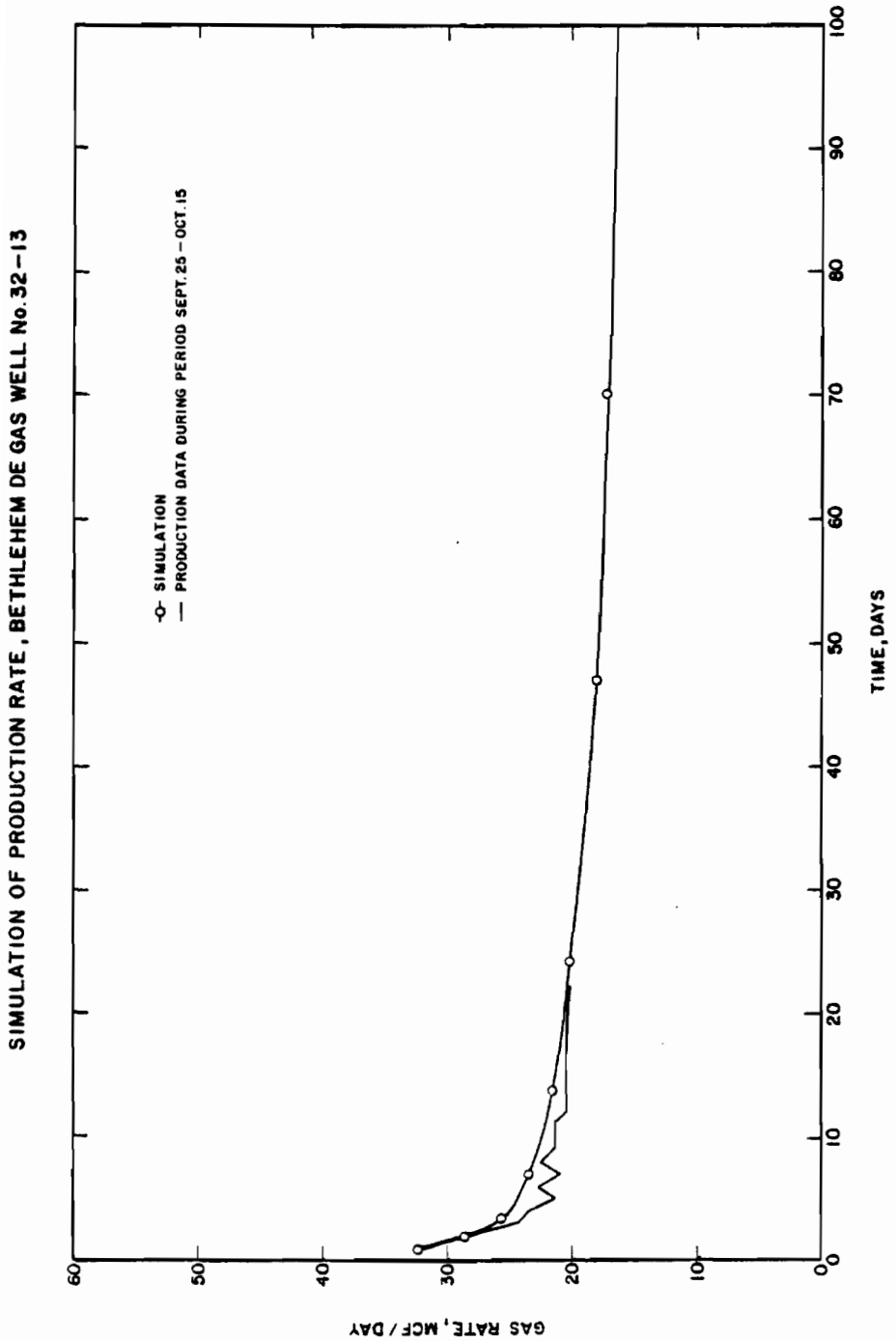

SIMULATION OF PRODUCTION RATE, BETHLEHEM DE GAS WELL No.32-13
-O- SIMULATION
— PRODUCTION DATA DURING PERIOD SEPT.25 – OCT.15
GAS RATE, MCF/DAY
TIME, DAYS
0
10
20
30
40
50
60
70
80
90
100

FIGURE 4

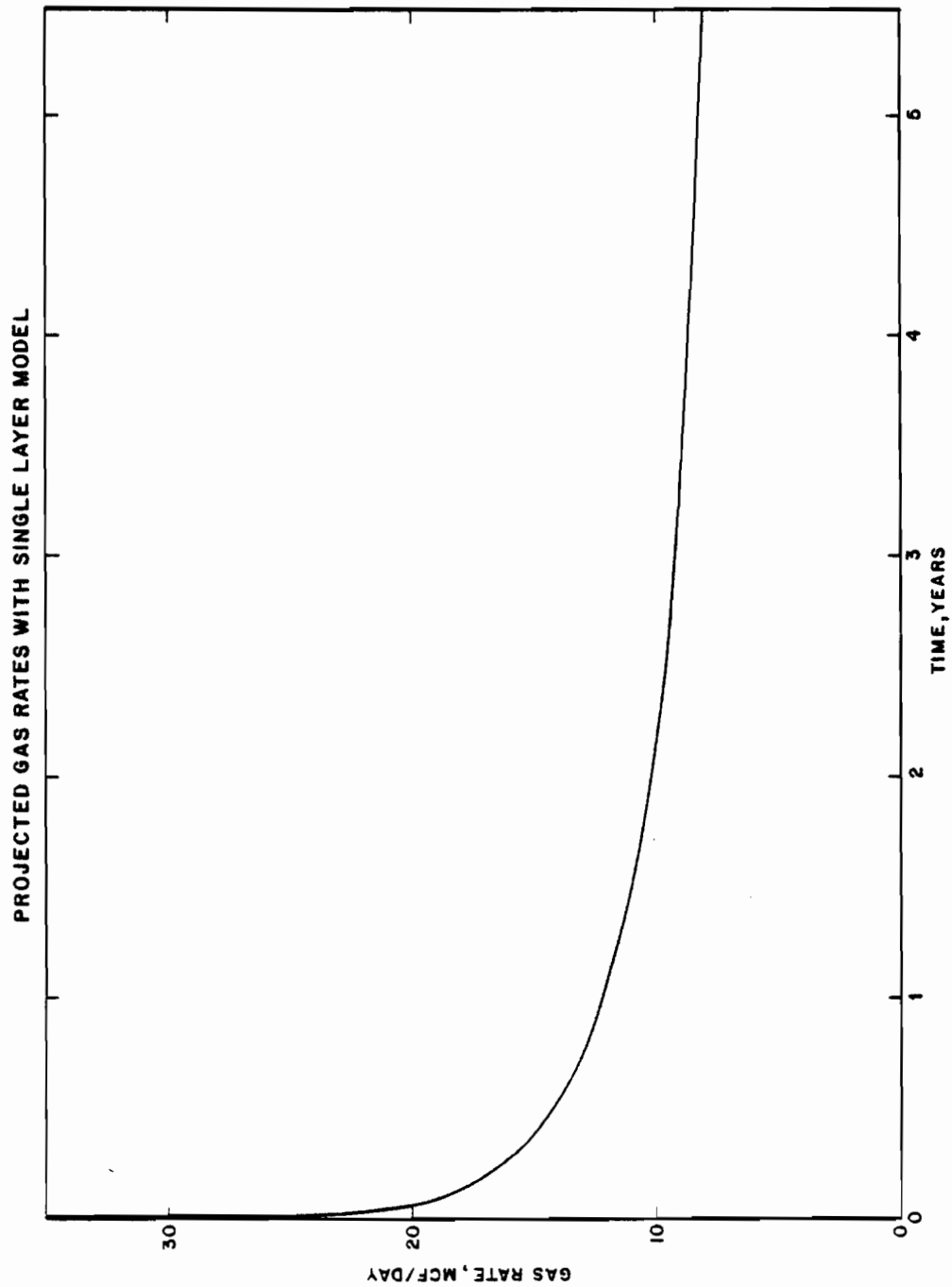

PROJECTED GAS RATES WITH SINGLE LAYER MODEL
GAS RATE, MCF/DAY
30
20
10
0
0
1
2
3
4
5
TIME, YEARS

FIGURE 5

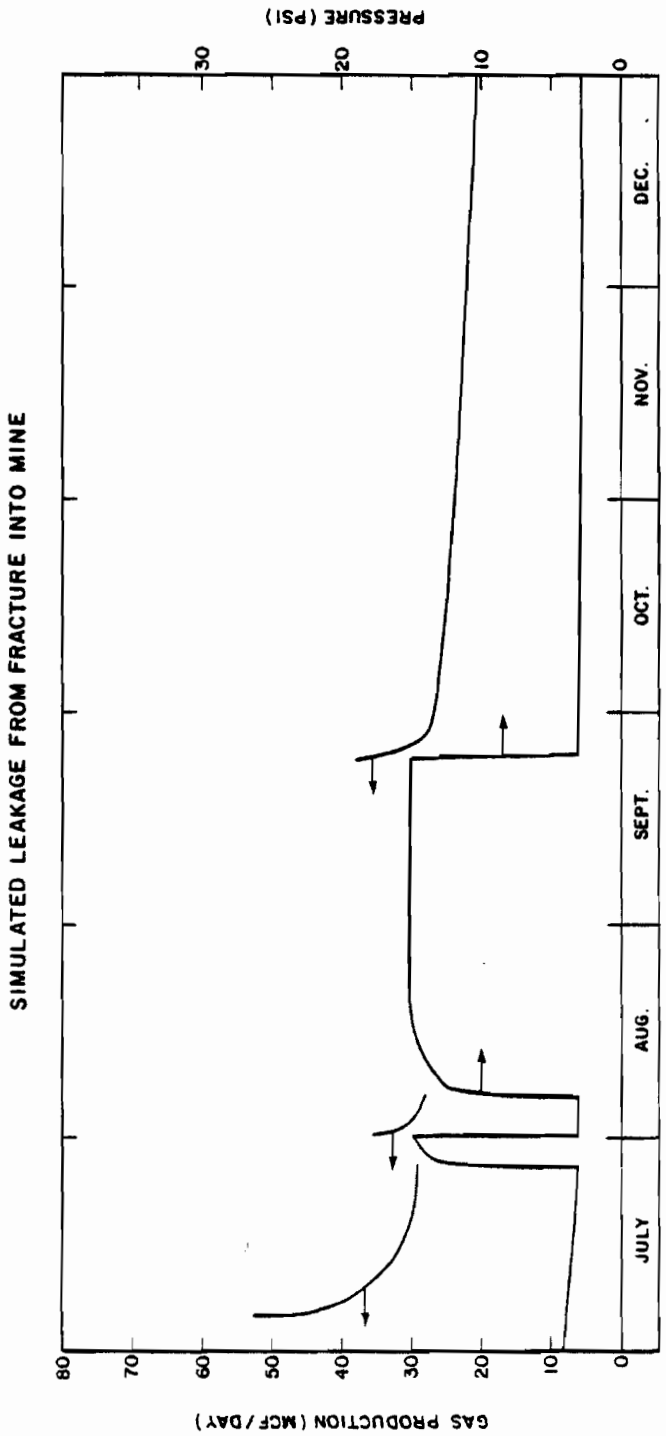

SIMULATED LEAKAGE FROM FRACTURE INTO MINE
GAS PRODUCTION (MCF/DAY)
80
70
60
50
40
30
20
10
0
PRESSURE (PSI)
30
20
10
0
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.

FIGURE 6

APPENDIX A

Stimulation Treatment Report
and
Actual Field Notes

UGR File #321
Intercomp
Nov. 1979

CONTROLLED STIMULATION AND PRODUCTION, INC.
CoSAP

September 13, 1979

Mr. Ken Ancell
INTERCOMP
Suite 200
1201 Dairy Ashford
Houston, Texas 77079

Re: Bethlehem Mine
De Gas Project

The Bethlehem mine project was abrasive jetted and fractured in four coal seams. Those present were: Don Weaver, Joe Wilcox, Bob Reed, Marty Patterson, and L. W. Sprague of Bethlehem Mines; Ray Malinchek, Bob Guiterriz, and Jim Savoy of Westinghouse; Dan Gilmore and Jerry Rennick of DOE; and Mike McKee and Don Kimmel of Halliburton. The analysis of the work is as below.

The well was logged by Go Wireline Company. It was perforated from 892 feet to 900 feet. Halliburton was hooked up, but could not pump into the formation. It was therefore decided to abrasive jet the coal. This proved to be the most sucessful way to handle the situation. However, in doing the abrasive jetting, it did create a change in plans of fracturing. Instead of fracturing down the 4½" casing, the coal was fractured down the annulus space between the 4½ and the 2 3/8" tubing. This only necesitated the chaining down of the 2 3/8" tubing.

Attached is a clean copy of the notes made during the abrasive jetting and also a copy of my field notes on the fracturing of each coal seam. Below is a summary of each zone fractured:

zone	No. stages	fluid vol.gals	sand lbs.	rate pressure
892-900	3	59,000	20,000	18b/m @ 1800 psig.
863-868	3	60,000	24,000	18 b/m @ 2200 psig.
784-790	3	54,000	23,800	20 b/m @ 1800 psig.
694-698	3	51,000	17,000	18 b/m @ 2600 psig.

There was sufficient data gathered during the abrasive jetting and fracturing to indicate that four coal seams were cut and fractured separately. The fracturing of each zone was conducted to extend the fracture out 1280 feet in three direction. In the first fracture of coal seam 892-900 the evidence during the fracture indicates that this was accomplished.

The zone 863-868 data shows that only two different fracture planes were created instead of the three, as desired.

The zone 784-790 data indicates that only two fractures were created and that one was probably much longer than the 1280' desired.

3604 Wentwood Dallas, Texas 75225 214-361-4704
~~1600 Two Turtle Creek Village, Dallas, Texas 75219, 214/522-8370~~

CONTROLLED STIMULATION AND PRODUCTION, INC.
CoSAP

Bethlehem Mines Project
page two

The third zone 694-698 indicates only one fracture plane opened and only someone else knows how far it went.

All zones took sand and were propped. It could be that we need to use a different type of propant in the soft coal since the 20/40 sand probably became imbedded.

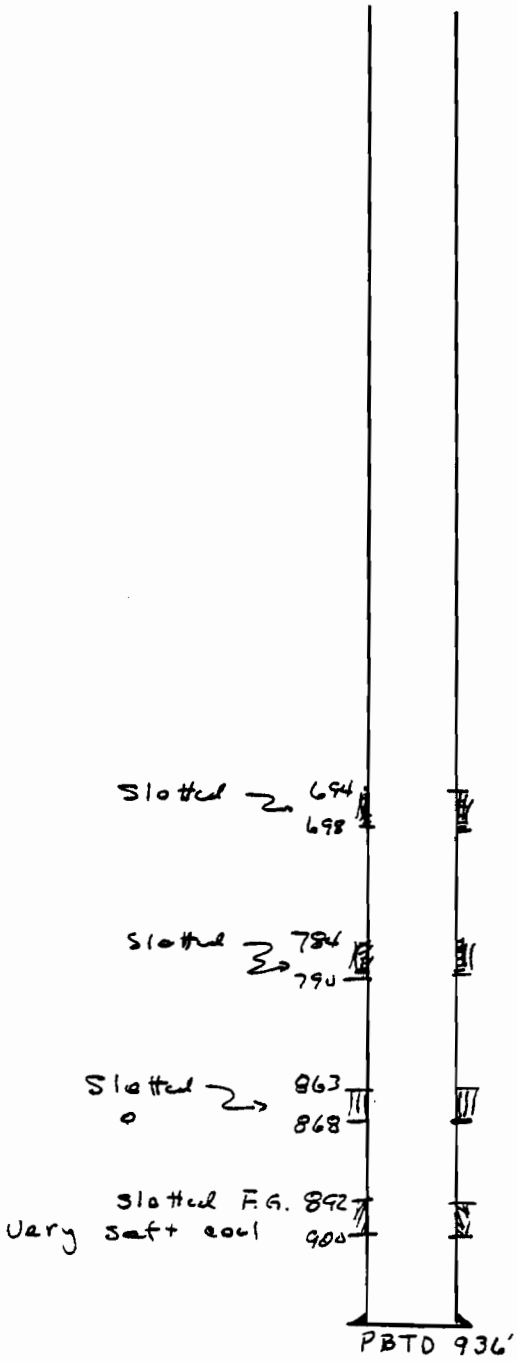
Very truly yours,

Fred A. Skidmore, Jr.

3604 Wentwood Dallas, Texas 75225 214-361-4704
~~1600 Two Turtle Creek Village, Dallas, Texas 75219, 214/522-6970~~

DIAGRAMATIC SKETCH

Bethlehem Mine DeGas #1
Field Notes -



1. Ran 31 Jts + 4' on 32 Jt. reached T.D. 936' then pulled 4' + 1 Jt. tbg. @ 901

2. Cut 8' slot in fiberglass 901-893
   cut 1' 893-892

3. Pulled 1 Jt.
   Frac'd see Notes

4. Frac'd zone 892-900

5. With Bottom tbg. @ 870 pulled up one foot cut 5' good hard coal

6. Pulled 1 Jt. Bottom tbg @ 839

7. Frac'd zone 863-868

8. Flowed well overnite making some gas.

9. A.M. Pulled 1 Jt. then came up 16' on next Jt.

10. Cut slot in fiber glass 784-790
    Allowed all sand and debree to fall down hole.

11. Pulled one Jt.
    " " Jt.
    " " "

12. Pulled up 16' and cut slot 699 to 692'
    good coal returns.

13. Pulled 2 Jts tbg.

14. Frac'd as scheduled

15. Flowed well back over nite and

16. When well died cleaned out sand to 936'

936'
- 4
932
- 31
901'
31
29 Jts → 870
- 31
28 Jts → 839
31
808
- 18
790

808
- 31
777
31
746
31
715
31
684
31
653

FAS

Intercomp
Nov. 1979

[illegible] CONTRACT
[illegible] TATMENT DATA

ATTACH TO INVOICE & TICKET NO. [illegible]

DISTRICT [illegible] DATE 6-[illegible]

TO: HALLIBURTON SERVICES YOU ARE HEREBY REQUESTED TO FURNISH EQUIPMENT AND SERVICEMEN TO DELIVER AND OPERATE THE SAME AS AN INDEPENDENT CONTRACTOR TO: Bethlehem Mines Corp. (CUSTOMER) AND DELIVER AND SELL PRODUCTS, SUPPLIES, AND MATERIALS FOR THE PURPOSE OF SERVICING

WELL NO. 32-13 LEASE GOLF COURSE LANE SEC. _____ TWP. _____ RANGE _____

FIELD Ebensburg COUNTY CAMBRIA STATE PA OWNED BY Bethlehem

THE FOLLOWING INFORMATION WAS FURNISHED BY THE CUSTOMER OR HIS AGENT

FORMATION NAME _____ TYPE _____

FORMATION THICKNESS _____ FROM _____ TO _____

PACKER: TYPE _____ SET AT _____

TOTAL DEPTH _____ MUD WEIGHT _____

BORE HOLE _____

INITIAL PROD: OIL _____ BPD, H_2O _____ BPD, GAS _____ MCF

PRESENT PROD: OIL _____ BPD, H_2O _____ BPD, GAS _____ MCF

	NEW USED	WEIGHT	SIZE	FROM	TO	MAX. ALLOW. P.S.I.
CASING	N	9.5	4½	0	504	
CASING FIBERGLASS	N	5.75	4½	504	938	
TUBING						
~~OPEN HOLE~~		Zone IV	E Seam	694	698	SHOTS/FT.
~~PERFORATIONS~~		Zone III	D Seam	784	790	
~~PERFORATIONS~~		Zone II	C Seam	863	868	
~~PERFORATIONS~~		Zone I	B Seam	893	900	

PREVIOUS TREATMENT: DATE _____ TYPE _____ MATERIALS _____

TREATMENT INSTRUCTIONS: TREAT THRU TUBING ☐ ANNULUS ☐ CASING ☐ TUBING/ANNULUS ☐ HYDRAULIC HORSEPOWER ORDERED _____

NOTCH + FRAC

CUSTOMER OR HIS AGENT STATES THE WELL IS IN PROPER CONDITION TO RECEIVE THE PRODUCTS, SUPPLIES, MATERIALS, AND SERVICES

THIS CONTRACT MUST BE SIGNED BEFORE WORK IS COMMENCED

As consideration, the above-named Customer agrees:

(a) To pay Halliburton in accord with the rates and terms stated in Halliburton's current price lists.

(b) Halliburton shall not be responsible for and Customer shall secure Halliburton against any liability for damage to property of Customer and of the well [illegible] (other than Customer), unless caused by the willful misconduct or gross negligence of Halliburton, this provision applying to but not limited to [illegible] damage and surface damage arising from subsurface damage.

(c) Customer shall be responsible for and secure Halliburton against any liability for reservoir loss or damage, or property damage resulting from subsurface [illegible] fluid [illegible] the well and/or a well blowout, unless such loss or damage is caused by the willful misconduct or gross negligence of Halliburton.

(d) Customer shall be responsible for and secure Halliburton against any and all liability of whatsoever nature for damages as a result of subsurface treatment, [illegible] action in the nature thereof, arising from a service operation performed by Halliburton hereunder.

(e) Customer shall be responsible for and secure Halliburton against any liability for injury to or death of persons, other than employees of Halliburton, [illegible] including, but not limited to, injury to the well), or any damages whatsoever, irrespective of cause, growing out of or in any way connected [illegible] material in the well hole, unless such damage shall be caused by the willful misconduct or gross negligence of Halliburton.

(f) [illegible] guarantee of the effectiveness of the products, supplies or materials, nor of the results of any treatment or service.

(g) [illegible] at its risk and expense, attempt to recover any Halliburton equipment, tools or instruments which are lost in the well and if such [illegible] are not recovered, Customer shall pay Halliburton its replacement cost unless such loss is due to the sole negligence of Halliburton. [illegible] of instruments are damaged in the well, Customer shall pay Halliburton the lesser of its replacement cost or the cost of [illegible] caused by the sole negligence of Halliburton. In the case of equipment, tools or instruments for marine operations, Customer [illegible] be fully responsible for loss of or damage to any of Halliburton's equipment, tools or instruments which occurs at any time after [illegible] leaving until returned to the landing, unless such loss or damage is caused by the sole negligence of Halliburton.

(h) [illegible] variability of variable well conditions and the necessity of relying on facts and supporting services furnished by others, Halliburton [illegible] of any chart interpretation, research analysis, job recommendation or other data furnished by Halliburton. Halliburton personnel will [illegible] gathering such information and their best judgment in interpreting it, but Customer agrees that Halliburton shall not be responsible [illegible] the use of such information except where due to Halliburton's gross negligence or willful misconduct in the preparation of [illegible]

(i) [illegible] only title to the products, supplies and materials is [illegible] that such are free from defects in workmanship and materials. [illegible] EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS OR OTHERWISE WHICH EXTEND BEYOND THOSE STATED [illegible] PRECEDING SENTENCE. Halliburton's liability and Customer's exclusive remedy in any cause of action (whether in [illegible] or otherwise) arising out of the sale or use of any products, supplies or materials is expressly limited to the replacement of such products, [illegible] on their return to Halliburton or, at Halliburton's option, to the allowance to the Customer of credit for the cost of such items. In no event shall [illegible] be liable for special, incidental, indirect, punitive or consequential damages.

(j) [illegible] default in the payment of Customer's account 60 days after date of invoice, such account will thereafter be subject to interest until paid, in [illegible] necessary to employ an attorney to enforce collection of such account, Customer agrees to pay all collection costs and attorney fees [illegible] per cent of the amount of the unpaid account.

[illegible] not be bound by any changes or modifications in this contract, except where such changes or modifications [illegible] by an officer of Halliburton.

I HAVE READ AND UNDERSTAND THIS CONTRACT [illegible] THAT I AM AUTHORIZED TO SIGN THE SAME AS [illegible]

SIGNED _____ (CUSTOMER)

DATE 6-[illegible]-79

TIME [illegible] A.M. P.M.

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[illegible] ICES
[illegible] SUMMARY

HALLIBURTON LOCATION: INDIANA, PA
BILLED ON TICKET NO.: 557760

WELL DATA

[illegible] SEC. ____ TWP. ____ RNG. ____ COUNTY: CLARIA STATE: PA

[illegible] NAME ____ TYPE ____
[illegible] THICKNESS ____ FROM ____ TO ____
[illegible] PROD: OIL ____ BPD. WATER ____ BPD. GAS ____ MCFD
[illegible] PROD: OIL ____ BPD. WATER ____ BPD. GAS ____ MCFD
[illegible] DATE ____ MUD TYPE ____ MUD WT. ____
[illegible] TYPE ____ SET AT ____
[illegible] HOLE TEMP. ____ PRESSURE ____
[illegible] DATA ____ TOTAL DEPTH ____

	NEW USED	WEIGHT	SIZE	FROM	TO	MAXIMUM PSI ALLOWABLE
CASING						
LINER						
TUBING						
OPEN HOLE						SHOTS/FT.
PERFORATIONS						
PERFORATIONS						
PERFORATIONS						

JOB DATA

CALLED OUT	ON LOCATION	JOB STARTED	JOB COMPLETED
DATE 6-13-79	DATE 6-13-79	DATE 6-13-79	DATE 6-14-79
TIME 0800	TIME 0800	TIME 0800	TIME 1730

TOOLS AND ACCESSORIES

TYPE AND SIZE	QTY.	MAKE
[illegible] COLLAR		
[illegible] SHOE		
[illegible] SHOE		
[illegible]		
[illegible] PLUG		
[illegible] PLUG		
[illegible]		
[illegible]		
[illegible] HYPE JET TOOL	1	HALLIBURTON

PERSONNEL AND SERVICE UNITS

NAME	UNIT NO. & TYPE	LOCATION
D. KIMMELL	OPER.	INDIANA, PA
R. [illegible]	2680 SP	
R. WILDEN	1510 HT	"
P. REIDELL	9497 HT	
B. NEAL	9136 CON	"
B. MILLER	"	
R. [illegible]	2214 EM	"
R. [illegible]	9303 AM	
M. [illegible]	ENG.	"
E. MILLER	FIT	

MATERIALS

[illegible] FLUID ____ DENSITY ____ LB/GAL.°API
[illegible] FLUID ____ DENSITY ____ LB/GAL.°API
[illegible] TYPE [illegible] SIZE 20/40 LB. 96000
[illegible] TYPE ____ SIZE ____ LB. ____
[illegible] TYPE ____ GAL. ____ %
[illegible] ____ GAL. ____ %
[illegible] TYPE ____ GAL. ____ %
[illegible] TYPE ____ GAL. ____ IN ____
[illegible] AGENT TYPE ____ GAL. ____ IN ____
[illegible] LOSS ADD. TYPE ____ GAL.-LB. ____ IN ____
[illegible] AGENT TYPE [illegible] GAL.-LB. 1575 IN ____
[illegible] AGENT TYPE ____ GAL.-LB. ____ IN ____
[illegible] TYPE ____ GAL.-LB. ____ IN ____
[illegible] AGENT TYPE ____ GAL.-LB. ____
[illegible] BALLS TYPE ____ QTY. ____
[illegible]
[illegible]

DEPARTMENT: STIM
DESCRIPTION OF JOB: FRAC

JOB DONE THRU: TUBING ☐ CASING ☐ ANNULUS ☐ TBG./ANN. ☒

CUSTOMER REPRESENTATIVE: [signature]

HALLIBURTON OPERATOR ____ COPIES REQUESTED ____

CEMENT DATA

STAGE	NUMBER OF SACKS	TYPE	API CLASS	BRAND	BULK LACKED	ADDITIVES	YIELD CU.FT./SK.	MIXED LBS./GAL.

PRESSURES IN PSI

[illegible] ____ DISPLACEMENT ____
[illegible] ____ MAXIMUM ____
[illegible] ____ FRACTURE GRADIENT ____
[illegible] ____ 5-MIN. ____ 15-MIN. ____

HYDRAULIC HORSEPOWER

[illegible] ____ AVAILABLE 2800 USED 1500

AVERAGE RATES IN BPM

[illegible] ____ DISPL. ____ OVERALL 19 1/10

CEMENT LEFT IN PIPE

[illegible] ____ REASON ____

SUMMARY

VOLUMES

PRESLUSH: BBL.-GAL. ____ TYPE ____
LOAD & BKDN: BBL.-GAL. ____ PAD: BBL.-GAL. ____
TREATMENT: BBL.-GAL. ____ DISPL: BBL.-GAL. ____
CEMENT SLURRY: BBL.-GAL. ____
TOTAL VOLUME: BBL.-GAL. ____

REMARKS

[illegible]

BETHLEHEM MINES CORP. GOLF COURT [illegible] WELL NO. [illegible] JOB TYPE [illegible] DATE 6-13-79

	RATE (BPM)	VOLUME (GAL)	PUMPS T	PUMPS C	PRESSURE (PSI) TUBING	PRESSURE (PSI) CASING	DESCRIPTION OF OPERATIONS AND MATERIALS
							ZONE I STAGE I
0700							SAFETY MEETING
1030			1		2000		HYDRO-JET
				1		1600	Pump into FORM.
1236	16 9/10			3		2400	All Pumps
1240						1700	START SAND
1253						1700	
1300						1600	
1303						1550	
1300		14816				1600	FINISH SAND
1306		6260		3		1600	FINISH FLUSH
	TOTAL	21160				1100	INSTANT SHUT DOWN
							AVE RATE 16 9/10
							AVE PSI 1750
							AVE HHP 721
							TOTAL SAND INSTANT 5180#
							SAND CONC: 7300-8350 — 12370-12970 1#/gal
							0-4200 — 8350-8400 1#/gal 12970-14230 —
							SAND CONC. 42-4700 1/2#/gal 8400-10030 — 14230-14960 2#/gal
							47-6750 — 10030-11080 1#/gal 14960-21160 —
							1750-7300 1/2#/gal 11080-12370 —
							ZONE II STAGE II
1227	16 9/10			3		1700	All Pumps
30						1900	START SAND
36						1800	
38						1800	
40						1900	
45		14000				1950	Finish Sand
51		3000		3		2000	Finish Flush
		17000	TOTAL			1400	INSTANT SHUT DOWN
							AVE RATE 16 9/10
							AVE PSI 1864
							AVE HP 772
							TOTAL SAND 6750#
							0-[illegible] — [illegible] —
							4-4500 1/2#/gal [illegible] 1#/gal
							45-5500 — [illegible] —
							55-6500 1#/gal [illegible]
							6-[illegible] — [illegible]

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WELL NO. [illegible]
CUSTOMER Occ Leathem Mine Corp. PAGE 2
JOB TYPE Frac DATE 6-13-79

TIME	RATE (BPM)	VOLUME (GAL)	PUMPS T	PUMPS C	PRESSURE (PSI) TUBING	PRESSURE (PSI) CASING	DESCRIPTION OF OPERATION AND MATERIALS
							ZONE II STAGE III
1115				3		2100	ALL PUMPS
21						1800	START SAND
24						1900	
29						1900	
34						1900	
40		17000				2100	FINISH SAND
41		4000		2		2400	FINISH FLUSH
	TOTAL	21000				1400	INSTANT SHUT DOWN
							AVE RATE 16.2 BPM
							AVE PSI 2000 PSI
							AVE HHP 988 HHP
							TOTAL SAND 7750 #
							0-4000 — 7-8000 1#/gal 11,7-12000 —
							4-4500 1/2#/gal 8-8700 — 13-14000 1#/gal
					SAND CONC.		45-5500 — 87-9700 1#/gal 14-11,000 —
							55-6000 1#/gal 97-10,700 — 16-17,000 2#/gal
							6-7000 — 10,7-11,700 2#/gal 17-21,000 —
							ZONE II STAGE I
1555			1		2000		HYDO-JET 20 SKS SAND
1700							SAND PLUG 25 SKS SAND
1734				3		2400	ALL PUMPS
37						2400	START SAND
39						2000	
45						2100	
51		14000				2000	FINISH SAND
54		3000		2		2300	FINISH FLUSH
Total		17000				1600	INSTANT SHUT DOWN
							AVE PSI 2240 PSI
							AVE RATE 20.2 BPM
							AVE HHP 1109 HHP
							SAND 17750 #
							0-4000 — 87-9700 1#/gal
							4-4550 1/2#/gal 97-10,700 —
							45-5500 — [illegible] 2#/gal
					SAND CONC.		55-6000 1#/gal 11,7-13,000 —
							6-7000 — 13-14,000 2#/gal
							7-9000 1#/gal 14-17,000 —
							8-9700 —

JOB LOG

CUSTOMER _____ PAGE NO. 3

JOB TYPE _____ DATE 6-14-79

TIME	RATE (BPM)	VOLUME (GAL)	PUMPS T	PUMPS C	PRESSURE (PSI) TUBING	PRESSURE (PSI) CASING	DESCRIPTION OF OPERATION AND MATERIALS
							ZONE II STAGE II
1804				3		2300	ALL PUMPS
1808						2300	START SAND
13						2300	
18						2200	
25		14000				2250	FINISH SAND
28		3000		3		2150	FINISH FLUSH
32		17000				1900	INSTANT SHUT DOWN
							AVE RATE 16.9 BPM
							AVE PSI 2280 PSI
							AVE HHP 1944 HHP
							SAND 6750#
							SAND CONC:
							SAME AS ZONE II STAGE I
							ZONE II STAGE III
43				3		3780	ALL PUMPS
45						2700	START SAND
49						2150	
52						2200	
[illegible]						2300	
55		20,000				2250	FINISH SAND
14½		4,000		3		2400	FINISH FLUSH
17	Total	24,000				1800	INSTANT SHUT DOWN
							AVE PSI 2266
							AVE RATE 18.1 BPM
							AVE HHP 1005 HHP
							SAND 10500#
							[illegible]
							0-4000 — 9-10000 — [illegible]
							4-5000 ½#/gal 10-11,000 [illegible]
							SAND 5-6000 — 11-12000 — [illegible]
							6-7000 1# [illegible]
							7-8000 — [illegible]

WELL NO. [illegible] TICKET NO. [illegible]
CUSTOMER Rotheldorn Mining Corp. PAGE NO. 4
JOB TYPE FRAC DATE 6-14-79

TIME	RATE (BPM)	VOLUME (BBL) (GAL)	PUMPS T	PUMPS C	PRESSURE (PSI) TUBING	PRESSURE (PSI) CASING	DESCRIPTION OF OPERATION AND MATERIALS
							ZONE III STAGE I
0700			1		2000		HYDR. JET 20 SKS SAND
20							SAND PLUG 6 SKS SAND
35							
55				3		2700	ALL PUMPS
1000				1		2700	START SAND
00				1		2700	
14		14000		1		2700	FINISH SAND
20½		2000		3		2100	FINISH FLUSH
		17000				1200	INSTANT SHUT DOWN
							AVE PSI 2200 PSI
							AVE RATE 15.8 BPM
							AVE HHP 852 HHP
							SAND LOAD #
							0-4000 — 8-9000 — 14-17,000 —
							40-4500 ½#/gal 9-10,000 1#/gal
					SAND		45-5500 — 10-11,000 —
					CONC.		55-6000 1#/gal 11-12,000 2#/gal
							6-7000 — 12-13,000 —
							7-8000 1#/gal 13-14,000 2#/gal
							ZONE III STAGE II
1:54				3		2050	ALL PUMPS
54				1		2000	START SAND
58				1		2000	
45				1		1950	
4[illegible]		[illegible]		1		1900	FINISH SAND
50		3000		3		1850	FINISH FLUSH
50		17000				1100	INSTANT SHUT DOWN
							AVE PSI 1930 PSI
							AVE RATE 19.3 BPM
							AVE HHP 913 HHP
							SAND 7750 #
							0-4000 — 9-10,000 2#/gal
							4-4500 ½#/gal 10-11,000
							45-5500 — 11-12,000 2#/gal
					SAND		55-6000 1#/gal 12-13,000 —
					CONC.		6-7000 — 13-14,000 2#/gal
							7-8000 1#/gal 14-17,000 —
							8-9000 —

WELL NO. [illegible] LEASE [illegible]

CUSTOMER Bethlehem Mines Corp. PAGE NO. 5

JOB TYPE FRAC DATE 6-14-79

TIME	RATE (BPM)	VOLUME (GAL)	PUMPS T	PUMPS C	PRESSURE (PSI) TUBING	PRESSURE (PSI) CASING	DESCRIPTION OF OPERATION AND MATERIALS
							ZONE III STAGE III
1100				3		1200	ALL PUMPS
04				1		1900	START SAND
08				1		1900	
12				1		1850	
16				1		1850	
20				1		1850	
21		17000		1		1800	FINISH SAND
24		2000		3		1800	FINISH FLUSH
		20000				100	INSTANT SHUT DOWN
							AVE PSI 1842.8 PSI
							AVE RATE 28.8 BPM
							AVE HHP 8944 HHP.
							SAND 95000#
							0-4000 — 10-11,000 1#/gal
							4-5000 1/2#/gal 11-12000 —
							5-6000 — 12-13,000 2#/gal
					SAND CONC.		6-7000 1#/gal 13-14,000 —
							7-8000 — 14-15000 2#/gal
							8-9000 1#/gal 15-16,000 —
							9-10,000 — 16-17,000 2#/gal 17-[illegible]
							ZONE IV STAGE I
1230					2000		HYDR TEST [illegible]
1315							SAND PLUG 9 SKS SAND
47				3		2300	ALL PUMPS
49				1		2000	START SAND
51				1		1900	
56				1		1800	
1404		1400		1		1800	FINISH SAND
10		3000		3		1700	FINISH FLUSH
10		17000				1050	INSTANT SHUT DOWN
							AVE PSI 1940 PSI
							AVE RATE 27.6 BPM
							AVE HHP 7994 HHP
							SAND 6500#
							0-4000 — 6-7000 — 10-11000 —
							4-5000 1/2#/gal 7-8000 1#/gal 11-12000 2#/gal
							5-6000 — 8-9000 — 12-13000 —

03

CUSTOMER Bethlehem Mine Corp. 6

JOB TYPE FRAC DATE 6-14-79

TIME	RATE (BPM)	VOLUME (GAL)	PUMPS T	PUMPS C	PRESSURE (PSI) TUBING	PRESSURE (PSI) CASING	DESCRIPTION OF OPERATION AND MATERIALS
							ZONE IV - STAGE II
1419				3		2350	ALL PUMPS
25						2150	START SAND
31						2000	
35		12460		3		2800	FINISH SAND BLOW PACK
							AVE RATE 17.9 BPM
							AVE PSI 2316 PSI
							AVE HHP 1018 HHP
							SAND 5700#
							SAND CONC:
							SAME AS ZONE IV STAGE II
							SAND OFF AT 12,400
							ZONE IV STAGE III
1450				3		2400	ALL PUMPS
1500						2400	START SAND
06						2500	
14						2750	
16		14800				2700	FINISH SAND
18		450		3		2800	FINISH FLUSH
18		15250				1000	INSTANT SHUT DOWN
							AVE PSI 2630 PSI
							AVE RATE 15.8 BPM
							AVE HHP 1018 HHP
							SAND 5000#
							0-4000 — 11,-12,000 —
							4-5000 1/2#/gal 12-13,000 2#/gal
							5-6000 — 13,-14000 —
							6-7000 1#/gal 14-15,250 2#/gal
							7-8000 —
							8-9000 1#/gal
							9-10,000 —
							10,-11,000 1#/gal

APPENDIX B

Bethlehem 32-13
Flow Test Data

EBENSBURG WELL 32-13 5-DAY SHUT-IN TEST

PRESSURE VERSUS TIME			
Date	Time	Accumulated Time, hrs.	Pressure, psig
7/27/79	9:00 am	0	0
	9:30 am	0.5	16.0
	10:00 am	1.0	18.4
	10:30 am	1.5	19.8
	11:00 am	2.0	20.5
	12:00 am	3.0	21.7
	1:00 pm	4.0	22.5
	2:00 pm	5.0	22.8
	3:00 pm	6.0	23.2
	4:00 pm	7.0	23.5
7/28/79	8:00 am	23.0	25.3
	4:00 pm	31.0	25.8
7/29/79	8:00 am	47.0	26.2
	4:00 pm	55.0	26.2
7/30/79	8:00 am	71.0	26.2
	4:00 pm	79.0	26.2
7/31/79	8:00 am	95.0	25.9
	4:00 pm	103.0	25.9
8/1/79	8:00 pm	119.0	25.9

CH_4 PRESSURE READINGS

120 MINUTE TEST

Date	Minutes	Pressure
7/20	30	17.6
7/23	30	17.5
	60	19.8
	90	21.0
	120	21.4
7/24	30	16.9
	60	18.8
	90	20.1
	120	20.9
7/25	30	17.0
	60	18.6
	90	20.0
	120	21.0

CH_4 PRESSURE READINGS

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Date	Time	Pressure
7/27	8:00 a.m.	0
	4:00 p.m.	23.5
7/28	8:00 a.m.	25.3
	4:00 p.m.	25.8
7/29	8:00 a.m.	26.2
	4:00 p.m.	26.2
7/30	8:00 a.m.	26.2
	4:00 p.m.	26.2
7/31	8:00 a.m.	25.9
	4:00 p.m.	25.9
8/1	8:00 a.m.	25.7
8/2	12:00 a.m.	18.3
8/3	2:30 p.m.	18.9
8/6	2:20 p.m.	18.9
8/7	8:00 a.m.	0
	4:00 p.m.	21.1
8/8	8:00 a.m.	23.2
	4:00 p.m.	23.6
8/9	8:00 a.m.	23.8
	4:00 p.m.	24.0
8/10	8:00 a.m.	24.0
	4:00 p.m.	22.0
8/13	8:00 a.m.	23.0
8/14	8:00 a.m.	23.0
8/15	8:00 a.m.	22.9
8/16	8:00 a.m.	22.7
8/17	8:00 a.m.	22.6
8/20	8:00 a.m.	22.5
8/21	8:00 a.m.	22.4
8/22	8:00 a.m.	22.4
8/23	8:00 a.m.	22.3
8/25	8:00 a.m.	22.2
8/27	8:00 a.m.	22.0
8/28	8:00 a.m.	22.0
8/29	8:00 a.m.	22.0
8/30	8:00 a.m.	22.0
8/31	8:00 a.m.	21.9
9/4	8:00 a.m.	21.8
9/5	8:00 a.m.	21.8
9/6	8:00 a.m.	21.8
9/7	8:00 a.m.	21.7
9/10	8:00 a.m.	21.5
9/11	8:00 a.m.	21.5
9/12	8:00 a.m.	21.4
9/13	8:00 a.m.	21.4
9/14	8:00 a.m.	21.4
9/16	8:00 a.m.	21.2
9/17	8:00 a.m.	21.1
9/18	8:00 a.m.	21.1
9/19	8:00 a.m.	21.0
9/20	8:00 a.m.	21.0
9/21	8:00 a.m.	20.9
9/24	8:00 a.m.	20.9
9/25	8:00 a.m.	20.9

ORIFICE WELL TESTER READINGS 3/8" DISC BETHLEHEM MINE 32-13

TIME	25 Sep.		26 Sep.		27 Sep.		28 Sep.		29 Sep.		30 Sep.		1 Oct.		2 Oct.		3 Oct.		4 Oct.		5 Oct.	
	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP
1:00 a.m.			5.0		3.4		3.0		2.5		2.8		2.8		2.8		2.5		2.5		2.2	
2:00 a.m.			4.8		3.3		3.0		2.5		2.8		2.8		2.8		2.5		2.5		2.2	
3:00 a.m.			4.5		3.2		3.0		2.5		2.8		2.5		2.8		2.5		2.5		2.3	
4:00 a.m.			4.0		3.2		3.0		2.5		2.8		2.5		2.8		2.5		2.5		2.5	
5:00 a.m.			4.0		3.1		3.0		2.7		2.8		2.5		2.8		2.5		2.5		2.5	
6:00 a.m.			4.0		3.1		3.0		2.7		2.8		2.5		2.8		2.5		2.5		2.5	
7:00 a.m.			4.0		3.1		3.0		2.7		2.8		2.5		2.8		2.5		2.5		2.5	
8:00 a.m.			4.0		3.1		3.0		2.6		2.8		2.5	*1.80	2.8		2.5	1.95	2.5	1.95	2.5	1.95
9:00 a.m.			4.0		3.1		3.0		2.5	*1.95	2.8	*1.95	2.8		2.8	1.95	2.5		2.5			
10:00 a.m.			4.0		3.1	2.5	3.0	*1.95	2.8		2.8		2.8		2.6		2.5		2.5			
11:00 a.m.			4.0		3.1		3.0		2.8		2.8		2.8		2.5		2.5		2.5			
12:00 a.m.			4.0	3.4	3.1		3.0		2.8		2.8		2.8		2.4		2.5		2.5			
1:00 p.m.			4.0		3.1		3.0		2.8		2.8		2.8		2.4		2.5		2.5			
2:00 p.m.			4.0		3.1		3.0		2.8		2.8		2.8		2.4		2.5		2.5			
3:00 p.m.	5.0	3.5	4.0		3.1		3.0		2.8		2.8		2.8		2.4		2.5		2.5			
4:00 p.m.	6.0		4.0	3.4	3.1		2.9		2.8		2.8		2.8		2.5		2.5		2.5			
5:00 p.m.	6.0		3.9		3.1		2.9		2.8		2.8		2.8		2.8		2.5		2.5			
6:00 p.m.	6.0		3.8		3.1		2.9		2.8		2.8		2.8		2.8		2.5		2.5			
7:00 p.m.	5.5		3.7		3.1		2.8		2.8		2.8		2.8		2.7		2.5		2.4			
8:00 p.m.	5.5		3.6		3.1		2.5		2.8		2.8		2.8		2.6		2.5		2.3			
9:00 p.m.	5.3		3.5		3.1		2.5		2.8		2.8		2.8		2.5		2.5		2.2			
10:00 p.m.	5.2		3.5		3.0		2.5		2.8		2.8		2.8		2.5		2.5		2.2			
11:00 p.m.	5.1		3.5		3.0		2.5		2.8		2.8		2.8		2.5		2.5		2.2			
12:00 p.m.	5.0		3.5		3.0		2.5		2.8		2.8		2.8		2.5		2.5		2.2			

Date	CH_4 Ft^3/Day	Time
25 Sep.	31,540	3:00 p.m.
26 Sep.	28,133	12:00 p.m.
27 Sep.	24,144	10:00 a.m.
28 Sep.	23,369	10:00 a.m.
29 Sep.	21,333	9:00 a.m.
30 Sep.	22,577	9:00 a.m.
1 Oct.	21,043	8:00 a.m.
2 Oct.	22,577	9:00 a.m.
3 Oct.	21,333	8:00 a.m.
4 Oct.	21,333	8:00 a.m.
5 Oct.	21,333	8:00 a.m.

Formula - Back Pressure

$Q, M\ ft^3/day = Fg\ Fm \sqrt{\Delta P\ H_2O" \times PSIA}$

$Fg = 1.3131$

$Fm = .682$ (3/8" Orifice)

$\Delta P\ H_2O" = Hg" \times 13.6085$

$PSIA = 14.73 \times PSIG$

*Pressure at TEE

HG" - Inches of Mercury
BP - Back Pressure

ORIFICE WELL TESTER READINGS 1/4" DISC BETHLEHEM MINE 32-13

TIME	5 Oct.		6 Oct.		7 Oct.		8 Oct.		9 Oct.		10 Oct.		11 Oct.		12 Oct.		13 Oct.		14 Oct.		15 Oct.	
	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP	Hg"	BP
1:00 a.m.			9.3		9.0		9.1		9.0		9.0		9.0		9.0		9.0		8.9		9.0	
2:00 a.m.			9.3		9.0		9.1		9.0		9.0		9.0		9.0		9.0		8.9		9.0	
3:00 a.m.			9.2		9.0		9.1		9.1		9.1		9.0		9.0		9.0		8.9		9.0	
4:00 a.m.			9.0		9.0		9.2		9.1		9.1		9.0		9.1		9.0		8.9		9.0	
5:00 a.m.			9.0		9.0		9.2		9.1		9.1		9.0		9.1		9.0		8.9		9.0	
6:00 a.m.			9.0		9.0		9.2		9.1		9.1		9.0		9.1		9.0		8.9		9.0	
7:00 a.m.			9.0		9.0		9.2		9.1		9.1		9.0		9.1		9.0		8.9		9.0	
8:00 a.m.	9.3	6.2	9.0		9.0	6.2	9.2	6.2	9.1	6.2	9.1	6.2	9.0	6.2	9.1	6.2	9.0	6.2	8.9	6.2	9.0	6.2
9:00 a.m.	9.3		9.0		9.2		9.1		9.1		9.0		9.1		9.1		9.0		9.0			
10:00 a.m.	9.3		9.2		9.2		9.1		9.1		9.0		9.1		9.1		9.0		9.0			
11:00 a.m.	9.3		9.2		9.2		9.1		9.1		9.0		9.1		9.1		9.0		9.0			
12:00 a.m.	9.3		9.2		9.2		9.1		9.1		9.0		9.1		9.1		9.0		9.0			
1:00 p.m.	9.3		9.2		9.2		9.1		9.1		9.0		9.1		9.1		9.0		9.0			
2:00 p.m.	9.3		9.2		9.2		9.1		9.1		9.0		9.1		9.1		9.0		9.0			
3:00 p.m.	9.3		9.2		9.2		9.2		9.1		9.0		9.1		9.2		9.0		9.0			
4:00 p.m.	9.3		9.2		9.2		9.2		9.1		9.0		9.1		9.2		9.0		9.0			
5:00 p.m.	9.3		9.2		9.2		9.2		9.1		9.0		9.1		9.2		9.0		9.0			
6:00 p.m.	9.3		9.2		9.2		9.2		9.1		9.0		9.1		9.2		9.0		9.0			
7:00 p.m.	9.3		9.2		9.1		9.1		9.1		9.0		9.1		9.1		9.0		9.0			
8:00 p.m.	9.3		9.2		9.1		9.1		9.0		9.0		9.1		9.1		8.9		8.9			
9:00 p.m.	9.3		9.1		9.0		9.0		9.0		9.0		9.0		9.0		8.9		8.9			
10:00 p.m.	9.3		9.0		9.0		9.0		9.0		9.0		9.0		9.0		8.9		8.9			
11:00 p.m.	9.3		9.0		9.0		9.0		9.0		9.0		9.0		9.0		8.9		8.9			
12:00 p.m.	9.3		9.0		9.0		9.0		9.0		9.0		9.0		9.0		8.9		8.9			

Date	CH_4 Ft^3/Day	Time
5 Oct.	20,612	8:00 a.m.
6 Oct.	20,277	9:00 a.m.
7 Oct.	20,277	8:00 a.m.
8 Oct.	20,501	8:00 a.m.
9 Oct.	20,390	8:00 a.m.
10 Oct.	20,390	8:00 a.m.
11 Oct.	20,277	8:00 a.m.
12 Oct.	20,390	8:00 a.m.
13 Oct.	20,277	8:00 a.m.
14 Oct.	20,164	8:00 a.m.
15 Oct.	20,277	8:00 a.m.

$$Q, M\ ft^3/Day = Fg\ Fm \sqrt{\Delta P\ H_2O" \times PSIA}$$

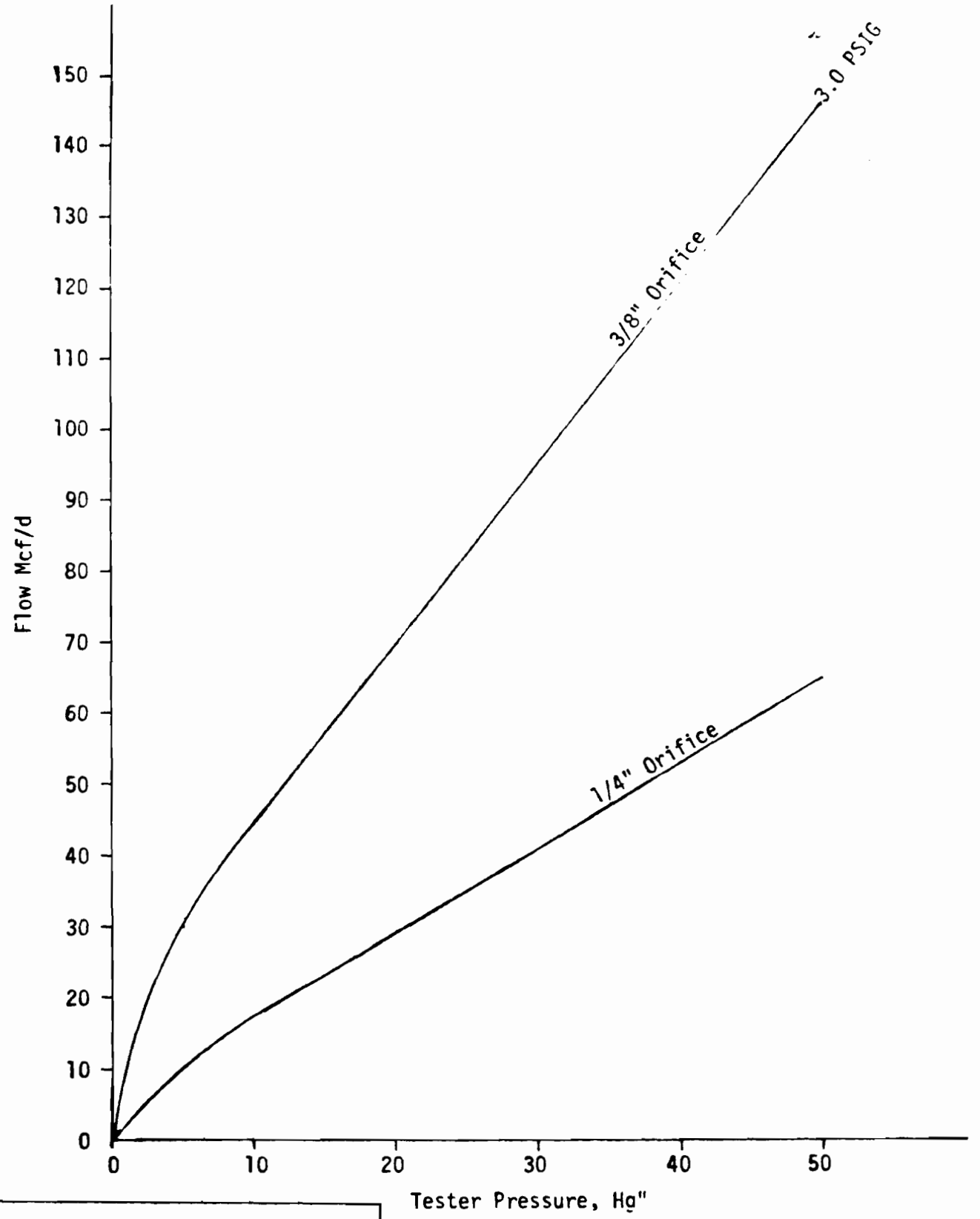
$$Fg = 1.3131$$

$$Fm = .305$$

$$\Delta P\ H_2O" = Hg" \times 13.6085$$

$$PSIA = 14.73 + PSIG\ (BP)$$

FLOW RATE ORIFICE WELL TESTER



$Mcf/d = Fg\ Fm\ \sqrt{\Delta p,\ "H_2O \times P,\ psia}$

Fm = .305, 1/4" Orifice
Fm = .682, 1/8" Orifice
Fg = 1.3131
Specific Gravity = 0.58

GAS RATE - SPECIFIC GRAVITY - 0.58 (Air=1) ATM. PRESSURE 14.4 PSIA

Orifice Size Inches	Pressure Reading In Hg	Psi	In H_2O	Psia (Static)	Orifice 1/4"	3/8"
1/4	2	.98	27.2	15.4	8,195	18,334
	4	1.96	54.4	16.4	11,961	26,759
	6	2.95	81.7	17.4	15,098	33,777
	8	3.92	108.9	18.3	17,876	39,992
	10	4.91	136.1	19.3	20,523	45,913
	12	5.89	163.3	20.3	23,056	51,581
	14	6.88	190.5	21.3	25,508	57,066
	16	7.86	217.7	22.3	27,901	62,424
	18	8.84	244.9	23.2	30,184	67,527
	20	9.82	272.2	24.2	32,501	72,711
	30	14.74	408.3	29.1	43,650	97,653
	40	19.65	544.4	34.1	54,562	122,066
	50	24.55	680.4	39.0	65,232	145,936

intercomp